

KORESPONDENSI  
WITH: RESEARCH ON CROPS (Q3) ISSN: 0972-3226

Title:  
Effect of the bioherbicide application timing and plant spacing on weed growth in rice  
(*Oryza sativa* L.) cultivation

Link Web Journal: <https://gauravpublications.com/journals/research-on-crops>

The screenshot shows the homepage of the 'Research on Crops' journal website. The header includes the Gaurav Publications logo (since 1986) and navigation links for Journals, Services, and Policies. A search bar and a 'Submit Manuscript' button are also present. The main content area features a navigation menu with options like 'Journal Home', 'Aims and Scope', 'Editorial Board', 'Current Issue', 'Archive', 'Author Guidelines', 'Online Published', and 'Publication Ethics'. Below this, the journal's details are listed: Chief Editor: Dr. Vedpal Singh, Print ISSN: 0972-3226, Online ISSN: 2348-7542, and Scientific Journal Ranking (SJR): Scopus Q3, SJR 2024: 0.27. A description of the journal's focus on crop science and agronomy is provided, along with an introduction and publication information.

H Index Journal:  
<https://www.scimagojr.com/journalsearch.php?q=19900191751&tip=sid&clean=0>

The screenshot displays the Scimago Journal Search results for 'Research on Crops'. The results are organized into a grid of information boxes:

COUNTRY	SUBJECT AREA AND CATEGORY	PUBLISHER	SJR 2024
India Universities and research institutions in India Media Ranking in India	Agricultural and Biological Sciences Agronomy and Crop Science Soil Science	Gaurav Publications	0.270 Q3
PUBLICATION TYPE	ISSN	COVERAGE	INFORMATION
Journals Publication cost estimator	09723226, 23487542	2008-2024	Homepage How to publish in this journal

**Manuscript Submission: Melalui Web Research on Crops pada tanggal 1 Agustus 2025**

**Cover Letter:**

COVER LETTER FOR SUBMISSION  
To Research on Crops

Dear Editor,

I would like to send a research article entitled: “**Salibu Rice Cultivation in Indonesia’s Lowlands: A Review of Agronomic Innovations and Sustainability Pathways**” for Research on Crops to consider. I confirm that this work is genuine and has not been published elsewhere, nor is it considered for publication elsewhere. We believe and hope that this manuscript is worthy of publication by Research on Crops. We are interested in publishing articles in this journal because it has an excellent reputation, so it is a matter of pride if published in Research on Crops. Here I attach the manuscript.

Thank you  
Best regards,

Paiman  
Universitas PGRI Yogyakarta, Indonesia

**Manuscript submission:**

**Salibu Rice Cultivation in Indonesia’s Lowlands: A Review of Agronomic Innovations and Sustainability Pathways**

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup>, ARGAWI KANDITO<sup>1</sup>

<sup>1</sup>*Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*

<sup>2</sup>*Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.*

<sup>3</sup>*Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia*

*\*(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))*

## ABSTRACT

The Salibu planting system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which enables multiple harvests from a single planting by regenerating tillers from post-harvest rice stubble. This review synthesizes agronomic principles, regional applications, and the sustainability potential of the Salibu system within Indonesia's lowland rice agroecosystems. Drawing upon scientific studies, field reports, and local practices, the review highlights key innovations such as precision stem cutting, the alternate wetting and drying (AWD) irrigation method, and the use of biofertilizers that improve regenerative growth, yield stability, and environmental efficiency. Despite these advantages, broader adoption remains limited by constraints such as incompatible rice varieties, variable soil conditions, low technical literacy among farmers, and weak institutional support. The success of Salibu implementation hinges on targeted farmer training, participatory extension models, and supportive agricultural policies. Furthermore, integrating the system into national strategies and climate-resilient food programs can scale its impact. In conclusion, the Salibu system offers strong potential to increase rice productivity, reduce environmental impacts, and support smallholder farmers. Unlocking this potential requires coordinated efforts in research, policy, and on-farm implementation. With appropriate support, Salibu system can play a vital role in advancing resilient and sustainable rice production in Indonesia.

**Key words:** agricultural innovation, lowland rice, rice cultivation, Salibu system, sustainable intensification

## INTRODUCTION

Rice is the main staple food for Indonesian people, serving as a **source** of carbohydrates for more than 90% of the population. Most of the national rice production more than 80% comes from lowland rice fields. This is not surprising, because the area has relatively stable agro-ecological conditions and a better managed irrigation system compared to rain-fed land (Sembiring *et al.*, 2020). However, despite the increasing use of modern inputs such as fertilizers and superior seeds, rice productivity in this region has actually stagnated over the past two decades. The main causes are decreased soil fertility, the use of varieties that are susceptible to disease, and low efficiency in the use of water and fertilizer (Wassmann *et al.*, 2009). Soil degradation, water stress, and

climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Dou *et al.*, 2016; Lal, 2015).

In response to these challenges, the Salibu planting system has emerged as a promising indigenous innovation rooted in West Sumatra's local farming traditions. The Salibu method utilizes the rice plant's natural ability to regenerate tillers from the remaining stubble after harvest, allowing for multiple harvests from a single planting without the need for reseeded or full land preparation (Abdulrachman *et al.*, 2015). When properly managed, Salibu systems can achieve yields comparable to initial plantings while reducing seed, labor, water, and energy inputs (Oda *et al.*, 2020; Shiraki *et al.*, 2020). These features make the Salibu approach particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Over the past decade, interest in Salibu cultivation has grown among researchers, extension agencies, and policymakers. Studies have examined its agronomic performance, cost-effectiveness, and adaptability across diverse environments, including rainfed, irrigated, and tidal lowlands (Fitri *et al.*, 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilizers have further enhanced the system's effectiveness and ecological value (Bouman *et al.*, 2007; Doni *et al.*, 2018). Despite its potential, Salibu adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka *et al.*, 2023).

The objective of this review is to synthesize current knowledge and field experiences related to Salibu rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. The review aims to: (1) highlight the key principles and regenerative mechanisms underlying the system, (2) assess its regional implementation and adoption challenges, and (3) explore strategic opportunities for integrating Salibu into national sustainable intensification frameworks.

The scope of this review is limited to Salibu practices in lowland rice ecosystems in Indonesia, including irrigated, rainfed, and tidal fields. It does not include ratooning systems in upland or highland environments, nor does it cover hybrid or mechanized rice systems in non-tropical regions. The article draws on peer-reviewed literature, national policy reports, and empirical field studies published between 2000 and 2024. The structure of this review article includes seven main sections: (1) an overview of lowland rice agroecosystems in Indonesia; (2)

detailed analysis of the Salibu planting system; (3) innovation in the salibu system for Lowland Rice; (4) Impact of Salibu system on lowland rice productivity; (5) adoption and dissemination of the Salibu system in lowland rice; (6) challenges and limitation of the Salibu system; and (7) future development directions and recommendations, and future directions.

### **Lowland Rice Agroecosystems in Indonesia**

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria *et al.*, 2011). Such soil properties facilitate higher yields and improved water productivity, particularly under prolonged waterlogged conditions (Dou *et al.*, 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totaling 8.1 million hectares.

The Salibu planting system, which enables regrowth from harvested stems, depends on precise harvest timing, accurate stem cutting, and careful management of water, fertilizers, and appropriate rice varieties. However, lowland rice productivity is hindered by the use of cultivars ill-equipped to cope with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration cultivars vulnerable to environmental extremes tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sironda Putih* and varieties carrying the *Sub1* gene demonstrate greater resilience (Wassmann *et al.*, 2009).

Climate resilience can also be enhanced through the application of biofertilizers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilizers and pesticides has led to soil degradation and reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong *et al.*, 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

## Salibu Planting System

The Salibu planting system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "Salibu" originates from the Minangkabau dialect in West Sumatra, meaning "once planted, can be harvested many times", as illustrated in Fig. 1.

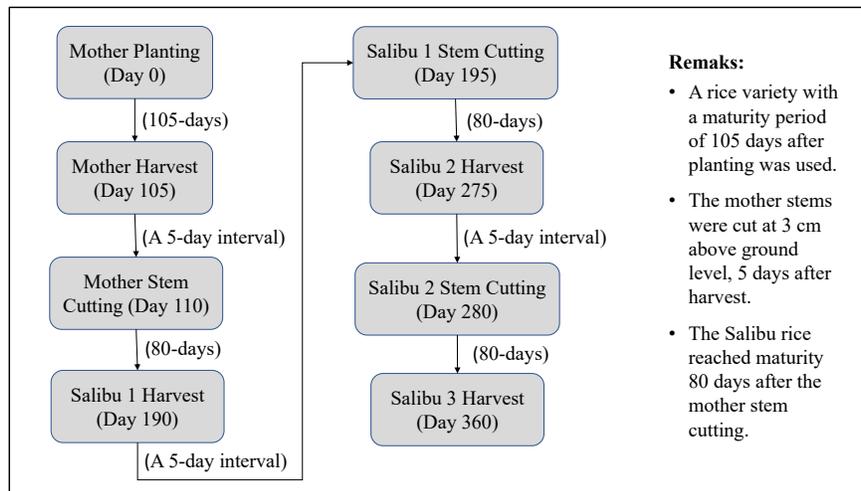


Fig. 1. Flow diagram of the Salibu planting system in lowland rice (one-year cycle).

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the Salibu system can reduce the need for seeds and labor, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki *et al.*, 2020).

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java, and West Nusa Tenggara (Fitri *et al.*, 2019).

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan *et al.*, 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labor and resources, while yielding about 60% of the main crop (Alekhya *et al.*, 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah *et al.*, 2023).

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu *et al.*, 2024). Drought, plant lodging, and post-harvest mismanagement may also reduce the success of regrowth (Shiraki *et al.*, 2020). While proper water-level control can increase yields, challenges remain in heavy-textured soils and areas with frequent submergence, such as tidal swamps (Imanudin *et al.*, 2018).

A brief comparison of the Salibu and conventional planting systems is shown in Table 1.

Table 1. Salibu vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days (Salibu)
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

## Innovation in the Salibu System for Lowland Rice

Innovations in the application of the Salibu system in lowland rice fields currently focus on improving basic agronomic practices, particularly stem cutting techniques and the timing of early regrowth. These two aspects are considered critical for maximizing shoot regeneration and overall yield. Research indicates that the optimal cutting height is between 20 and 25 cm above the soil surface, where the lower stem nodes remain physiologically active and capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant's growing point. Although efficacy depends on soil moisture, the double-cutting technique first at 20–40 cm, then at 5 cm has been shown to improve grain yield (Shiraki *et al.*, 2020).

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertilizer (Alridiwirah *et al.*, 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman *et al.*, 2015). Although lower cutting heights (e.g., 3 cm) may delay the generative phase, they can improve yield components and ratoon yield. In fact, cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan *et al.*, 2014).

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionized water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman *et al.*, 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu *et al.*, 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam *et al.*, 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill *et al.*, 2023).

The integration of environmentally friendly inputs is another critical component in developing the Salibu system. Organic and biological fertilizers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilizers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane *et al.*, 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-

grain weight, while reducing disease symptoms by up to 64.7% (Sutarman *et al.*, 2023). *Trichoderma*-based biofertilizers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni *et al.*, 2018).

Selecting high-performing cultivars compatible with the Salibu system is equally important. Varieties like *Ciherang*, *Inpari 32*, and *Mekongga* exhibit strong regenerative abilities due to vigorous tillering, sturdy stems, and responsiveness to re-fertilization. These traits make them well-suited for Salibu-type cropping systems. National and international research is increasingly focused on breeding for regenerative systems. Compared to traditional cultivars, *Inpari 13*, *Ciherang*, and *Mekongga* demonstrate superior yield components, such as higher 1000-grain weight and more filled grains. Applying 300 kg/ha of NPK to *Inpari 42* has been shown to enhance plant height, productive tiller number, and dry grain yield. *Inpari 32* also performs well in the Jajar Legowo planting system, which improves light penetration and air circulation (Khairullah *et al.*, 2021).

Several mechanization innovations have been introduced to improve efficiency in Salibu implementation. One major challenge is achieving accurate and consistent stem cutting, which is labor-intensive if done manually. To address this, portable motorized stem cutters have been developed, enabling precise cutting at the ideal height (Dixit *et al.*, 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang *et al.*, 2020). Recent innovations in mechanical harvesting tools, including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu *et al.*, 2022).

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD application (Tuong *et al.*, 2005). Micro-sprinklers with an evapotranspiration rate (ET<sub>c</sub>) of 1.25 have been shown to increase plant height, biomass, leaf area, and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar *et al.*, 2008).

For post-harvest and land preparation, lightweight, eco-friendly equipment like mini tillers help preserve root systems, improve soil aeration, and support shoot regeneration. Tools like the

Rice Seedling Planter, designed to plant 15–21-day-old seedlings at optimal depths (2.5–7.5 cm), maintain soil structure and encourage early growth (Saleh *et al.*, 2018).

### **Impact of Salibu System on Lowland Rice Productivity**

One of the main advantages of the Salibu system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that Salibu yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka *et al.*, 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles comparable to initial planting yields and indicative of high production efficiency (Oda *et al.*, 2020; Shiraki *et al.*, 2020). Additionally, Salibu increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda *et al.*, 2020).

The performance of the Salibu system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina *et al.*, 2021). When managed correctly through proper stem cutting, supplemental fertilization, and AWD irrigation, the system maintains stable productivity. Unlike conventional replanting systems that require approximately 240 days per cycle, Salibu allows two harvests within 180–200 days. With optimal water management and the use of double-cutting techniques, yields can increase by up to 69% compared to continuous flooding systems (Shiraki *et al.*, 2020). These findings affirm that Salibu is a viable and efficient method to sustain rice production amid climate challenges (Hong and Huang, 2024; Yamaoka *et al.*, 2023).

The Salibu system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labor costs (Fitri *et al.*, 2019; Paman *et al.*, 2014). Since regeneration occurs from existing stubble, seed use can be reduced by nearly 100%. Compared to the double-replanting method, the Salibu system improves labor and seed efficiency by 29% and 52%, respectively (Shiraki *et al.*, 2020). By enabling multiple harvests from a single planting, Salibu saves time, water, seed, and labor (Fitri *et al.*, 2019). Furthermore, moderate AWD irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq *et al.*, 2020). Depending on the intensity and duration of drying cycles, AWD has also been shown to reduce greenhouse gas emissions and global warming potential (GWP) by up to 73%, with minimal yield losses (Gao

*et al.*, 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill *et al.*, 2020).

Environmental efficiency in the Salibu system is also supported by the use of organic and microbial fertilizers. Biofertilizers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation has significantly improved rice growth and yield, serving as a more sustainable alternative to synthetic nitrogen fertilizers. Meanwhile, *Trichoderma*-based biofertilizers can increase yields by up to 30%, while also mitigating the negative impacts of excessive chemical input (Razie and Anas, 2008).

From an economic perspective, the benefits of the Salibu system are clear. According to a study by the West Sumatra Agricultural Technology Assessment Institute, the system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labor, seed, and land preparation (Abdulrachman *et al.*, 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of Salibu are higher than those of conventional systems, indicating greater farming feasibility (Fitri *et al.*, 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, Salibu contributes to household food security and income stability (Wassmann *et al.*, 2009). Some studies even report up to four harvests from a single planting within a year an impressive feat in the context of intensified agriculture (Sakti *et al.*, 2021).

From a social standpoint, increased productivity from Salibu promotes the engagement of local labor in key agricultural tasks such as pruning, fertilizing, and irrigation management. Moreover, this system encourages resource-efficient farming, reduces dependency on external inputs, and strengthens community-based agricultural resilience. In Percut Sei Tuan District, for instance, Salibu implementation not only increased farmer income but also prevented the conversion of productive rice fields into industrial land. Local farmers were further empowered through their active involvement in producing organic pesticides and bokashi compost, reinforcing sustainable agricultural practices (Mayly and Syafri, 2018).

Overall, the Salibu system can reduce water usage by up to 60%, lower labor requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman *et al.*, 2022). From economic, environmental, and social perspectives, Salibu represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

## Adoption and Dissemination of the Salibu System in Lowland Rice

The successful adoption of the Salibu planting system is influenced by a combination of social, technical, and institutional factors. Among the most critical is farmers' technical capacity, particularly in post-harvest fertilization, water management, and precision stubble cutting. Without adequate knowledge and hands-on training, many farmers struggle to regenerate tillers optimally leading to discouragement and eventual abandonment of the practice (Effendy *et al.*, 2021; Mayly and Syafri, 2018; Paiman *et al.*, 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the Salibu system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management especially through techniques like AWD must be consistently applied (Yamaoka *et al.*, 2023). However, the absence of structured technical assistance in many regions often becomes a bottleneck to successful field implementation. Beyond technical challenges, land suitability also plays a decisive role. The Salibu system is best suited for sandy loam soils with adequate water supply and efficient drainage. Conversely, heavy clay soils or poorly drained areas can hinder shoot regeneration and overall system performance (Shiraki *et al.*, 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti *et al.*, 2021).

Institutional support particularly from pioneer farmers and agricultural extension officers serves as a key driver of Salibu adoption. Farmers who have successfully implemented the system often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye *et al.*, 2021; Yitayew *et al.*, 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Solok Regency in West Sumatra, recognized as the birthplace of the Salibu system, serves as a model region for the development and dissemination of this technology. Since the early 2000s, collaborative efforts between Assessment Institute for Agricultural Technology and the local Department of Agriculture have facilitated technical assistance and innovation refinement. Pioneer farmers in Solok helped develop site-specific fertilization and cutting techniques tailored to

seasonal and varietal characteristics (Abdulrachman *et al.*, 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Sakti *et al.*, 2021; Shiraki *et al.*, 2020).

### **Challenges and Limitations of the Salibu System**

Despite its potential to increase rice yields and resource-use efficiency, the implementation of the Salibu system faces several biophysical and socio-institutional constraints. One of the primary agronomic limitations lies in varietal suitability. Not all rice cultivars possess strong regenerative capacity following stubble cutting. Early-maturing varieties with robust root systems and high tillering potential such as *Ciherang* and *Inpari 32* are more compatible with the Salibu system. In contrast, late-maturing or soft-stemmed cultivars often fail to develop vigorous ratoon tillers. While *Ciherang* performs well under favorable conditions, it is more susceptible to *tungro* virus compared to varieties like *Inpari 1*, *Inpari 3*, and *Inpari 5*, which are better suited to rainfed or limited-irrigation environments (Khaerana *et al.*, 2023).

Soil characteristics also play a critical role in determining the success of the Salibu system. Ideal conditions include soils with stable moisture levels, good drainage, and moderate texture. Overly dry or waterlogged soils inhibit tiller regeneration and increase susceptibility to abiotic stress (Agustina *et al.*, 2022; Shiraki *et al.*, 2020). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana *et al.*, 2023). Therefore, the success of the Salibu system depends on a combination of appropriate varietal selection, conducive soil conditions, and timely agronomic interventions.

One of the most significant technical challenges is the limited knowledge and training among both farmers and agricultural extension workers. Many farmers lack understanding of shoot regeneration physiology, appropriate pruning techniques, and efficient water management. Compounding the issue, many field extension agents have not received formal training specific to Salibu, resulting in inconsistent adoption and suboptimal results across regions (Abdulrachman *et al.*, 2015). The impact of climate change particularly shifts in pest and disease dynamics further complicates management, underscoring the need for integrated pest surveillance and predictive modeling to support adaptive, ecosystem-based control strategies (Subedi *et al.*, 2023).

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina *et al.*, 2021; Zarwazi *et al.*, 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the Salibu system across diverse agroecosystems remains constrained.

From a socio-economic perspective, adoption of the Salibu system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Skepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka *et al.*, 2023).

At the institutional level, barriers include insufficient regulatory frameworks, limited infrastructure investment, and a prevailing policy bias toward land expansion and input subsidies rather than promoting efficiency-based innovations such as Salibu. In regions like Tanah Datar Regency, implementation has been suboptimal due to the absence of localized policy instruments, shortage of trained personnel, and socio-economic constraints at the regional level (Rada *et al.*, 2011).

### **Future Development Directions and Recommendations**

The sustainable development of the Salibu system necessitates a comprehensive, interdisciplinary research and policy agenda. One of the foremost priorities is to optimize the adaptation of Salibu-based practices and rice cultivars to suit Indonesia's diverse lowland rice agroecosystems, which vary in terms of soil types, microclimates, and irrigation infrastructure. Agronomic parameters such as soil water availability, cutting height, and fertilization timing are crucial determinants of success, thus warranting site-specific management strategies (Paiman *et al.*, 2022).

The system has demonstrated adaptability to elevated temperature conditions, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda *et al.*, 2020). However, yield outcomes remain variable across regions; in some locations, Salibu yields still lag behind those of conventional replanting systems (Sakti *et al.*, 2021; Yamaoka *et al.*, 2023).

Future research should explore the long-term environmental impacts of Salibu implementation, including its effects on greenhouse gas emissions, soil quality, and water-use efficiency. In light of global climate change and the push for low-emission agriculture, adopting life cycle assessment (LCA) frameworks will be essential to evaluate the sustainability of Salibu comprehensively. Initial LCA-based studies conducted in Solok suggest that the system can reduce non-point source pollution and mitigate emissions while improving environmental performance (Aswin *et al.*, 2023; Qiao *et al.*, 2024).

For the Salibu system to be scaled up effectively, extension strategies must be context-specific and rooted in evidence-based methodologies. Extension materials should be designed in practical, easily comprehensible formats such as visual guides, mobile-accessible videos, and hands-on field training to empower both farmers and extension workers (Mayly & Syafri, 2018). Combining local wisdom with scientific agronomy enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo *et al.*, 2022).

While digital platforms (e.g., WhatsApp, Facebook) have emerged as effective channels for peer-to-peer knowledge exchange, their reach remains limited in areas with low digital literacy. Therefore, hybrid communication strategies that combine ICT and traditional outreach **methods** are recommended (Agnese *et al.*, 2024). Participation in digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim *et al.*, 2024; Mendes *et al.*, 2024). In this regard, involving lead farmers as local mentors and organizing farmer groups or cooperatives can accelerate innovation diffusion at the grassroots level.

To broaden its application, the Salibu system must be strategically integrated into national agricultural development programs, such as the Food Estate initiative and the IP400 intensification program. Salibu aligns well with IP400's goal of achieving four rice harvests per year, as it enables two harvests from a single planting, thereby saving labor, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

However, policy incentives are essential to overcome adoption barriers. These may include subsidies for biofertilizers, discounted crop insurance premiums for environmentally friendly practices, or support for semi-mechanical tools such as portable stem cutters (Lal, 2015). Additionally, digital incentive models, such as climate-smart agriculture insurance or mobile-based input vouchers have proven effective in other contexts and could be adapted for Indonesia (Limpo *et al.*, 2022).

## CONCLUSION

This review underscores the Salibu planting system as a viable and sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By leveraging the rice plant's natural regenerative ability, Salibu enables multiple harvests from a single planting, thereby reducing seed, labor, and water inputs while maintaining competitive yields. Key agronomic innovations including precision stem cutting, AWD irrigation, and the integration of biofertilizers enhance the system's efficiency and adaptability in diverse environmental conditions. Despite these advantages, broader adoption remains limited by constraints such as incompatible rice varieties, variable soil conditions, low technical literacy among farmers, and weak institutional support. The success of Salibu implementation hinges on targeted farmer training, participatory extension models, and supportive agricultural policies. Furthermore, integrating the system into national strategies like IP400 and climate-resilient food programs can scale its impact. In conclusion, the Salibu system holds significant promise for enhancing productivity, reducing environmental impact, and improving smallholder livelihoods. To realize this potential, coordinated efforts across research, policy, and farmer-level implementation are essential. With the right support, Salibu system can contribute meaningfully to building a resilient and sustainable rice production future in Indonesia.

## ACKNOWLEDGMENTS

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

## REFERENCES

- Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian. (In Indonesian)
- Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural

- Sarawak, Malaysia. *Interactive Learning Environments*, **32**: 5699–5710.
- Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) Salibu paddy cultivation. *Asian Journal of Applied Sciences*, **10**: 1–8.
- Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *International Journal of Environment and Climate Change*, **14**: 424–436.
- Alridiwersah, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer. *Acta Agrobotanica*, **74** : 1–12.
- Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip and micro sprinkler irrigation. *Agricultural Science Digest*, **28**: 124–126.
- Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *AJARCDE (Asian Journal of Applied Research for Community Development and Empowerment)*, **7** : 160–169.
- Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agronomy Journal*, **112**: 5115–5124.
- Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agronomy Journal*, **115**: 1735–1745.
- Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi salibu daerah Sumatera Barat. *Jurnal Teknologi Pertanian Andalas*, **25**: 90–95.
- Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). Water management in irrigated rice: Coping with water scarcity. In *International Rice Research Institute*.
- Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy*, **14** : 1926.
- Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agricultural Engineering International*, **24**: 90–101.

- Dobermann, A. and Fairhurst, T. (2000). Rice: Nutrient disorders & nutrient management. In *Medical Instrumentation*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI).
- Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Organic Agriculture*, **8**: 207–223.
- Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE*, **11** : e0150549.
- Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of Salibu rice technology in Garut Regency, West Java-Indonesia. *International Journal of Innovative Science and Research Technology*, **6**: 644–649.
- Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *International Journal of Intellectual Discourse (IJID)*, **7**: 44–57.
- Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy*, **11**: 777.
- Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Communications in Soil Science and Plant Analysis*, **42**: 1913–1933.
- Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). Salibu technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy and Water Environment*, **17**: 403–410.
- Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon rice. *Agriculture (Switzerland)*, **12**: 620.
- Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields:

A global meta-analysis. *Agricultural and Forest Meteorology*, **353**: 110075.

- Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Molecular Soil Biology*, **15**: 87–98.
- Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Applied Sciences (Switzerland)*, **10**: 4432.
- Ilar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *The Journal of Public Affairs and Development*, **2**: 107–142. <https://www.ukdr.uplb.edu.ph/jpad/vol2/iss2/2/>
- Imanudin, M. S., Bakri, B. and Jelita, R. (2018). Ratoon systems in tidal lowland: Study of groundwater dynamics and the change of nutrient status on rice growth. *Sains Tanah- Journal of Soil Science and Agroclimatology*, **15**: 93–103.
- Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agricultural Water Management*, **241**: 106363.
- Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *European Journal of Soil Science*, **75**: e13533. <https://doi.org/10.1111/ejss.13533>
- Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). Salibu rice cultivation in tungro endemis region. *Jurnal Teknik Pertanian Lampung*, **12**: 338–349.
- Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertanian (Agricultural Science)*, **6**: 163–174.
- Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability (Switzerland)*, **7**: 5875–5895.
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustainability (Switzerland)*, **14**: 2952.
- Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock

- production in developing countries: The potential role of icts. *Sustainability (Switzerland)*, **13**: 5868.
- Mayly, S. and Syafri, A. (2018). Implementation of Salibu rice cultivation technology in Percut Sei Tuan Sub-District. *Journal of Saintech Transfer*, **1**: 33–40.
- Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *Journal of Agribusiness in Developing and Emerging Economies*, **14**: 676–693.
- Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustainability (Switzerland)*, **16**: 9297.
- Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of SALIBU to triple-cropping in Vietnam. *F1000Research*, **8**: 1825.
- Paiman, Isnawan, B., Aziez, A., Subeni and Salisu, M. A. (2022). The role of agronomic factors in Salibu rice cultivation. *The Open Agriculture Journal*, **16**: 1–7.
- Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor requirements and costs. *Engineering in Agriculture, Environment and Food*, **7**: 122–126.
- Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustainability (Switzerland)*, **16**: 9920.
- Rada, N. E., Buccola, S. T. and Fuglie, K. O. (2011). Government policy and agricultural productivity in Indonesia. *American Journal of Agricultural Economics*, **93**: 867–884.
- Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *Jurnal Ilmu Tanah dan Lingkungan*, **10**: 41–45.
- Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah*, **18**: 65–72.
- Saleh, A. S., Asyim, A. R. M., Wibisono, Y., Supriono and Suryana, Y. (2018). Engineering of ergonomic and affordable rice planting tool for effort to meet the energy scarcity of

agriculture. *Jurnal Ilmiah Inovasi*, **17**: 1–8.

- Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agriculture (Switzerland)*, **10**: 1–13.
- Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita*, **36**: 72–80.
- Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the Salibu system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy*, **10**: 1621.
- Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *Journal of Agriculture and Food Research*, **14**: 100733.
- Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian Journal of Agriculture and Rural Development*, **13**: 277–287.
- Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. *New Directions for a Diverse Planet. Proceedings of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia*, **8**: 231–241.
- Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. In *Advances in Agronomy*, **102**: 91–133.
- Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C., Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food and Energy Security*, **9**: e206.
- Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). *Salibu rice ratoon cropping system*. Japan International Research Center for Agricultural Sciences.
- Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of

agricultural extension services on the adoption of improved wheat variety in Ethiopia: A cluster randomized controlled trial. *World Development*, **146**: 105605.

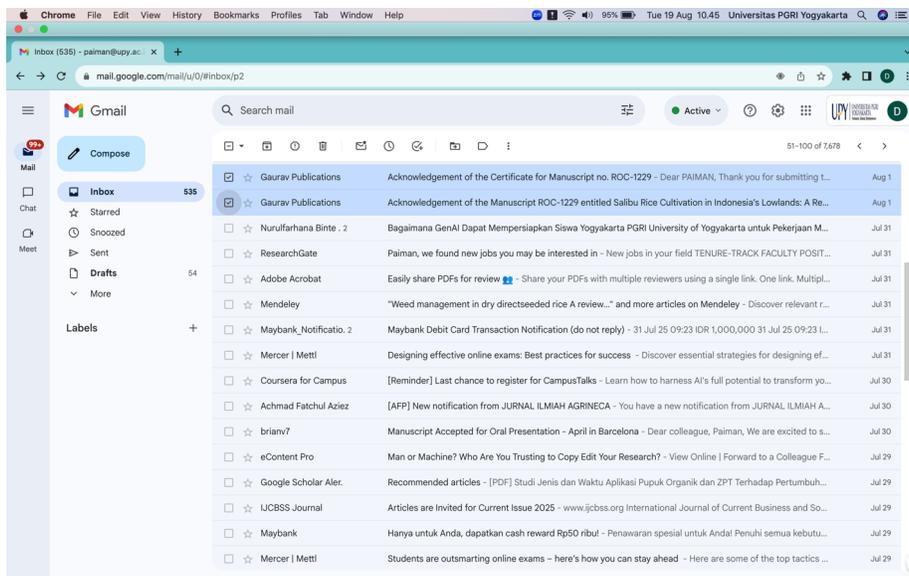
Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *Field Crops Research*, **234**: 66–72.

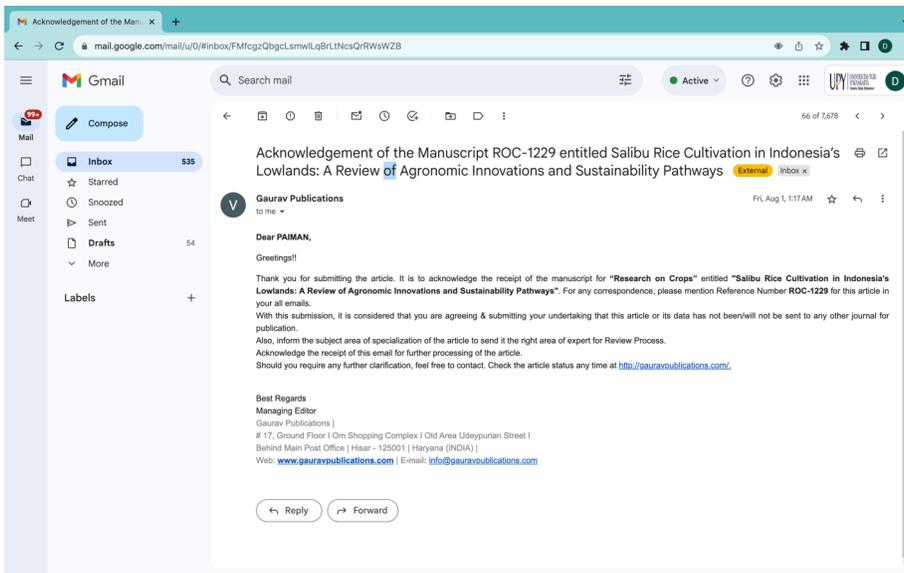
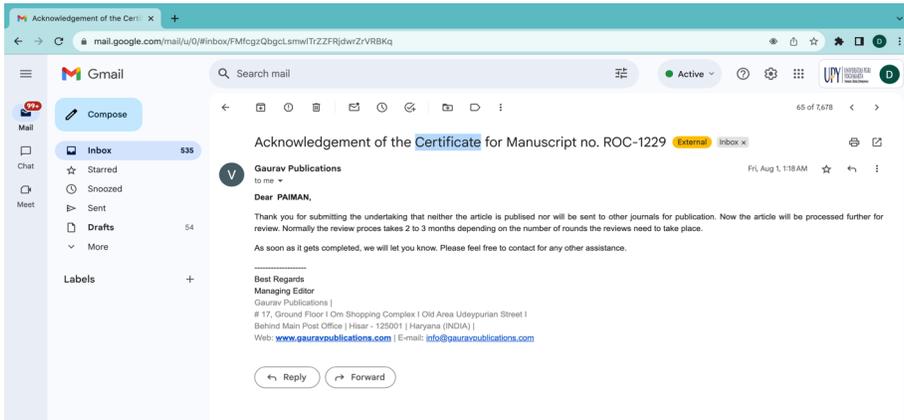
Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, **13**: 186–197.

Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon salibu cultivation. *Biodiversitas*, **23**: 1065–1071.

Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Ziama, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *African Journal of Agricultural Research*, **19**: 20–23.

URL: <https://mail.google.com/mail/u/0/#inbox/p2>





mail.google.com/mail/u/0/#inbox

Search mail

Active

1-50 of 7678

☆ Gaurav, Vedpal 3 Comments of Reviewer on the manuscript " ROC-1229 " - References in the list of references should be corre... Aug 17

☆ Google Security alert for paimanupy@gmail.com - This is a copy of a security alert sent to paimanupy@gmail.com. p... Aug 17

☆ Journal of Water an. Review invitation reminder (JWLD-01934-2025-01) - Dear Dr. Paiman, We would like to inform you that tomo... Aug 17

☆ Google Scholar Aler. Recommended articles - PENGARUH BERAT UMBI BENIH BAWANG TERHADAP PERTUMBUHAN DAN HASIL B... Aug 17

☆ AJJSER JOURNAL Call For Paper | August Issue | Sciences and Engineering Journal - Greetings from American Journal of Scien... Aug 16

☆ wijcreditorial off. Submit your research and review articles: Quick publication - INTERNATIONAL JOURNAL OF CURRENT RESE... Aug 16

☆ eContent Pro eContent Pro Launches New Book Publishing Program - Facebook Logo Twitterx Logo LinkedIn Logo View O... Aug 15

☆ ResearchGate Paiman, you have 2 more citations - Paiman, you have 2 more citations Paiman Paiman Paiman, we found 2 cl... Aug 15

☆ Levi's® Red Tab™ Celebrate Independence Day with 45% OFF! 🇺🇸 Meriahkan 17an dengan outfit stylish dan diskon spesial... Aug 15

☆ Google Scholar Aler. Recommended articles - Introgression of submergence tolerance QTL (SUB1) into mega rice variety ADT (R) ... Aug 14

☆ eContent Pro Avoid the Endless Loop of Rejection - View Online | Forward to a Colleague Facebook | X | LinkedIn Share Thi... Aug 14

☆ ResearchGate Paiman, we found new jobs you may be interested in - New jobs in your field Faculty position announcement... Aug 14

☆ Mendeley "Weed management in dry directseeded rice A review..." and more articles on Mendeley - Discover relevant r... Aug 14

☆ BPRG UMY Newsletter UMY June 2025 - Dear Paiman Paiman Wishing you a great day! Universitas Muhammadiyah Yogy... Aug 13

☆ mcm Clearing (ID SKNLLG) Transfer - Transaction Execution Notification Multiple Transfer by File Upload - Dear V... Aug 13

Show side panel

Chrome File Edit View History Bookmarks Profiles Tab Window Help

mail.google.com/mail/u/0/#inbox/FTMtgZqcpkFTxNNVbMVwRqMDfxrGT

Search mail

Active

5 of 7678

Comments of Reviewer on the manuscript " ROC-1229 " External inbox x

☆ Gaurav Publications Dear PAIMAN, It is with reference to your Manuscript No. Gaurav Publications/ROC-1229 entitled Salibu Rice Cultivation in Indonesia's Lowlands: A Review of Agro... Sun, Aug 13, 8:05 PM (2 days ago)

☆ Vedpal Singh References in the list of references should be corrected according to the attached guidelines. Thank you Sun, Aug 11, 8:10 PM (2 days ago)

☆ Vedpal Singh to me Sun, Aug 11, 8:12 PM (2 days ago)

One attachment - Scanned by Gmail

Guidelines for wrt...

Reply Forward

Manuscript Reviewed: 17 Agustus 2025

## Salibu Rice Cultivation in Indonesia's Lowlands: A Review of Agronomic Innovations and Sustainability Pathways

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup> AND ARGAWI KANDITO<sup>1</sup>

<sup>1</sup>*Department of Agrotechnology, Faculty of Agriculture  
Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*

*\*(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))*

<sup>2</sup>Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.

<sup>3</sup>Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia.

### ABSTRACT

The Salibu planting system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which enables multiple harvests from a single planting by regenerating tillers from post-harvest rice stubble. This review synthesises agronomic principles, regional applications, and the sustainability potential of the Salibu system within Indonesia's lowland rice agroecosystems. Drawing upon scientific studies, field reports, and local practices, the review highlights key innovations such as precision stem cutting, the alternate wetting and drying (AWD) irrigation method, and the use of biofertilizers that improve regenerative growth, yield stability, and environmental efficiency. Despite these advantages, broader adoption remains limited by constraints such as incompatible rice varieties, variable soil conditions, low technical literacy among farmers, and weak institutional support. The success of Salibu implementation hinges on targeted farmer training, participatory extension models, and supportive agricultural policies. Furthermore, integrating the system into national strategies and climate-resilient food programs can scale its impact. In conclusion, the Salibu system offers strong potential to increase rice productivity, reduce environmental impacts, and support smallholder farmers. Unlocking this potential requires coordinated efforts in research, policy, and on-farm implementation. With appropriate support, the Salibu system can play a vital role in advancing resilient and sustainable rice production in Indonesia.

**Key words:** agricultural innovation, lowland rice, rice cultivation, Salibu system, sustainable intensification

**Commented [SH1]:** Rewrite in the format below

- 1.Start with novel background of research on why the present review is needed. (You have written it well)
- 2.Provide the topics discussed in this manuscript
- 3.Provide the findings of the manuscript and conclude appropriately.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the main staple food for Indonesian people, serving as a **source** of carbohydrates for more than 90% of the population. Most of the national rice production, more than 80% comes from lowland rice fields. This is not surprising, because the area has relatively stable agro-ecological conditions and a better-managed irrigation system compared to rain-fed land (Sembiring *et al.*, 2020). However, despite the increasing use of modern inputs such as fertilisers and superior seeds, rice productivity in this region has stagnated over the past two decades. The main causes are decreased soil fertility, the use of varieties that are susceptible to disease, and low efficiency in the use of water and fertiliser (Wassmann *et al.*, 2009). Soil degradation, water stress, and climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Lal, 2015; Dou *et al.*, 2016).

In response to these challenges, the Salibu planting system has emerged as a promising indigenous innovation rooted in West Sumatra's local farming traditions. The Salibu method utilises the rice plant's natural ability to regenerate tillers from the remaining stubble after harvest, allowing for multiple harvests from a single planting without the need for reseeded or full land preparation (Abdulrachman *et al.*, 2015). When properly managed, Salibu systems can achieve yields comparable to initial plantings while reducing seed, labour, water, and energy inputs (Oda *et al.*, 2020; Shiraki *et al.*, 2020). These features make the Salibu approach particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Over the past decade, interest in Salibu cultivation has grown among researchers, extension agencies, and policymakers. Studies have examined its agronomic performance, cost-effectiveness, and adaptability across diverse environments, including rainfed, irrigated, and tidal lowlands (Fitri *et al.*, 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilizers have further enhanced the system's effectiveness and ecological value (Bouman *et al.*, 2007; Doni *et al.*, 2018). Despite its potential, Salibu adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka *et al.*, 2023).

The objective of this review is to synthesise current knowledge and field experiences related to Salibu rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. [The review aims to: \(1\) highlight the key principles and regenerative](#)

mechanisms underlying the system, (2) assess its regional implementation and adoption challenges, and (3) explore strategic opportunities for integrating Salibu into national sustainable intensification frameworks.

**Commented [SH2]:** Write in running statement.

The scope of this review is limited to Salibu practices in lowland rice ecosystems in Indonesia, including irrigated, rainfed, and tidal fields. It does not include ratooning systems in upland or highland environments, nor does it cover hybrid or mechanised rice systems in non-tropical regions. The article draws on peer-reviewed literature, national policy reports, and empirical field studies published between 2000 and 2024. The structure of this review article includes seven main sections: (1) an overview of lowland rice agroecosystems in Indonesia; (2) detailed analysis of the Salibu planting system; (3) innovation in the salibu system for Lowland Rice; (4) Impact of Salibu system on lowland rice productivity; (5) adoption and dissemination of the Salibu system in lowland rice; (6) challenges and limitation of the Salibu system; and (7) future development directions and recommendations, and future directions.

**Commented [SH3]:** Well written. The concise version of this is to be presented in the abstract.

### **Lowland Rice Agroecosystems in Indonesia**

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria *et al.*, 2011). Such soil properties facilitate higher yields and improved water productivity, particularly under prolonged waterlogged conditions (Dou *et al.*, 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totalling 8.1 million hectares.

The Salibu planting system, which enables regrowth from harvested stems, depends on precise harvest timing, accurate stem cutting, and careful management of water, fertilizers, and appropriate rice varieties. However, lowland rice productivity is hindered by the use of cultivars ill-equipped to cope with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration cultivars vulnerable to environmental extremes tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sirona Putiah* and varieties carrying the *Sub1* gene demonstrate greater resilience (Wassmann *et al.*, 2009).

Climate resilience can also be enhanced through the application of biofertilizers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilizers and pesticides has led to soil degradation and

reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong *et al.*, 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

### **Salibu Planting System**

The Salibu planting system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "*Salibu*" originates from the Minangkabau dialect in West Sumatra, meaning "*once planted, can be harvested many times*", as illustrated in Fig. 1.

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the Salibu system can reduce the need for seeds and labour, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki *et al.*, 2020).

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java, and West Nusa Tenggara (Fitri *et al.*, 2019).

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan *et al.*, 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labour and resources, while yielding about 60% of the main crop (Alekhya *et al.*, 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah *et al.*, 2023).

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu *et al.*, 2024). Drought, plant lodging, and post-harvest

mismanagement may also reduce the success of regrowth (Shiraki *et al.*, 2020). While proper water-level control can increase yields, challenges remain in heavy-textured soils and areas with frequent submergence, such as tidal swamps (Imanudin *et al.*, 2018). A brief comparison of the Salibu and conventional planting systems is shown in Table 1.

### **Innovation in the Salibu System for Lowland Rice**

Innovations in the application of the Salibu system in lowland rice fields currently focus on improving basic agronomic practices, particularly stem cutting techniques and the timing of early regrowth. These two aspects are considered critical for maximising shoot regeneration and overall yield. Research indicates that the optimal cutting height is between 20 and 25 cm above the soil surface, where the lower stem nodes remain physiologically active and capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant's growing point. Although efficacy depends on soil moisture, the double-cutting technique, first at 20–40 cm, then at 5 cm, has been shown to improve grain yield (Shiraki *et al.*, 2020).

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertiliser (Alridiwirsah *et al.*, 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman *et al.*, 2015). Although lower cutting heights (e.g., 3 cm) may delay the generative phase, they can improve yield components and ratoon yield. Cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan *et al.*, 2014).

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionised water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman *et al.*, 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu *et al.*, 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam *et al.*, 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill *et al.*, 2023).

The integration of environmentally friendly inputs is another critical component in developing the Salibu system. Organic and biological fertilisers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilizers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane *et al.*, 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-grain weight, while reducing disease symptoms by up to 64.7% (Sutarman *et al.*, 2023). *Trichoderma*-based biofertilizers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni *et al.*, 2018).

Selecting high-performing cultivars compatible with the Salibu system is equally important. Varieties like *Ciherang*, *Inpari 32*, and *Mekongga* exhibit strong regenerative abilities due to vigorous tillering, sturdy stems, and responsiveness to re-fertilisation. These traits make them well-suited for Salibu-type cropping systems. National and international research is increasingly focused on breeding for regenerative systems. Compared to traditional cultivars, *Inpari 13*, *Ciherang*, and *Mekongga* demonstrate superior yield components, such as higher 1000-grain weight and more filled grains. Applying 300 kg/ha of NPK to *Inpari 42* has been shown to enhance plant height, productive tiller number, and dry grain yield. *Inpari 32* also performs well in the Jajar Legowo planting system, which improves light penetration and air circulation (Khairullah *et al.*, 2021).

Several mechanisation have been introduced to improve efficiency in Salibu implementation. One major challenge is achieving accurate and consistent stem cutting, which is labour-intensive if done manually. To address this, portable motorised stem cutters have been developed, enabling precise cutting at the ideal height (Dixit *et al.*, 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang *et al.*, 2020). Recent innovations in mechanical harvesting tools, including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu *et al.*, 2022).

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD applications (Tuong *et al.*, 2005). Micro-sprinklers with an evapotranspiration rate (ETc) of 1.25 have been shown to increase plant height, biomass, leaf area,

and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar *et al.*, 2008).

For post-harvest and land preparation, lightweight, eco-friendly equipment like mini tillers helps preserve root systems, improve soil aeration, and support shoot regeneration. Tools like the Rice Seedling Planter, designed to plant 15–21-day-old seedlings at optimal depths (2.5–7.5 cm), maintain soil structure and encourage early growth (Saleh *et al.*, 2018).

### **Impact of Salibu System on Lowland Rice Productivity**

One of the main advantages of the Salibu system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that Salibu yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka *et al.*, 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles, comparable to initial planting yields and indicative of high production efficiency (Oda *et al.*, 2020; Shiraki *et al.*, 2020). Additionally, Salibu increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda *et al.*, 2020).

The performance of the Salibu system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina *et al.*, 2021). When managed correctly through proper stem cutting, supplemental fertilisation, and AWD irrigation, the system maintains stable productivity. Unlike conventional replanting systems that require approximately 240 days per cycle, Salibu allows two harvests within 180–200 days. With optimal water management and the use of double-cutting techniques, yields can increase by up to 69% compared to continuous flooding systems (Shiraki *et al.*, 2020). These findings affirm that Salibu is a viable and efficient method to sustain rice production amid climate challenges (Yamaoka *et al.*, 2023; Hong and Huang, 2024).

The Salibu system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labour costs (Paman *et al.*, 2014; Fitri *et al.*, 2019). Since regeneration occurs from existing stubble, seed use can be reduced by nearly 100%. Compared to the double-replanting method, the Salibu system improves labour and seed efficiency by 29% and 52%, respectively (Shiraki *et al.*, 2020). By enabling multiple harvests from a single planting, Salibu saves time, water, seed, and labour (Fitri *et al.*,

2019). Furthermore, moderate AWD irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq *et al.*, 2020). Depending on the intensity and duration of drying cycles, AWD has also been shown to reduce greenhouse gas emissions and global warming potential (GWP) by up to 73%, with minimal yield losses (Gao *et al.*, 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill *et al.*, 2020).

Environmental efficiency in the Salibu system is also supported by the use of organic and microbial fertilisers. Biofertilizers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation has significantly improved rice growth and yield, serving as a more sustainable alternative to synthetic nitrogen fertilizers. Meanwhile, *Trichoderma*-based biofertilizers can increase yields by up to 30%, while also mitigating the negative impacts of excessive chemical input (Razie and Anas, 2008).

From an economic perspective, the benefits of the Salibu system are clear. According to a study by the West Sumatra Agricultural Technology Assessment Institute, the system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labour, seed, and land preparation (Abdulrachman *et al.*, 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of Salibu are higher than those of conventional systems, indicating greater farming feasibility (Fitri *et al.*, 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, Salibu contributes to household food security and income stability (Wassmann *et al.*, 2009). Some studies even report up to four harvests from a single planting within a year, an impressive feat in the context of intensified agriculture (Sakti *et al.*, 2021).

From a social standpoint, increased productivity from Salibu promotes the engagement of local labour in key agricultural tasks such as pruning, fertilising, and irrigation management. Moreover, this system encourages resource-efficient farming, reduces dependency on external inputs, and strengthens community-based agricultural resilience. In Percut Sei Tuan District, for instance, Salibu implementation not only increased farmer income but also prevented the conversion of productive rice fields into industrial land. Local farmers were further empowered through their active involvement in producing organic pesticides and bokashi compost, reinforcing sustainable agricultural practices (Mayly and Syafri, 2018).

Overall, the Salibu system can reduce water usage by up to 60%, lower labour requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman *et al.*, 2022). From economic, environmental, and social perspectives, Salibu represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

#### **Adoption and Dissemination of the Salibu System in Lowland Rice**

The successful adoption of the Salibu planting system is influenced by a combination of social, technical, and institutional factors. Among the most critical is farmers' technical capacity, particularly in post-harvest fertilisation, water management, and precision stubble cutting. Without adequate knowledge and hands-on training, many farmers struggle to regenerate tillers optimally, leading to discouragement and eventual abandonment of the practice (Mayly and Syafri, 2018; Effendy *et al.*, 2021; Paiman *et al.*, 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the Salibu system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management, especially through techniques like AWD, must be consistently applied (Yamaoka *et al.*, 2023). However, the absence of structured technical assistance in many regions often becomes a bottleneck to successful field implementation. Beyond technical challenges, land suitability also plays a decisive role. The Salibu system is best suited for sandy loam soils with adequate water supply and efficient drainage. Conversely, heavy clay soils or poorly drained areas can hinder shoot regeneration and overall system performance (Shiraki *et al.*, 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content, benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti *et al.*, 2021).

Institutional support, particularly from pioneer farmers and agricultural extension officers, serves as a key driver of Salibu adoption. Farmers who have successfully implemented the system often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye *et al.*, 2021; Yitayew *et al.*, 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Solok Regency in West Sumatra, recognised as the birthplace of the Salibu system, serves as a model region for the development and dissemination of this technology. Since the early 2000s, collaborative efforts between the Assessment Institute for Agricultural Technology and the local Department of Agriculture have facilitated technical assistance and innovation refinement. Pioneer farmers in Solok helped develop site-specific fertilisation and cutting techniques tailored to seasonal and varietal characteristics (Abdulrachman *et al.*, 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Shiraki *et al.*, 2020; Sakti *et al.*, 2021).

### **Challenges and Limitations of the Salibu System**

Despite its potential to increase rice yields and resource-use efficiency, the implementation of the Salibu system faces several biophysical and socio-institutional constraints. One of the primary agronomic limitations lies in varietal suitability. Not all rice cultivars possess strong regenerative capacity following stubble cutting. Early-maturing varieties with robust root systems and high tillering potential, such as *Ciherang* and *Inpari 32*, are more compatible with the Salibu system. In contrast, late-maturing or soft-stemmed cultivars often fail to develop vigorous ratoon tillers. While *Ciherang* performs well under favourable conditions, it is more susceptible to *tungro* virus compared to varieties like *Inpari 1*, *Inpari 3*, and *Inpari 5*, which are better suited to rainfed or limited-irrigation environments (Khaerana *et al.*, 2023).

Soil characteristics also play a critical role in determining the success of the Salibu system. Ideal conditions include soils with stable moisture levels, good drainage, and moderate texture. Overly dry or waterlogged soils inhibit tiller regeneration and increase susceptibility to abiotic stress (Shiraki *et al.*, 2020; Agustina *et al.*, 2022). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana *et al.*, 2023). Therefore, the success of the Salibu system depends on a combination of appropriate varietal selection, conducive soil conditions, and timely agronomic interventions.

One of the most significant technical challenges is the limited knowledge and training among both farmers and agricultural extension workers. Many farmers lack understanding of shoot regeneration physiology, appropriate pruning techniques, and efficient water management. Compounding the issue, many field extension agents have not received formal training specific to Salibu, resulting in inconsistent adoption and suboptimal results across regions (Abdulrachman *et*

*al.*, 2015). The impact of climate change, particularly shifts in pest and disease dynamics, further complicates management, underscoring the need for integrated pest surveillance and predictive modelling to support adaptive, ecosystem-based control strategies (Subedi *et al.*, 2023).

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina *et al.*, 2021; Zarwazi *et al.*, 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the Salibu system across diverse agroecosystems remains constrained.

From a socio-economic perspective, adoption of the Salibu system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Scepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka *et al.*, 2023).

At the institutional level, barriers include insufficient regulatory frameworks, limited infrastructure investment, and a prevailing policy bias toward land expansion and input subsidies rather than promoting efficiency-based innovations such as Salibu. In regions like Tanah Datar Regency, implementation has been suboptimal due to the absence of localised policy instruments, shortage of trained personnel, and socio-economic constraints at the regional level (Rada *et al.*, 2011).

#### **Future Development Directions and Recommendations**

The sustainable development of the Salibu system necessitates a comprehensive, interdisciplinary research and policy agenda. One of the foremost priorities is to optimise the adaptation of Salibu-based practices and rice cultivars to suit Indonesia's diverse lowland rice agroecosystems, which vary in terms of soil types, microclimates, and irrigation infrastructure. Agronomic parameters such as soil water availability, cutting height, and fertilisation timing are crucial determinants of success, thus warranting site-specific management strategies (Paiman *et al.*, 2022).

The system has demonstrated adaptability to elevated temperature conditions, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda *et al.*, 2020). However, yield outcomes remain variable across regions; in some

locations, Salibu yields still lag behind those of conventional replanting systems (Sakti *et al.*, 2021; Yamaoka *et al.*, 2023).

Future research should explore the long-term environmental impacts of Salibu implementation, including its effects on greenhouse gas emissions, soil quality, and water-use efficiency. In light of global climate change and the push for low-emission agriculture, adopting life cycle assessment (LCA) frameworks will be essential to evaluate the sustainability of Salibu comprehensively. Initial LCA-based studies conducted in Solok suggest that the system can reduce non-point source pollution and mitigate emissions while improving environmental performance (Aswin *et al.*, 2023; Qiao *et al.*, 2024).

For the Salibu system to be scaled up effectively, extension strategies must be context-specific and rooted in evidence-based methodologies. Extension materials should be designed in practical, easily comprehensible formats such as visual guides, mobile-accessible videos, and hands-on field training to empower both farmers and extension workers (Mayly and Syafri, 2018). Combining local wisdom with scientific agronomy enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo *et al.*, 2022).

While digital platforms (*e.g.*, WhatsApp, Facebook) have emerged as effective channels for peer-to-peer knowledge exchange, their reach remains limited in areas with low digital literacy. Therefore, hybrid communication strategies that combine ICT and traditional outreach methods are recommended (Agnese *et al.*, 2024). Participation in digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim *et al.*, 2024; Mendes *et al.*, 2024). In this regard, involving lead farmers as local mentors and organising farmer groups or cooperatives can accelerate innovation diffusion at the grassroots level.

To broaden its application, the Salibu system must be strategically integrated into national agricultural development programs, such as the Food Estate initiative and the IP400 intensification program. Salibu aligns well with IP400's goal of achieving four rice harvests per year, as it enables two harvests from a single planting, thereby saving labour, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

However, policy incentives are essential to overcome adoption barriers. These may include subsidies for biofertilizers, discounted crop insurance premiums for environmentally friendly practices, or support for semi-mechanical tools such as portable stem cutters (Lal, 2015). Additionally, digital incentive models, such as climate-smart agriculture insurance or mobile-

based input vouchers, have proven effective in other contexts and could be adapted for Indonesia (Limpo *et al.*, 2022).

### CONCLUSION

This review underscores the Salibu planting system as a viable and sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By leveraging the rice plant's natural regenerative ability, Salibu enables multiple harvests from a single planting, thereby reducing seed, labour, and water inputs while maintaining competitive yields. Key agronomic innovations, including precision stem cutting, AWD irrigation, and the integration of biofertilizers, enhance the system's efficiency and adaptability in diverse environmental conditions. Despite these advantages, broader adoption remains limited by constraints such as incompatible rice varieties, variable soil conditions, low technical literacy among farmers, and weak institutional support. The success of Salibu implementation hinges on targeted farmer training, participatory extension models, and supportive agricultural policies. Furthermore, integrating the system into national strategies like IP400 and climate-resilient food programs can scale its impact. In conclusion, the Salibu system holds significant promise for enhancing productivity, reducing environmental impact, and improving smallholder livelihoods. To realise this potential, coordinated efforts across research, policy, and farmer-level implementation are essential. With the right support, the Salibu system can contribute meaningfully to building a resilient and sustainable rice production future in Indonesia.

### ACKNOWLEDGMENTS

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

### REFERENCES

- Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian. (In Indonesian)
- Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural Sarawak, Malaysia. *Interactive Learning Environments*, **32**: 5699–5710.

- Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) Salibu paddy cultivation. *Asian Journal of Applied Sciences*, **10**: 1–8.
- Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *International Journal of Environment and Climate Change*, **14**: 424–436.
- Alridiwirsa, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer. *Acta Agrobotanica*, **74** : 1–12.
- Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip and micro sprinkler irrigation. *Agricultural Science Digest*, **28**: 124–126.
- Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *AJARCADE (Asian Journal of Applied Research for Community Development and Empowerment)*, **7** : 160–169.
- Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agronomy Journal*, **112**: 5115–5124.
- Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agronomy Journal*, **115**: 1735–1745.
- Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi salibu daerah Sumatera Barat. *Jurnal Teknologi Pertanian Andalas*, **25**: 90–95.
- Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). Water management in irrigated rice: Coping with water scarcity. In *International Rice Research Institute*.
- Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy*, **14** : 1926.
- Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agricultural Engineering International*, **24**: 90–101.
- Dobermann, A. and Fairhurst, T. (2000). Rice: Nutrient disorders & nutrient management. In

*Medical Instrumentation*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI).

- Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Organic Agriculture*, **8**: 207–223.
- Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE*, **11** : e0150549.
- Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of Salibu rice technology in Garut Regency, West Java-Indonesia. *International Journal of Innovative Science and Research Technology*, **6**: 644–649.
- Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *International Journal of Intellectual Discourse (IJID)*, **7**: 44–57.
- Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy*, **11**: 777.
- Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Communications in Soil Science and Plant Analysis*, **42**: 1913–1933.
- Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). Salibu technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy and Water Environment*, **17**: 403–410.
- Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon rice. *Agriculture (Switzerland)*, **12**: 620.
- Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields: A global meta-analysis. *Agricultural and Forest Meteorology*, **353**: 110075.

- Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Molecular Soil Biology*, **15**: 87–98.
- Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Applied Sciences (Switzerland)*, **10**: 4432.
- Ilar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *The Journal of Public Affairs and Development*, **2**: 107–142. <https://www.ukdr.uplb.edu.ph/jpad/vol2/iss2/2/>
- Imanudin, M. S., Bakri, B. and Jelita, R. (2018). Ratoon systems in tidal lowland: Study of groundwater dynamics and the change of nutrient status on rice growth. *Sains Tanah- Journal of Soil Science and Agroclimatology*, **15**: 93–103.
- Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agricultural Water Management*, **241**: 106363.
- Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *European Journal of Soil Science*, **75**: e13533. <https://doi.org/10.1111/ejss.13533>
- Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). Salibu rice cultivation in tungro endemis region. *Jurnal Teknik Pertanian Lampung*, **12**: 338–349.
- Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertanian (Agricultural Science)*, **6**: 163–174.
- Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability (Switzerland)*, **7**: 5875–5895.
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustainability (Switzerland)*, **14**: 2952.
- Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of icts. *Sustainability (Switzerland)*,

13: 5868.

- Mayly, S. and Syafri, A. (2018). Implementation of Salibu rice cultivation technology in Percut Sei Tuan Sub-District. *Journal of Saintech Transfer*, **1**: 33–40.
- Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *Journal of Agribusiness in Developing and Emerging Economies*, **14**: 676–693.
- Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustainability (Switzerland)*, **16**: 9297.
- Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of SALIBU to triple-cropping in Vietnam. *F1000Research*, **8**: 1825.
- Paiman, Isnawan, B., Aziez, A., Subeni and Salisu, M. A. (2022). The role of agronomic factors in Salibu rice cultivation. *The Open Agriculture Journal*, **16**: 1–7.
- Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor requirements and costs. *Engineering in Agriculture, Environment and Food*, **7**: 122–126.
- Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustainability (Switzerland)*, **16**: 9920.
- Rada, N. E., Buccola, S. T. and Fuglie, K. O. (2011). Government policy and agricultural productivity in Indonesia. *American Journal of Agricultural Economics*, **93**: 867–884.
- Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *Jurnal Ilmu Tanah dan Lingkungan*, **10**: 41–45.
- Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah*, **18**: 65–72.
- Salch, A. S., Asyim, A. R. M., Wibisono, Y., Supriono and Suryana, Y. (2018). Engineering of ergonomic and affordable rice planting tool for effort to meet the energy scarcity of agriculture. *Jurnal Ilmiah Inovasi*, **17**: 1–8.

- Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agriculture (Switzerland)*, **10**: 1–13.
- Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita*, **36**: 72–80.
- Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the Salibu system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy*, **10**: 1621.
- Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *Journal of Agriculture and Food Research*, **14**: 100733.
- Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian Journal of Agriculture and Rural Development*, **13**: 277–287.
- Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. *New Directions for a Diverse Planet. Proceedings of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia*, **8**: 231–241.
- Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. In *Advances in Agronomy*, **102**: 91–133.
- Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C., Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food and Energy Security*, **9**: e206.
- Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). *Salibu rice ratoon cropping system*. Japan International Research Center for Agricultural Sciences.
- Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of agricultural extension services on the adoption of improved wheat variety in Ethiopia: A

cluster randomized controlled trial. *World Development*, **146**: 105605.

Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *Field Crops Research*, **234**: 66–72.

Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, **13**: 186–197.

Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon salibu cultivation. *Biodiversitas*, **23**: 1065–1071.

Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Ziama, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *African Journal of Agricultural Research*, **19**: 20–23.

Table 1. Salibu vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days (Salibu)
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

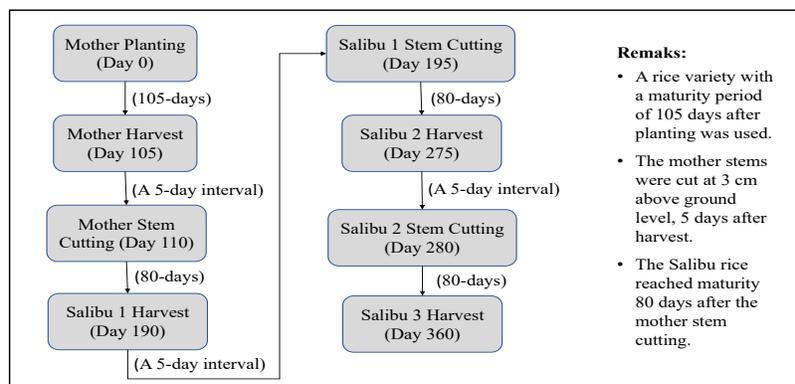


Fig. 1. Flow diagram of the Salibu planting system in lowland rice (one-year cycle).

Manuscript Re-submission: 24 Agustus 2025

**Salibu Rice Cultivation in Indonesia's Lowlands: A Review of Agronomic Innovations and Sustainability Pathways**

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup> AND ARGAWI KANDITO<sup>1</sup>

*<sup>1</sup>Department of Agrotechnology, Faculty of Agriculture  
Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*

*\*(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))*

*<sup>2</sup>Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.*

*<sup>3</sup>Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia.*

**ABSTRACT**

The Salibu planting system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which allows multiple harvests from a single planting through the regeneration of tillers from post-harvest rice stubble. Despite its promising potential to enhance

rice productivity and sustainability, its adoption remains limited, highlighting the need for a comprehensive review of its principles, applications, and constraints. The structure of this review comprises seven main sections, including an overview of Indonesia's lowland rice agroecosystems, the Salibu system, innovations, productivity impacts, adoption strategies, challenges, and future development recommendations. This review synthesises agronomic principles, regional applications, and the sustainability potential of the Salibu system within Indonesia's lowland rice agroecosystems, and key innovations such as precision stem cutting, alternate wetting and drying (AWD) irrigation, and the use of biofertilizers. Drawing from scientific literature, field reports, and local practices, the review identifies that these innovations can improve regenerative growth, yield stability, and environmental efficiency. However, broader implementation faces challenges, including incompatible rice varieties, variable soil conditions, limited farmer knowledge, and weak institutional support. The findings suggest that successful adoption depends on targeted farmer training, participatory extension models, and supportive agricultural policies. In conclusion, the Salibu system offers strong potential to increase rice yields, reduce environmental impacts, and support smallholder livelihoods. Coordinated efforts in research, policy, and on-farm implementation are essential to scale its impact and integrate it into national climate-resilient food strategies.

**Key words:** agricultural innovation, lowland rice, rice cultivation, Salibu system, sustainable intensification

## **INTRODUCTION**

Rice (*Oryza sativa* L.) is the primary staple food for over 90% of Indonesians, with more than 80% of national production sourced from lowland rice fields due to their stable agro-ecological conditions and well-managed irrigation. However, despite increased use of modern inputs like fertilisers and high-yielding varieties, productivity has stagnated over the past two decades. This is largely due to declining soil fertility, disease-prone varieties, and inefficient water and fertiliser use (Wassmann et al., 2009). Soil degradation, water stress, and climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Lal, 2015; Dou et al., 2016).

In response to these challenges, the Salibu planting system has emerged as a promising indigenous innovation rooted in West Sumatra's farming traditions. It leverages the rice plant's natural ability to regenerate tillers from post-harvest stubble, enabling multiple harvests without reseeded or full land preparation (Abdulrachman et al., 2015). When properly managed, Salibu systems can achieve yields comparable to initial plantings while reducing seed, labour, water, and energy inputs (Oda et al., 2020; Shiraki et al., 2020). These features make the Salibu approach particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Over the past decade, growing interest in Salibu cultivation among researchers, extension agencies, and policymakers has led to studies on its agronomic performance, cost-effectiveness, and adaptability in rainfed, irrigated, and tidal lowlands (Fitri et al., 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilizers have further enhanced the system's effectiveness and ecological value (Bouman et al., 2007; Doni et al., 2018). Despite its potential, Salibu adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka et al., 2023).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font color: Text 1

The objective of this review is to synthesise current knowledge and field experiences related to Salibu rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. The review aims to highlight the key principles and regenerative mechanisms underlying the Salibu system, assess its regional implementation and the challenges associated with its adoption, and explore strategic opportunities for integrating Salibu into national sustainable intensification frameworks.

Formatted: Font: (Default) Times New Roman, Font color: Text 1

This review focuses on Salibu practices in Indonesia's lowland rice ecosystems, including irrigated, rainfed, and tidal fields. It excludes ratooning systems in upland or highland areas and hybrid or mechanised rice systems in non-tropical regions, drawing on literature from 2000 to 2024. The structure of this review comprises seven main sections, including an overview of lowland rice agroecosystems in Indonesia, detailed analysis of the Salibu planting system, innovation in the Salibu system for lowland rice, impact of the Salibu system on lowland rice productivity, adoption and dissemination of the Salibu system in lowland rice, challenges and limitation of the Salibu system, and future development directions and recommendations.

Commented [SH4]: Well written. The concise version of this is to be presented in the abstract.

Formatted: Font: (Default) Times New Roman, 12 pt, Font color: Text 1

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

### Lowland Rice Agroecosystems in Indonesia

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria et al., 2011). Such soil properties facilitate higher yields and improved water productivity, particularly under prolonged waterlogged conditions (Dou et al., 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totalling 8.1 million hectares.

Formatted: Font: (Default) Times New Roman

The Salibu planting system, which enables regrowth from harvested stems, relies on precise harvest timing, accurate stem cutting, and careful management of water, fertilizers, and suitable rice varieties. However, productivity in lowland rice systems is often limited by cultivars that struggle with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration varieties tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sironda Putiah* and varieties with the *Sub1* gene offer greater resilience (Wassmann et al., 2009).

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Climate resilience can also be enhanced through the application of biofertilizers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilizers and pesticides has led to soil degradation and reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong et al., 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

Formatted: Font: (Default) Times New Roman

### **Detailed analyses of the Salibu Planting System**

The Salibu planting system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "*Salibu*" originates from the Minangkabau dialect in West Sumatra, meaning "*once planted, can be harvested many times*", as illustrated in Fig. 1.

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the Salibu system can reduce the need for seeds and labour, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki et al., 2020).

Formatted: Font: (Default) Times New Roman

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce

Formatted: Font: (Default) Times New Roman

productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java, and West Nusa Tenggara (Fitri et al., 2019).

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan et al., 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labour and resources, while yielding about 60% of the main crop (Alekhya et al., 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah et al., 2023).

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu et al., 2024). Drought, plant lodging, and post-harvest mismanagement may also reduce the success of regrowth (Shiraki et al., 2020). A brief comparison of the Salibu and conventional planting systems is shown in Table 1.

### **Innovation in the Salibu System for Lowland Rice**

Current innovations in applying the Salibu system in lowland rice focus on improving basic agronomic practices, especially stem cutting techniques and the timing of early regrowth. These factors are crucial for maximising shoot regeneration and yield. Research shows that an optimal cutting height of 20–25 cm above the soil surface preserves active lower stem nodes capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant's growing point. Although efficacy depends on soil moisture, the double-cutting technique, first at 20–40 cm, then at 5 cm, has been shown to improve grain yield (Shiraki et al., 2020).

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertiliser (Alridiwersah et al., 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman et al., 2015). Although lower cutting heights (e.g., 3 cm) may delay the generative phase, they can improve yield components and ratoon yield. Cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan et al., 2014).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionised water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman et al., 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu et al., 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam et al., 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill et al., 2023).

The integration of environmentally friendly inputs is another critical component in developing the Salibu system. Organic and biological fertilisers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilizers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane et al., 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-grain weight, while reducing disease symptoms by up to 64.7% (Sutarman et al., 2023). *Trichoderma*-based biofertilizers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni et al., 2018).

Selecting high-performing cultivars compatible with the Salibu system is essential. Varieties like Ciherang, Inpari 32, and Mekongga have strong regenerative traits, such as vigorous tillering, sturdy stems, and good response to re-fertilisation. Research is increasingly focused on breeding for regenerative rice systems with improved yield components. Inpari 42 responds well to 300 kg/ha of NPK, while Inpari 32 performs effectively in the Jajar Legowo system, which enhances light and air penetration (Khairullah et al., 2021).

Several mechanisation have been introduced to improve efficiency in Salibu implementation. One major challenge is achieving accurate and consistent stem cutting, which is labour-intensive if done manually. To address this, portable motorised stem cutters have been developed, enabling precise cutting at the ideal height (Dixit et al., 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang et al., 2020). Recent innovations in mechanical harvesting tools, including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu et al., 2022).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD applications (Tuong et al., 2005). Micro-sprinklers with an evapotranspiration rate (ETc) of 1.25 have been shown to increase plant height, biomass, leaf area, and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar et al., 2008).

### **Impact of Salibu System on Lowland Rice Productivity**

One of the main advantages of the Salibu system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that Salibu yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka et al., 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles, comparable to initial planting yields and indicative of high production efficiency (Oda et al., 2020; Shiraki et al., 2020). Additionally, Salibu increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda et al., 2020).

The performance of the Salibu system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina et al., 2021). With proper stem cutting, supplemental fertilisation, and AWD irrigation, the Salibu system can maintain stable productivity. Compared to conventional replanting, it enables two harvests within 180–200 days, and with optimal water management and double-cutting, yields can increase by up to 69% (Shiraki et al., 2020). These findings affirm that Salibu is a viable and efficient method to sustain rice production amid climate challenges (Yamaoka et al., 2023; Hong and Huang, 2024).

The Salibu system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labour costs (Paman et al., 2014; Fitri et al., 2019). By regenerating from existing stubble, the Salibu system reduces seed use by nearly 100% and improves labour and seed efficiency by 29% and 52% compared to double replanting (Shiraki et al., 2020). By enabling multiple harvests from a single planting, Salibu saves time, water, seed, and labour (Fitri et al., 2019). Furthermore, moderate AWD irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq et al., 2020). The AWD can reduce greenhouse gas emissions

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

and global warming potential by up to 73%, with minimal yield loss, depending on the drying cycle's intensity and duration (Gao et al., 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill et al., 2020).

Environmental efficiency in the Salibu system is also supported by the use of organic and microbial fertilisers. Biofertilizers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation significantly improves rice growth and yield, offering a sustainable alternative to synthetic nitrogen fertilizers. *Trichoderma*-based biofertilizers can increase yields by up to 30% and reduce the harmful effects of excessive chemical use (Razie and Anas, 2008).

From an economic perspective, the Salibu system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labour, seed, and land preparation (Abdulrachman et al., 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of Salibu are higher than those of conventional systems, indicating greater farming feasibility (Fitri et al., 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, Salibu contributes to household food security and income stability (Wassmann et al., 2009). Some studies even report up to four harvests from a single planting within a year, an impressive feat in the context of intensified agriculture (Sakti et al., 2021).

From a social perspective, increased productivity from the Salibu system boosts local labour participation in key tasks like pruning, fertilising, and irrigation. It also encourages resource-efficient farming, reduces reliance on external inputs, and strengthens community resilience. In Percut Sei Tuan District, Salibu improved farmer incomes, prevented land conversion, and empowered farmers to produce organic pesticides and bokashi compost, supporting sustainable agriculture (Mayly and Syafri, 2018).

Overall, the Salibu system can reduce water usage by up to 60%, lower labour requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman et al., 2022). From economic, environmental, and social perspectives, Salibu represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

#### **Adoption and Dissemination of the Salibu System in Lowland Rice**

The successful adoption of the Salibu system depends on social, technical, and institutional factors, especially farmers' skills in post-harvest fertilisation, water management, and precise

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

stubble cutting. Without proper knowledge and training, many farmers fail to regenerate tillers effectively, causing discouragement and abandonment of the practice (Mayly and Syafri, 2018; Effendy *et al.*, 2021; Paiman *et al.*, 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the Salibu system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management, especially through techniques like AWD, must be consistently applied (Yamaoka *et al.*, 2023). The lack of structured technical assistance in many regions often blocks successful implementation. Additionally, the Salibu system performs best on sandy loam soils with good water supply and drainage, while heavy clay or poorly drained soils hinder shoot regeneration and overall performance (Shiraki *et al.*, 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content, benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti *et al.*, 2021).

Institutional support, particularly from pioneer farmers and agricultural extension officers, serves as a key driver of Salibu adoption. Farmers who have successfully implemented the system often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye *et al.*, 2021; Yitayew *et al.*, 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Solok Regency in West Sumatra, the birthplace of the Salibu system, serves as a model for its development and dissemination. Since the early 2000s, collaboration between the Agricultural Technology Institute and local authorities has supported technical assistance and innovation, with pioneer farmers developing site-specific fertilisation and cutting techniques (Abdulrachman *et al.*, 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Shiraki *et al.*, 2020; Sakti *et al.*, 2021).

### **Challenges and Limitations of the Salibu System**

Despite its potential, the Salibu system faces biophysical and socio-institutional challenges. A key limitation is varietal suitability, as not all rice cultivars regenerate well after stubble cutting.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Early-maturing varieties like Ciherang and Inpari 32 are compatible, while late-maturing or soft-stemmed cultivars often underperform (Khaerana et al., 2023).

Soil characteristics, including stable moisture, good drainage, and moderate texture, are crucial for Salibu success, while overly dry or waterlogged soils hinder tiller regeneration and increase stress vulnerability (Shiraki et al., 2020; Agustina et al., 2022). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana et al., 2023).

A major technical challenge is the limited knowledge and training of both farmers and extension workers. Many lack understanding of shoot regeneration, pruning, and water management, while extension agents often have no formal Salibu training, causing inconsistent adoption and results (Abdulrachman et al., 2015). The impact of climate change, particularly shifts in pest and disease dynamics, further complicates management, underscoring the need for integrated pest surveillance and predictive modelling to support adaptive, ecosystem-based control strategies (Subedi et al., 2023).

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina et al., 2021; Zarwazi et al., 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the Salibu system across diverse agroecosystems remains constrained.

From a socio-economic perspective, adoption of the Salibu system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Scepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka et al., 2023).

### **Future Development Directions and Recommendations**

The sustainable development of the Salibu system requires a comprehensive, interdisciplinary research and policy approach. Key priorities include adapting Salibu practices and rice cultivars to Indonesia's diverse lowland agroecosystems, with site-specific management of soil water, cutting height, and fertilisation timing (Paiman et al., 2022).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

The system has demonstrated adaptability to **elevated temperature conditions**, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda et al., 2020). However, yield outcomes remain variable across regions; in some locations, Salibu yields still lag behind those of conventional replanting systems (Sakti et al., 2021; Yamaoka et al., 2023).

Future research should investigate the long-term environmental impacts of Salibu, including greenhouse gas emissions, soil quality, and water-use efficiency. Using life cycle assessment (LCA) frameworks is essential for evaluating its sustainability, with initial Solok studies showing reduced pollution and emissions alongside improved environmental performance (Aswin et al., 2023; Qiao et al., 2024).

Effective scaling of the Salibu system requires context-specific, evidence-based extension using practical materials like visual guides, mobile videos, and hands-on training to empower farmers and workers (Mayly and Syafri, 2018). Combining **local wisdom** with **scientific agronomy** enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo et al., 2022).

Digital platforms like WhatsApp and Facebook aid peer-to-peer learning but have limited reach in low digital literacy areas. Thus, hybrid strategies combining ICT and traditional outreach are recommended (Agnese et al., 2024). Participation in digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim et al., 2024; Mendes et al., 2024). In this regard, involving **lead farmers as local mentors** and organising **farmer groups or cooperatives** can accelerate innovation diffusion at the grassroots level.

To broaden its application, the Salibu system must be strategically **integrated into national agricultural development programs**, such as the **Food Estate initiative** and the **IP400 intensification program**. Salibu aligns well with IP400's goal of achieving four rice harvests per year, as it enables **two harvests from a single planting**, thereby saving labour, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

## **CONCLUSION**

Formatted: Font color: Text 1

Formatted: Font: (Default) Times New Roman

This review highlights the Salibu planting system as a sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By using the rice plant's natural regenerative ability, Salibu allows multiple harvests from a single planting, reducing seed, labour, and water use while maintaining competitive yields. Agronomic innovations like stem cutting, AWD irrigation, and biofertilizers improve efficiency and adaptability. However, adoption is limited by unsuitable rice varieties, soil variability, low farmer technical skills, and weak institutional support. Successful implementation depends on targeted training, participatory extension, and supportive policies. Integrating Salibu into national strategies and climate-resilient programs can expand its impact. Overall, the system offers great potential to boost productivity, reduce environmental impact, and support smallholders, but requires coordinated efforts in research, policy, and on-farm practice to realize this promise.

Formatted: Font: (Default) Times New Roman, Font color: Text 1

#### ACKNOWLEDGMENTS

Formatted: Font: (Default) Times New Roman

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

#### REFERENCES

- Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian, Jakarta. pp: 26 (In Indonesian)
- Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural Sarawak, Malaysia. *Interact. Learn. Environ.*, **32**: 5699–710.
- Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) Salibu paddy cultivation. *Asian J. Appl. Sci.*, **10**: 1–8.
- Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *Int. J. Environ. Clim. Chang.*, **14**: 424–36.
- Alridiwirah, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer.

Formatted: Font: (Default) Times New Roman, Font color: Text 1

*Acta Agrobot.*, **74** : 1–12.

Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip and micro sprinkler irrigation. *Agri. Sci. Dig.*, **28**: 124–6.

Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *Asian J. Appl. Res. Community Dev. Empower.*, **7** : 160–9.

Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agron. J.*, **112**: 5115–24.

Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agron. J.*, **115**: 1735–45.

Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi salibu daerah Sumatera Barat. *J. Tek. Pert. Andalas*, **25**: 90–5. (in Indonesian)

Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). *Water management in irrigated rice: Coping with water scarcity*. International Rice Research Institute, Los Baños, Philippines. pp: 54.

Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy*, **14** : 1926.

Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agric. Eng. Int.*, **24**: 90–101.

Dobermann, A. and Fairhurst, T. (2000). *Rice: Nutrient disorders & nutrient management*, Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI), Makati, Philippines. pp: 193.

Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Org. Agric.*, **8**: 207–23.

Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water

**Formatted:** Font: (Default) Times New Roman

**Formatted:** Font: (Default) Times New Roman, Font color: Text 1

**Formatted:** Font: (Default) Times New Roman

**Formatted:** Font: (Default) Times New Roman, Font color: Text 1

regimes. *PLoS ONE*, **11**: e0150549.

Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of Salibu rice technology in Garut Regency, West Java-Indonesia. *Int. J. Innov. Sci. Res. Technol.*, **6**: 644–9.

Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *Int. J. Intellectual Discourse (IJID)*, **7**: 44–57.

Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy*, **11**: 777.

Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Commun. Soil Sci. Plant Anal.*, **42**: 1913–33.

Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). Salibu technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy and Water Environ.*, **17**: 403–10.

Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon rice. *Agric.*, **12**: 620.

Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields: A global meta-analysis. *Agric. For. Meteorol.*, **353**: 110075.

Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Mol. Soil Biol.*, **15**: 87–98.

Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Appl. Sci.*, **10**: 4432.

Ijar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *J. Public. Aff. Dev.*, **2**: 107–42.

Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

- Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agric. Water Manag.*, **241**: 106363.
- Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *Eur. J. Soil Sci.*, **75**: e13533.
- Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). Salibu rice cultivation in tungro endemic region. *J. Tek. Pertan. Lampung*, **12**: 338–49.
- Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertan.*, **6**: 163–74.
- Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustain.*, **7**: 5875–95.
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustain.*, **14**: 2952.
- Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of icts. *Sustain.*, **13**: 5868.
- Mayly, S. and Syafri, A. (2018). Implementation of Salibu rice cultivation technology in Percut Sei Tuan Sub-District. *J. Saintech Transf.*, **1**: 33–40.
- Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *J. Agribus. Dev. Emerg. Econ.*, **14**: 676–93.
- Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustain.*, **16**: 9297.
- Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of SALIBU to triple-cropping in Vietnam. *F1000Research*, **8**: 1825.
- Paiman, Isnawan, B., Aziez, A., Subeni and Salisu, M. A. (2022). The role of agronomic factors in Salibu rice cultivation. *Open Agric. J.*, **16**: 1–7.
- Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor

requirements and costs. *Eng. Agric. Environ. Food*, **7**: 122–6.

Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustain.*, **16**: 9920.

Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *J. Ilmu Tanah dan Lingkung.*, **10**: 41–5.

Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah*, **18**: 65–72.

Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agric.*, **10**: 1–13.

Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita*, **36**: 72–80.

Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the Salibu system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy*, **10**: 1621.

Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *J. Agric. Food Res.*, **14**: 100733.

Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian J. Agric. Rural Dev.*, **13**: 277–87.

Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. New Directions for a Diverse Planet. In: Proc. of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia. pp: 231–41.

Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). *Regional vulnerability of climate change impacts on asian rice production and scope for adaptation*. In: Advances in Agronomy,

Academic Press, Burlington. pp: 91–133.

Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C., Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food Energy Secur.*, **9**: e206.

Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). *Salibu rice ratoon cropping system*. JIRCAS Japan International Agriculture Series No. 26. pp: 166.

Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of agricultural extension services on the adoption of improved wheat variety in Ethiopia: A cluster randomized controlled trial. *World Dev.*, **146**: 105605.

Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *F. Crop. Res.*, **234**: 66–72.

Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *J. Lahan Suboptimal J. Suboptimal Lands*, **13**: 186–97.

Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon salibu cultivation. *Biodiversitas*, **23**: 1065–71.

Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Zياما, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *African J. Agric. Res.*, **19**: 20–3.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Text 1

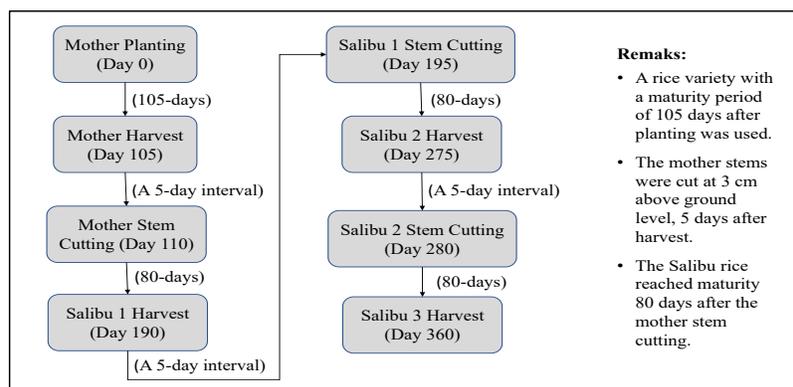
Formatted: Font: (Default) Times New Roman

Table 1. Salibu vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days (Salibu)
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman



Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Fig. 1. Flow diagram of the Salibu planting system in lowland rice (one-year cycle).

**MANUSCRIPT REVISED WITH HIGHLIGHTS:**

**Salibu Rice Cultivation in Indonesia's Lowlands: A Review of Agronomic Innovations and Sustainability Pathways**

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup> AND ARGAWI KANDITO<sup>1</sup>

<sup>1</sup>*Department of Agrotechnology, Faculty of Agriculture  
Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*

<sup>\*</sup>(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))

<sup>2</sup>Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.

<sup>3</sup>Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia.

**ABSTRACT**

The Salibu planting system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which allows multiple harvests from a single planting through the regeneration of tillers from post-harvest rice stubble. Despite its promising potential to enhance rice productivity and sustainability, its adoption remains limited, highlighting the need for a comprehensive review of its principles, applications, and constraints. The structure of this review comprises seven main sections, including an overview of Indonesia's lowland rice agroecosystems, the Salibu system, innovations, productivity impacts, adoption strategies, challenges, and future development recommendations. This review synthesises agronomic principles, regional applications, and the sustainability potential of the Salibu system within Indonesia's lowland rice agroecosystems, and key innovations such as precision stem cutting, alternate wetting and drying (AWD) irrigation, and the use of biofertilizers. Drawing from scientific literature, field reports, and local practices, the review identifies that these innovations can improve regenerative growth, yield stability, and environmental efficiency. However, broader implementation faces challenges, including incompatible rice varieties, variable soil conditions, limited farmer knowledge, and weak institutional support. The findings suggest that successful adoption depends on targeted farmer training, participatory extension models, and supportive agricultural policies. In conclusion, the Salibu system offers strong potential to increase rice yields, reduce environmental impacts, and support smallholder livelihoods. Coordinated efforts in research, policy, and on-farm implementation are essential to scale its impact and integrate it into national climate-resilient food strategies.

**Key words:** agricultural innovation, lowland rice, rice cultivation, Salibu system, sustainable intensification

**INTRODUCTION**

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, No underline

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, No underline

Formatted: Font: (Default) Times New Roman

Commented [SH5]: Rewrite in the format below

4.Start with novel background of research on why the present review is needed. (You have written it well)  
5.Provide the topics discussed in this manuscript  
6.Provide the findings of the manuscript and conclude appropriately.

Formatted: Font: (Default) Times New Roman

Rice (*Oryza sativa* L.) is the primary staple food for over 90% of Indonesians, with more than 80% of national production sourced from lowland rice fields due to their stable agro-ecological conditions and well-managed irrigation (Sembiring et al., 2020). However, despite increased use of modern inputs like fertilisers and high-yielding varieties, productivity has stagnated over the past two decades. This is largely due to declining soil fertility, disease-prone varieties, and inefficient water and fertiliser use (Wassmann et al., 2009). Soil degradation, water stress, and climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Lal, 2015; Dou et al., 2016).

Formatted: Font: (Default) Times New Roman, Italic  
Formatted: Font: (Default) Times New Roman  
Formatted: Normal, Indent: First line: 1.25 cm

In response to these challenges, the Salibu planting system has emerged as a promising indigenous innovation rooted in West Sumatra's farming traditions. It leverages the rice plant's natural ability to regenerate tillers from post-harvest stubble, enabling multiple harvests without reseeded or full land preparation (Abdulrachman et al., 2015). When properly managed, Salibu systems can achieve yields comparable to initial plantings while reducing seed, labour, water, and energy inputs (Oda et al., 2020; Shiraki et al., 2020). These features make the Salibu approach particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Formatted: Font: (Default) Times New Roman  
Formatted: Normal

Over the past decade, growing interest in Salibu cultivation among researchers, extension agencies, and policymakers has led to studies on its agronomic performance, cost-effectiveness, and adaptability in rainfed, irrigated, and tidal lowlands (Fitri et al., 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilizers have further enhanced the system's effectiveness and ecological value (Bouman et al., 2007; Doni et al., 2018). Despite its potential, Salibu adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka et al., 2023).

Formatted: Font: (Default) Times New Roman  
Formatted: Font: (Default) Times New Roman  
Formatted: Font: (Default) Times New Roman  
Formatted: Font: (Default) Times New Roman

The objective of this review is to synthesise current knowledge and field experiences related to Salibu rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. The review aims to highlight the key principles and regenerative mechanisms underlying the Salibu system, assess its regional implementation and the challenges associated with its adoption, and explore strategic opportunities for integrating Salibu into national sustainable intensification frameworks.

Formatted: Font: (Default) Times New Roman  
Formatted: Font: (Default) Times New Roman  
Formatted: Font: 12 pt  
Formatted: Highlight

This review focuses on Salibu practices in Indonesia's lowland rice ecosystems, including irrigated, rainfed, and tidal fields. It excludes ratooning systems in upland or highland areas and hybrid or mechanised rice systems in non-tropical regions, drawing on literature from 2000 to 2024. The structure of this review comprises seven main sections, including an overview of lowland rice agroecosystems in Indonesia, detailed analysis of the Salibu planting system, innovation in the Salibu system for lowland rice, impact of the Salibu system on lowland rice productivity, adoption and dissemination of the Salibu system in lowland rice, challenges and limitation of the Salibu system, and future development directions and recommendations.

Formatted: Font: (Default) Times New Roman

### Lowland Rice Agroecosystems in Indonesia

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria et al., 2011). Such soil properties facilitate higher yields and improved water productivity, particularly under prolonged waterlogged conditions (Dou et al., 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totalling 8.1 million hectares.

Commented [SH6]: Well written. The concise version of this is to be presented in the abstract.

Formatted: Font: (Default) Times New Roman

The Salibu planting system, which enables regrowth from harvested stems, relies on precise harvest timing, accurate stem cutting, and careful management of water, fertilizers, and suitable rice varieties. However, productivity in lowland rice systems is often limited by cultivars that struggle with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration varieties tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sironda Putih* and varieties with the *Sub1* gene offer greater resilience (Wassmann et al., 2009).

Formatted: Font: (Default) Times New Roman

Climate resilience can also be enhanced through the application of biofertilizers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilizers and pesticides has led to soil degradation and reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

et al., 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

Formatted: Font: (Default) Times New Roman

### Detailed analyses of the Salibu Planting System

The Salibu planting system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "Salibu" originates from the Minangkabau dialect in West Sumatra, meaning "once planted, can be harvested many times", as illustrated in Fig. 1.

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the Salibu system can reduce the need for seeds and labour, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki et al., 2020).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java, and West Nusa Tenggara (Fitri et al., 2019).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan et al., 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labour and resources, while yielding about 60% of the main crop (Alekhya et al., 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah et al., 2023).

Formatted: Font: (Default) Times New Roman

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu et al., 2024). Drought, plant lodging, and post-harvest mismanagement may also reduce the success of regrowth (Shiraki et al., 2020). A brief comparison of the Salibu and conventional planting systems is shown in Table 1.

Formatted: Font: (Default) Times New Roman

### Innovation in the Salibu System for Lowland Rice

Current innovations in applying the Salibu system in lowland rice focus on improving basic agronomic practices, especially stem cutting techniques and the timing of early regrowth. These

factors are crucial for maximising shoot regeneration and yield. Research shows that an optimal cutting height of 20–25 cm above the soil surface preserves active lower stem nodes capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant's growing point. Although efficacy depends on soil moisture, the double-cutting technique, first at 20–40 cm, then at 5 cm, has been shown to improve grain yield (Shiraki et al., 2020).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertiliser (Alridiwersah et al., 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman et al., 2015). Although lower cutting heights (e.g., 3 cm) may delay the generative phase, they can improve yield components and ratoon yield. Cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan et al., 2014).

Formatted: Font: (Default) Times New Roman

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionised water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman et al., 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu et al., 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam et al., 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill et al., 2023).

Formatted: Font: (Default) Times New Roman

The integration of environmentally friendly inputs is another critical component in developing the Salibu system. Organic and biological fertilisers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilizers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane et al., 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-grain weight, while reducing disease symptoms by up to 64.7% (Sutarman et al., 2023). *Trichoderma*-based biofertilizers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni et al., 2018).

Formatted: Font: (Default) Times New Roman

Selecting high-performing cultivars compatible with the Salibu system is essential. Varieties like Ciherang, Inpari 32, and Mekongga have strong regenerative traits, such as vigorous tillering, sturdy stems, and good response to re-fertilisation. Research is increasingly focused on breeding for regenerative rice systems with improved yield components. Inpari 42 responds well to 300 kg/ha of NPK, while Inpari 32 performs effectively in the Jajar Legowo system, which enhances light and air penetration (Khairullah et al., 2021).

Several mechanisation have been introduced to improve efficiency in Salibu implementation. One major challenge is achieving accurate and consistent stem cutting, which is labour-intensive if done manually. To address this, portable motorised stem cutters have been developed, enabling precise cutting at the ideal height (Dixit et al., 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang et al., 2020). Recent innovations in mechanical harvesting tools, including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu et al., 2022).

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD applications (Tuong et al., 2005). Micro-sprinklers with an evapotranspiration rate (ETc) of 1.25 have been shown to increase plant height, biomass, leaf area, and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar et al., 2008).

### Impact of Salibu System on Lowland Rice Productivity

One of the main advantages of the Salibu system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that Salibu yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka et al., 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles, comparable to initial planting yields and indicative of high production efficiency (Oda et al., 2020; Shiraki et al., 2020). Additionally, Salibu increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda et al., 2020).

Formatted: Font: (Default) Times New Roman

The performance of the Salibu system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina et al., 2021). With proper stem cutting, supplemental fertilisation, and AWD irrigation, the Salibu system can maintain stable productivity. Compared to conventional replanting, it enables two harvests within 180–200 days, and with optimal water management and double-cutting, yields can increase by up to 69% (Shiraki et al., 2020). These findings affirm that Salibu is a viable and efficient method to sustain rice production amid climate challenges (Yamaoka et al., 2023; Hong and Huang, 2024).

The Salibu system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labour costs (Paman et al., 2014; Fitri et al., 2019). By regenerating from existing stubble, the Salibu system reduces seed use by nearly 100% and improves labour and seed efficiency by 29% and 52% compared to double replanting (Shiraki et al., 2020). By enabling multiple harvests from a single planting, Salibu saves time, water, seed, and labour (Fitri et al., 2019). Furthermore, moderate AWD irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq et al., 2020). The AWD can reduce greenhouse gas emissions and global warming potential by up to 73%, with minimal yield loss, depending on the drying cycle's intensity and duration (Gao et al., 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill et al., 2020).

Environmental efficiency in the Salibu system is also supported by the use of organic and microbial fertilisers. Biofertilizers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation significantly improves rice growth and yield, offering a sustainable alternative to synthetic nitrogen fertilizers. *Trichoderma*-based biofertilizers can increase yields by up to 30% and reduce the harmful effects of excessive chemical use (Razie and Anas, 2008).

From an economic perspective, the Salibu system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labour, seed, and land preparation (Abdulrachman et al., 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of Salibu are higher than those of conventional systems, indicating greater farming feasibility (Fitri et al., 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, Salibu contributes to household food security and income stability

- Formatted: Indent: First line: 1 cm
- Formatted: Font: (Default) Times New Roman
- Formatted: Indent: First line: 1 cm
- Formatted: Font: (Default) Times New Roman
- Formatted: Font: (Default) Times New Roman, Italic
- Formatted: Font: (Default) Times New Roman, Italic
- Formatted: Font: (Default) Times New Roman, Italic
- Formatted: Font: (Default) Times New Roman
- Formatted: Indent: First line: 1.25 cm
- Formatted: Font: (Default) Times New Roman

(Wassmann et al., 2009). Some studies even report up to four harvests from a single planting within a year, an impressive feat in the context of intensified agriculture (Sakti et al., 2021).

From a social perspective, increased productivity from the Salibu system boosts local labour participation in key tasks like pruning, fertilising, and irrigation. It also encourages resource-efficient farming, reduces reliance on external inputs, and strengthens community resilience. In Percut Sei Tuan District, Salibu improved farmer incomes, prevented land conversion, and empowered farmers to produce organic pesticides and bokashi compost, supporting sustainable agriculture (Mayly and Syafri, 2018).

Overall, the Salibu system can reduce water usage by up to 60%, lower labour requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman et al., 2022). From economic, environmental, and social perspectives, Salibu represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

#### Adoption and Dissemination of the Salibu System in Lowland Rice

The successful adoption of the Salibu system depends on social, technical, and institutional factors, especially farmers' skills in post-harvest fertilisation, water management, and precise stubble cutting. Without proper knowledge and training, many farmers fail to regenerate tillers effectively, causing discouragement and abandonment of the practice (Mayly and Syafri, 2018; Effendy et al., 2021; Paiman et al., 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the Salibu system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management, especially through techniques like AWD, must be consistently applied (Yamaoka et al., 2023). The lack of structured technical assistance in many regions often blocks successful implementation. Additionally, the Salibu system performs best on sandy loam soils with good water supply and drainage, while heavy clay or poorly drained soils hinder shoot regeneration and overall performance (Shiraki et al., 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content, benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti et al., 2021).

Institutional support, particularly from pioneer farmers and agricultural extension officers, serves as a key driver of Salibu adoption. Farmers who have successfully implemented the system

Formatted: Font: (Default) Times New Roman

Formatted

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Font color: Auto

Formatted: Font: (Default) Times New Roman

often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye et al., 2021; Yitayew et al., 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Formatted: Font: (Default) Times New Roman

Solok Regency in West Sumatra, the birthplace of the Salibu system, serves as a model for its development and dissemination. Since the early 2000s, collaboration between the Agricultural Technology Institute and local authorities has supported technical assistance and innovation, with pioneer farmers developing site-specific fertilisation and cutting techniques (Abdulrachman et al., 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Shiraki et al., 2020; Sakti et al., 2021).

Formatted: Font: (Default) Times New Roman

### Challenges and Limitations of the Salibu System

Despite its potential, the Salibu system faces biophysical and socio-institutional challenges. A key limitation is varietal suitability, as not all rice cultivars regenerate well after stubble cutting. Early-maturing varieties like Ciherang and Inpari 32 are compatible, while late-maturing or soft-stemmed cultivars often underperform (Khaerana et al., 2023).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Justified, Indent: First line: 1.25 cm, Line spacing: 1.5 lines

Formatted: Font: (Default) Times New Roman

Soil characteristics, including stable moisture, good drainage, and moderate texture, are crucial for Salibu success, while overly dry or waterlogged soils hinder tiller regeneration and increase stress vulnerability (Shiraki et al., 2020; Agustina et al., 2022). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana et al., 2023).

A major technical challenge is the limited knowledge and training of both farmers and extension workers. Many lack understanding of shoot regeneration, pruning, and water management, while extension agents often have no formal Salibu training, causing inconsistent adoption and results (Abdulrachman et al., 2015). The impact of climate change, particularly shifts in pest and disease dynamics, further complicates management, underscoring the need for integrated pest surveillance and predictive modelling to support adaptive, ecosystem-based control strategies (Subedi et al., 2023).

Formatted: Font: (Default) Times New Roman

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina et al., 2021; Zarwazi et al., 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the Salibu system across diverse agroecosystems remains constrained.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

From a socio-economic perspective, adoption of the Salibu system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Scepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka et al., 2023).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

#### Future Development Directions and Recommendations

The sustainable development of the Salibu system requires a comprehensive, interdisciplinary research and policy approach. Key priorities include adapting Salibu practices and rice cultivars to Indonesia's diverse lowland agroecosystems, with site-specific management of soil water, cutting height, and fertilisation timing (Paiman et al., 2022).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

The system has demonstrated adaptability to **elevated temperature conditions**, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda et al., 2020). However, yield outcomes remain variable across regions; in some locations, Salibu yields still lag behind those of conventional replanting systems (Sakti et al., 2021; Yamaoka et al., 2023).

Future research should investigate the long-term environmental impacts of Salibu, including greenhouse gas emissions, soil quality, and water-use efficiency. Using life cycle assessment (LCA) frameworks is essential for evaluating its sustainability, with initial Solok studies showing reduced pollution and emissions alongside improved environmental performance (Aswin et al., 2023; Qiao et al., 2024).

Formatted: Font color: Auto

Effective scaling of the Salibu system requires context-specific, evidence-based extension using practical materials like visual guides, mobile videos, and hands-on training to empower farmers and workers (Mayly and Syafri, 2018). Combining **local wisdom** with **scientific agronomy** enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo et al., 2022).

Formatted: Font color: Auto

Digital platforms like WhatsApp and Facebook aid peer-to-peer learning but have limited reach in low digital literacy areas. Thus, hybrid strategies combining ICT and traditional outreach are recommended (Agnese et al., 2024). Participation in digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim et al., 2024; Mendes et al., 2024). In this regard, involving **lead farmers as local mentors** and organising **farmer groups or cooperatives** can accelerate innovation diffusion at the grassroots level.

To broaden its application, the Salibu system must be strategically **integrated into national agricultural development programs**, such as the **Food Estate initiative** and the **IP400 intensification program**. Salibu aligns well with IP400's goal of achieving four rice harvests per year, as it enables **two harvests from a single planting**, thereby saving labour, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

### CONCLUSION

This review highlights the Salibu planting system as a sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By using the rice plant's natural regenerative ability, Salibu allows multiple harvests from a single planting, reducing seed, labour, and water use while maintaining competitive yields. Agronomic innovations like stem cutting, AWD irrigation, and biofertilizers improve efficiency and adaptability. However, adoption is limited by unsuitable rice varieties, soil variability, low farmer technical skills, and weak institutional support. Successful implementation depends on targeted training, participatory extension, and supportive policies. Integrating Salibu into national strategies and climate-resilient programs can expand its impact. Overall, the system offers great potential to boost productivity, reduce environmental impact, and support smallholders, but requires coordinated efforts in research, policy, and on-farm practice to realize this promise.

### ACKNOWLEDGMENTS

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

### REFERENCES

Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan

Formatted: Font: (Default) Times New Roman

Formatted: Justified, Indent: First line: 1.25 cm, Line spacing: 1.5 lines

Pengembangan Pertanian Kementerian Pertanian, Jakarta. pp: 26 (In Indonesian)

- Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural Sarawak, Malaysia. *Interact. Learn. Environ.*, **32**: 5699–710.
- Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) Salibu paddy cultivation. *Asian J. Appl. Sci.*, **10**: 1–8.
- Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *Int. J. Environ. Clim. Chang.*, **14**: 424–36.
- Alridiwersah, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer. *Acta Agrobot.*, **74** : 1–12.
- Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip and micro sprinkler irrigation. *Agri. Sci. Dig.*, **28**: 124–6.
- Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *Asian J. Appl. Res. Community Dev. Empower.*, **7** : 160–9.
- Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agron. J.*, **112**: 5115–24.
- Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agron. J.*, **115**: 1735–45.
- Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi salibu daerah Sumatera Barat. *J. Tek. Pert. Andalas*, **25**: 90–5. (in Indonesian)
- Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). *Water management in irrigated rice: Coping with water scarcity*. International Rice Research Institute, Los Baños, Philippines. pp: 54.
- Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy*, **14** :

1926.

- Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agric. Eng. Int.*, **24**: 90–101.
- Dobermann, A. and Fairhurst, T. (2000). *Rice: Nutrient disorders & nutrient management*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI), Makati, Philippines. pp: 193.
- Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Org. Agric.*, **8**: 207–23.
- Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE*, **11**: e0150549.
- Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of Salibu rice technology in Garut Regency, West Java-Indonesia. *Int. J. Innov. Sci. Res. Technol.*, **6**: 644–9.
- Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *Int. J. Intellect. Discourse (IJID)*, **7**: 44–57.
- Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy*, **11**: 777.
- Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Commun. Soil Sci. Plant Anal.*, **42**: 1913–33.
- Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). Salibu technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy and Water Environ.*, **17**: 403–10.
- Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon

rice. *Agric.*, **12**: 620.

- Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields: A global meta-analysis. *Agric. For. Meteorol.*, **353**: 110075.
- Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Mol. Soil Biol.*, **15**: 87–98.
- Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Appl. Sci.*, **10**: 4432.
- Ilar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *J. Public. Aff. Dev.*, **2**: 107–42.
- Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agric. Water Manag.*, **241**: 106363.
- Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *Eur. J. Soil Sci.*, **75**: e13533.
- Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). Salibu rice cultivation in tungro endemis region. *J. Tek. Pertan. Lampung*, **12**: 338–49.
- Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertan.*, **6**: 163–74.
- Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustain.*, **7**: 5875–95.
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustain.*, **14**: 2952.
- Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of icts. *Sustain.*, **13**: 5868.
- Mayly, S. and Syafri, A. (2018). Implementation of Salibu rice cultivation technology in Percut Sei Tuan Sub-District. *J. Saintech Transf.*, **1**: 33–40.
- Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and

impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *J. Agribus. Dev. Emerg. Econ.*, **14**: 676–93.

- Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustain.*, **16**: 9297.
- Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of SALIBU to triple-cropping in Vietnam. *F1000Research*, **8**: 1825.
- Paiman, Isnawan, B., Aziez, A., Subeni and Salisu, M. A. (2022). The role of agronomic factors in Salibu rice cultivation. *Open Agric. J.*, **16**: 1–7.
- Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor requirements and costs. *Eng. Agric. Environ. Food*, **7**: 122–6.
- Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustain.*, **16**: 9920.
- Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *J. Ilmu Tanah dan Lingkungan.*, **10**: 41–5.
- Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah*, **18**: 65–72.
- Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agric.*, **10**: 1–13.
- Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita*, **36**: 72–80.
- Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the Salibu system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy*, **10**: 1621.
- Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology

and ecology: Implications for pest management strategies, crop production, and food security. *J. Agric. Food Res.*, **14**: 100733.

Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian J. Agric. Rural Dev.*, **13**: 277–87.

Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. New Directions for a Diverse Planet. In: *Proc. of the 4th International Crop Science Congress*, 26 Sep – 1 Oct 2004, Brisbane, Australia. **pp**: 231–41.

Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). *Regional vulnerability of climate change impacts on asian rice production and scope for adaptation*. In: *Advances in Agronomy*. Academic Press, Burlington, **pp**: 91–133.

Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C., Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food Energy Secur.*, **9**: e206.

Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). *Salibu rice ratoon cropping system*. JIRCAS Japan International Agriculture Series No. 26. **pp**: 166.

Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of agricultural extension services on the adoption of improved wheat variety in Ethiopia: A cluster randomized controlled trial. *World Dev.*, **146**: 105605.

Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *F. Crop. Res.*, **234**: 66–72.

Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *J. Lahan Suboptimal J. Suboptimal Lands*, **13**: 186–97.

Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon salibu cultivation. *Biodiversitas*, **23**: 1065–71.

Formatted: Font: (Default) Times New Roman, Not Italic

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Not Italic

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman, Not Italic

Formatted: Font: (Default) Times New Roman

Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Ziama, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *African J. Agric. Res*, **19**: 20–3.

Table 1. Salibu vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days (Salibu)
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

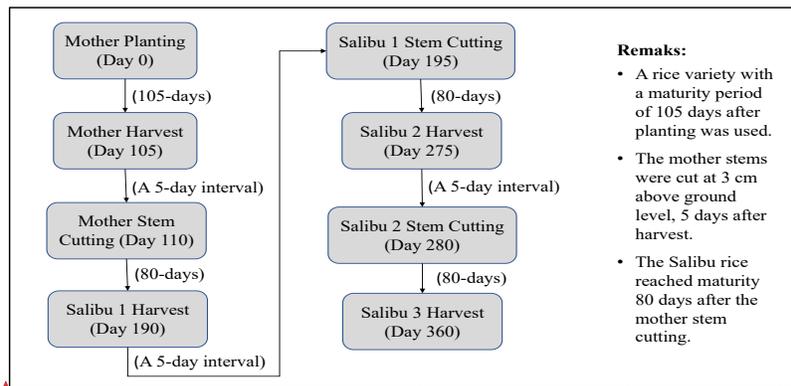


Fig. 1. Flow diagram of the Salibu planting system in lowland rice (one-year cycle).

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Deleted: ¶  
¶

## MANUSCRIPT REVISED WITHOUT HIGHLIGHTS:

### Salibu Rice Cultivation in Indonesia's Lowlands: A Review of Agronomic Innovations and Sustainability Pathways

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup> AND ARGAWI KANDITO<sup>1</sup>

<sup>1</sup>*Department of Agrotechnology, Faculty of Agriculture  
Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia*

*\*(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))*

<sup>2</sup>Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.

<sup>3</sup>Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia.

#### ABSTRACT

The Salibu planting system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which allows multiple harvests from a single planting through the regeneration of tillers from post-harvest rice stubble. Despite its promising potential to enhance rice productivity and sustainability, its adoption remains limited, highlighting the need for a comprehensive review of its principles, applications, and constraints. The structure of this review comprises seven main sections, including an overview of Indonesia's lowland rice agroecosystems, the Salibu system, innovations, productivity impacts, adoption strategies,

Formatted: Line spacing: 1.5 lines

challenges, and future development recommendations. This review synthesises agronomic principles, regional applications, and the sustainability potential of the Salibu system within Indonesia's lowland rice agroecosystems, and key innovations such as precision stem cutting, alternate wetting and drying (AWD) irrigation, and the use of biofertilizers. Drawing from scientific literature, field reports, and local practices, the review identifies that these innovations can improve regenerative growth, yield stability, and environmental efficiency. However, broader implementation faces challenges, including incompatible rice varieties, variable soil conditions, limited farmer knowledge, and weak institutional support. The findings suggest that successful adoption depends on targeted farmer training, participatory extension models, and supportive agricultural policies. In conclusion, the Salibu system offers strong potential to increase rice yields, reduce environmental impacts, and support smallholder livelihoods. Coordinated efforts in research, policy, and on-farm implementation are essential to scale its impact and integrate it into national climate-resilient food strategies.

**Key words:** agricultural innovation, lowland rice, rice cultivation, Salibu system, sustainable intensification

## INTRODUCTION

Rice (*Oryza sativa* L.) is the primary staple food for over 90% of Indonesians, with more than 80% of national production sourced from lowland rice fields due to their stable agro-ecological conditions and well-managed irrigation (Sembiring et al., 2020). However, despite increased use of modern inputs like fertilisers and high-yielding varieties, productivity has stagnated over the past two decades. This is largely due to declining soil fertility, disease-prone varieties, and inefficient water and fertiliser use (Wassmann et al., 2009). Soil degradation, water stress, and climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Lal, 2015; Dou *et al.*, 2016).

In response to these challenges, the Salibu planting system has emerged as a promising indigenous innovation rooted in West Sumatra's farming traditions. It leverages the rice plant's natural ability to regenerate tillers from post-harvest stubble, enabling multiple harvests without reseeded or full land preparation (Abdulrachman et al., 2015). When properly managed, Salibu systems can achieve yields comparable to initial plantings while reducing seed, labour, water, and energy inputs (Oda et al., 2020; Shiraki et al., 2020). These features make the Salibu approach

particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Over the past decade, growing interest in Salibu cultivation among researchers, extension agencies, and policymakers has led to studies on its agronomic performance, cost-effectiveness, and adaptability in rainfed, irrigated, and tidal lowlands (Fitri et al., 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilizers have further enhanced the system's effectiveness and ecological value (Bouman et al., 2007; Doni et al., 2018). Despite its potential, Salibu adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka *et al.*, 2023).

The objective of this review is to synthesise current knowledge and field experiences related to Salibu rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. The review aims to highlight the key principles and regenerative mechanisms underlying the Salibu system, assess its regional implementation and the challenges associated with its adoption, and explore strategic opportunities for integrating Salibu into national sustainable intensification frameworks.

This review focuses on Salibu practices in Indonesia's lowland rice ecosystems, including irrigated, rainfed, and tidal fields. It excludes ratooning systems in upland or highland areas and hybrid or mechanised rice systems in non-tropical regions, drawing on literature from 2000 to 2024. The structure of this review comprises seven main sections, including an overview of lowland rice agroecosystems in Indonesia, detailed analysis of the Salibu planting system, innovation in the Salibu system for lowland rice, impact of the Salibu system on lowland rice productivity, adoption and dissemination of the Salibu system in lowland rice, challenges and limitation of the Salibu system, and future development directions and recommendations.

### **Lowland Rice Agroecosystems in Indonesia**

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria et al., 2011). Such soil properties facilitate higher yields and improved water productivity,

Formatted

Formatted: Space Before: 0 pt, After: 0 pt

Formatted

particularly under prolonged waterlogged conditions (Dou et al., 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totalling 8.1 million hectares.

The Salibu planting system, which enables regrowth from harvested stems, relies on precise harvest timing, accurate stem cutting, and careful management of water, fertilizers, and suitable rice varieties. However, productivity in lowland rice systems is often limited by cultivars that struggle with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration varieties tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sironda Putih* and varieties with the *Sub1* gene offer greater resilience (Wassmann et al., 2009).

Climate resilience can also be enhanced through the application of biofertilizers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilizers and pesticides has led to soil degradation and reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong et al., 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

### **Detailed analyses of the Salibu Planting System**

The Salibu planting system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "*Salibu*" originates from the Minangkabau dialect in West Sumatra, meaning "*once planted, can be harvested many times*", as illustrated in Fig. 1.

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the Salibu system can reduce the need for seeds and labour, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki et al., 2020).

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java, and West Nusa Tenggara (Fitri et al., 2019).

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan et al., 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labour and resources, while yielding about 60% of the main crop (Alekhya et al., 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah et al., 2023).

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu et al., 2024). Drought, plant lodging, and post-harvest mismanagement may also reduce the success of regrowth (Shiraki et al., 2020). A brief comparison of the Salibu and conventional planting systems is shown in Table 1.

#### **Innovation in the Salibu System for Lowland Rice**

Current innovations in applying the Salibu system in lowland rice focus on improving basic agronomic practices, especially stem cutting techniques and the timing of early regrowth. These factors are crucial for maximising shoot regeneration and yield. Research shows that an optimal cutting height of 20–25 cm above the soil surface preserves active lower stem nodes capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant's growing point. Although efficacy depends on soil moisture, the double-cutting technique, first at 20–40 cm, then at 5 cm, has been shown to improve grain yield (Shiraki et al., 2020).

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertiliser (Alridiwersah et al., 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman et al., 2015). Although lower cutting heights (e.g., 3 cm) may delay

the generative phase, they can improve yield components and ratoon yield. Cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan et al., 2014).

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionised water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman et al., 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu et al., 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam et al., 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill *et al.*, 2023).

The integration of environmentally friendly inputs is another critical component in developing the Salibu system. Organic and biological fertilisers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilizers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane et al., 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-grain weight, while reducing disease symptoms by up to 64.7% (Sutarman et al., 2023). *Trichoderma*-based biofertilizers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni et al., 2018).

Selecting high-performing cultivars compatible with the Salibu system is essential. Varieties like Ciherang, Inpari 32, and Mekongga have strong regenerative traits, such as vigorous tillering, sturdy stems, and good response to re-fertilisation. Research is increasingly focused on breeding for regenerative rice systems with improved yield components. Inpari 42 responds well to 300 kg/ha of NPK, while Inpari 32 performs effectively in the Jajar Legowo system, which enhances light and air penetration (Khairullah et al., 2021).

Several mechanisation have been introduced to improve efficiency in Salibu implementation. One major challenge is achieving accurate and consistent stem cutting, which is labour-intensive if done manually. To address this, portable motorised stem cutters have been developed, enabling precise cutting at the ideal height (Dixit et al., 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang et al., 2020). Recent innovations in mechanical harvesting tools,

including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu et al., 2022).

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD applications (Tuong et al., 2005). Micro-sprinklers with an evapotranspiration rate (ET<sub>c</sub>) of 1.25 have been shown to increase plant height, biomass, leaf area, and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar et al., 2008).

#### **Impact of Salibu System on Lowland Rice Productivity**

One of the main advantages of the Salibu system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that Salibu yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka et al., 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles, comparable to initial planting yields and indicative of high production efficiency (Oda et al., 2020; Shiraki et al., 2020). Additionally, Salibu increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda et al., 2020).

The performance of the Salibu system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina et al., 2021). With proper stem cutting, supplemental fertilisation, and AWD irrigation, the Salibu system can maintain stable productivity. Compared to conventional replanting, it enables two harvests within 180–200 days, and with optimal water management and double-cutting, yields can increase by up to 69% (Shiraki et al., 2020). These findings affirm that Salibu is a viable and efficient method to sustain rice production amid climate challenges (Yamaoka *et al.*, 2023; Hong and Huang, 2024).

The Salibu system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labour costs (Paman *et al.*, 2014; Fitri *et al.*, 2019). By regenerating from existing stubble, the Salibu system reduces seed use by nearly 100% and improves labour and seed efficiency by 29% and 52% compared to double replanting (Shiraki et al., 2020). By enabling multiple harvests from a single planting, Salibu saves time, water, seed, and labour (Fitri et al., 2019). Furthermore, moderate AWD

irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq et al., 2020). The AWD can reduce greenhouse gas emissions and global warming potential by up to 73%, with minimal yield loss, depending on the drying cycle's intensity and duration (Gao et al., 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill *et al.*, 2020).

Environmental efficiency in the Salibu system is also supported by the use of organic and microbial fertilisers. Biofertilizers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation significantly improves rice growth and yield, offering a sustainable alternative to synthetic nitrogen fertilizers. *Trichoderma*-based biofertilizers can increase yields by up to 30% and reduce the harmful effects of excessive chemical use (Razie and Anas, 2008).

From an economic perspective, the Salibu system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labour, seed, and land preparation (Abdulrachman et al., 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of Salibu are higher than those of conventional systems, indicating greater farming feasibility (Fitri et al., 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, Salibu contributes to household food security and income stability (Wassmann et al., 2009). Some studies even report up to four harvests from a single planting within a year, an impressive feat in the context of intensified agriculture (Sakti et al., 2021).

From a social perspective, increased productivity from the Salibu system boosts local labour participation in key tasks like pruning, fertilising, and irrigation. It also encourages resource-efficient farming, reduces reliance on external inputs, and strengthens community resilience. In Percut Sei Tuan District, Salibu improved farmer incomes, prevented land conversion, and empowered farmers to produce organic pesticides and bokashi compost, supporting sustainable agriculture (Mayly and Syafri, 2018).

Overall, the Salibu system can reduce water usage by up to 60%, lower labour requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman et al., 2022). From economic, environmental, and social perspectives, Salibu represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

### **Adoption and Dissemination of the Salibu System in Lowland Rice**

The successful adoption of the Salibu system depends on social, technical, and institutional factors, especially farmers' skills in post-harvest fertilisation, water management, and precise stubble cutting. Without proper knowledge and training, many farmers fail to regenerate tillers effectively, causing discouragement and abandonment of the practice (Mayly and Syafri, 2018; Effendy *et al.*, 2021; Paiman *et al.*, 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the Salibu system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management, especially through techniques like AWD, must be consistently applied (Yamaoka *et al.*, 2023). The lack of structured technical assistance in many regions often blocks successful implementation. Additionally, the Salibu system performs best on sandy loam soils with good water supply and drainage, while heavy clay or poorly drained soils hinder shoot regeneration and overall performance (Shiraki *et al.*, 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content, benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti *et al.*, 2021).

Institutional support, particularly from pioneer farmers and agricultural extension officers, serves as a key driver of Salibu adoption. Farmers who have successfully implemented the system often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye *et al.*, 2021; Yitayew *et al.*, 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Solok Regency in West Sumatra, the birthplace of the Salibu system, serves as a model for its development and dissemination. Since the early 2000s, collaboration between the Agricultural Technology Institute and local authorities has supported technical assistance and innovation, with pioneer farmers developing site-specific fertilisation and cutting techniques (Abdulrachman *et al.*, 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Shiraki *et al.*, 2020; Sakti *et al.*, 2021).

### Challenges and Limitations of the Salibu System

Despite its potential, the Salibu system faces biophysical and socio-institutional challenges. A key limitation is varietal suitability, as not all rice cultivars regenerate well after stubble cutting. Early-maturing varieties like Ciherang and Inpari 32 are compatible, while late-maturing or soft-stemmed cultivars often underperform (Khaerana et al., 2023).

Soil characteristics, including stable moisture, good drainage, and moderate texture, are crucial for Salibu success, while overly dry or waterlogged soils hinder tiller regeneration and increase stress vulnerability (Shiraki et al., 2020; Agustina et al., 2022). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana et al., 2023).

A major technical challenge is the limited knowledge and training of both farmers and extension workers. Many lack understanding of shoot regeneration, pruning, and water management, while extension agents often have no formal Salibu training, causing inconsistent adoption and results (Abdulrachman et al., 2015). The impact of climate change, particularly shifts in pest and disease dynamics, further complicates management, underscoring the need for integrated pest surveillance and predictive modelling to support adaptive, ecosystem-based control strategies (Subedi et al., 2023).

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina et al., 2021; Zarwazi et al., 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the Salibu system across diverse agroecosystems remains constrained.

From a socio-economic perspective, adoption of the Salibu system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Scepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka et al., 2023).

### Future Development Directions and Recommendations

The sustainable development of the Salibu system requires a comprehensive, interdisciplinary research and policy approach. Key priorities include adapting Salibu practices

Formatted

and rice cultivars to Indonesia's diverse lowland agroecosystems, with site-specific management of soil water, cutting height, and fertilisation timing (Paiman et al., 2022).

The system has demonstrated adaptability to **elevated temperature conditions**, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda et al., 2020). However, yield outcomes remain variable across regions; in some locations, Salibu yields still lag behind those of conventional replanting systems (Sakti et al., 2021; Yamaoka et al., 2023).

Future research should investigate the long-term environmental impacts of Salibu, including greenhouse gas emissions, soil quality, and water-use efficiency. Using life cycle assessment (LCA) frameworks is essential for evaluating its sustainability, with initial Solok studies showing reduced pollution and emissions alongside improved environmental performance (Aswin et al., 2023; Qiao et al., 2024).

Effective scaling of the Salibu system requires context-specific, evidence-based extension using practical materials like visual guides, mobile videos, and hands-on training to empower farmers and workers (Mayly and Syafri, 2018). Combining **local wisdom** with **scientific agronomy** enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo et al., 2022).

Digital platforms like WhatsApp and Facebook aid peer-to-peer learning but have limited reach in low digital literacy areas. Thus, hybrid strategies combining ICT and traditional outreach are recommended (Agnese et al., 2024). Participation in digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim et al., 2024; Mendes et al., 2024). In this regard, involving lead farmers as local mentors and organising farmer groups or cooperatives can accelerate innovation diffusion at the grassroots level.

To broaden its application, the Salibu system must be strategically integrated into national agricultural development programs, such as the Food Estate initiative and the IP400 intensification program. Salibu aligns well with IP400's goal of achieving four rice harvests per year, as it enables two harvests from a single planting, thereby saving labour, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

## CONCLUSION

This review highlights the Salibu planting system as a sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By using the rice plant's

Formatted: Space Before: 0 pt, After: 0 pt

natural regenerative ability, Salibu allows multiple harvests from a single planting, reducing seed, labour, and water use while maintaining competitive yields. Agronomic innovations like stem cutting, AWD irrigation, and biofertilizers improve efficiency and adaptability. However, adoption is limited by unsuitable rice varieties, soil variability, low farmer technical skills, and weak institutional support. Successful implementation depends on targeted training, participatory extension, and supportive policies. Integrating Salibu into national strategies and climate-resilient programs can expand its impact. Overall, the system offers great potential to boost productivity, reduce environmental impact, and support smallholders, but requires coordinated efforts in research, policy, and on-farm practice to realize this promise.

#### ACKNOWLEDGMENTS

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

#### REFERENCES

- Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian, Jakarta. pp: 26 (In Indonesian)
- Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural Sarawak, Malaysia. *Interact. Learn. Environ.*, **32**: 5699–710.
- Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) Salibu paddy cultivation. *Asian J. Appl. Sci.*, **10**: 1–8.
- Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *Int. J. Environ. Clim. Chang.*, **14**: 424–36.
- Alridiwirah, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer. *Acta Agrobot.*, **74** : 1–12.
- Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip

- and micro sprinkler irrigation. *Agri. Sci. Dig.*, **28**: 124–6.
- Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *Asian J. Appl. Res. Community Dev. Empower.*, **7** : 160–9.
- Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agron. J.*, **112**: 5115–24.
- Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agron. J.*, **115**: 1735–45.
- Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi salibu daerah Sumatera Barat. *J. Tek. Pert. Andalas*, **25**: 90–5. (in Indonesian)
- Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). *Water management in irrigated rice: Coping with water scarcity*. International Rice Research Institute, Los Baños, Philippines. pp: 54.
- Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy*, **14** : 1926.
- Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agric. Eng. Int.*, **24**: 90–101.
- Dobermann, A. and Fairhurst, T. (2000). *Rice: Nutrient disorders & nutrient management*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI), Makati, Philippines. pp: 193.
- Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Org. Agric.*, **8**: 207–23.
- Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE*, **11**: e0150549.
- Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of

- Salibu rice technology in Garut Regency, West Java-Indonesia. *Int. J. Innov. Sci. Res. Technol.*, **6**: 644–9.
- Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *Int. J. Intellectual Discourse (IJID)*, **7**: 44–57.
- Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy*, **11**: 777.
- Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Commun. Soil Sci. Plant Anal.*, **42**: 1913–33.
- Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). Salibu technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy and Water Environ.*, **17**: 403–10.
- Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon rice. *Agric.*, **12**: 620.
- Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields: A global meta-analysis. *Agric. For. Meteorol.*, **353**: 110075.
- Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Mol. Soil Biol.*, **15**: 87–98.
- Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Appl. Sci.*, **10**: 4432.
- Iilar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *J. Public. Aff. Dev.*, **2**: 107–42.
- Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agric. Water Manag.*, **241**: 106363.

- Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *Eur. J. Soil Sci.*, **75**: e13533.
- Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). Salibu rice cultivation in tungro endemis region. *J. Tek. Pertan. Lampung*, **12**: 338–49.
- Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertan.*, **6**: 163–74.
- Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustain.*, **7**: 5875–95.
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustain.*, **14**: 2952.
- Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of icts. *Sustain.*, **13**: 5868.
- Mayly, S. and Syafri, A. (2018). Implementation of Salibu rice cultivation technology in Percut Sei Tuan Sub-District. *J. Saintech Transf.*, **1**: 33–40.
- Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *J. Agribus. Dev. Emerg. Econ.*, **14**: 676–93.
- Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustain.*, **16**: 9297.
- Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of SALIBU to triple-cropping in Vietnam. *F1000Research*, **8**: 1825.
- Paiman, Isnawan, B., Aziez, A., Subeni and Salisu, M. A. (2022). The role of agronomic factors in Salibu rice cultivation. *Open Agric. J.*, **16**: 1–7.
- Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor requirements and costs. *Eng. Agric. Environ. Food*, **7**: 122–6.
- Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An

environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustain.*, **16**: 9920.

- Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *J. Ilmu Tanah dan Lingkungan.*, **10**: 41–5.
- Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah*, **18**: 65–72.
- Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agric.*, **10**: 1–13.
- Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita*, **36**: 72–80.
- Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the Salibu system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy*, **10**: 1621.
- Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *J. Agric. Food Res.*, **14**: 100733.
- Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian J. Agric. Rural Dev.*, **13**: 277–87.
- Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. New Directions for a Diverse Planet. In: Proc. of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia. **pp**: 231–41.
- Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). *Regional vulnerability of climate change impacts on asian rice production and scope for adaptation*. In: Advances in Agronomy, Academic Press, Burlington. **pp**: 91–133.
- Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C.,

- Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food Energy Secur.*, **9**: e206.
- Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). *Salibu rice ratoon cropping system*. JIRCAS Japan International Agriculture Series No. 26. pp: 166.
- Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of agricultural extension services on the adoption of improved wheat variety in Ethiopia: A cluster randomized controlled trial. *World Dev.*, **146**: 105605.
- Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *F. Crop. Res.*, **234**: 66–72.
- Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *J. Lahan Suboptimal J. Suboptimal Lands*, **13**: 186–97.
- Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon salibu cultivation. *Biodiversitas*, **23**: 1065–71.
- Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Zياما, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *African J. Agric. Res*, **19**: 20–3.

Table 1. Salibu vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days (Salibu)
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

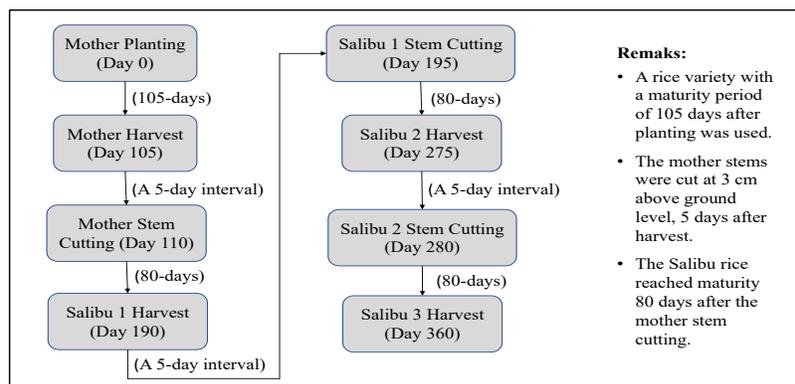
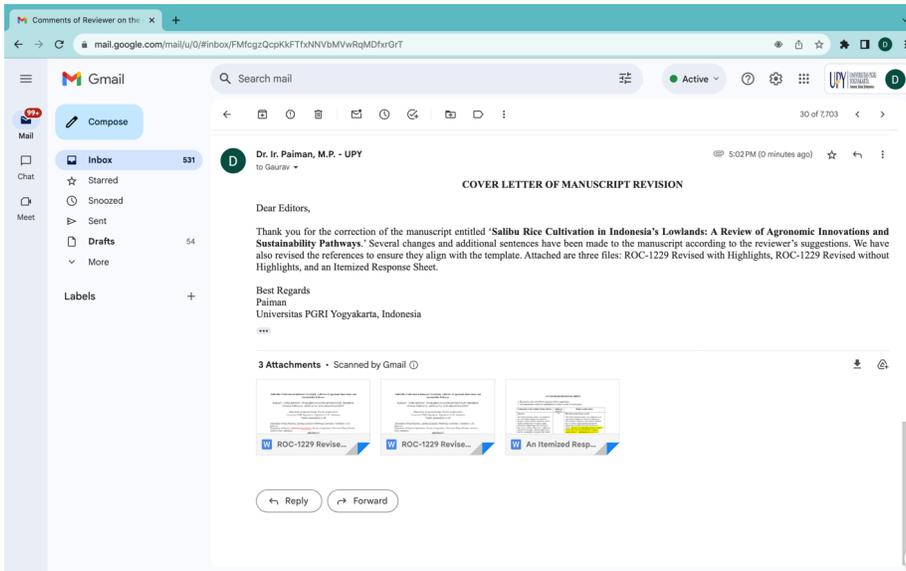
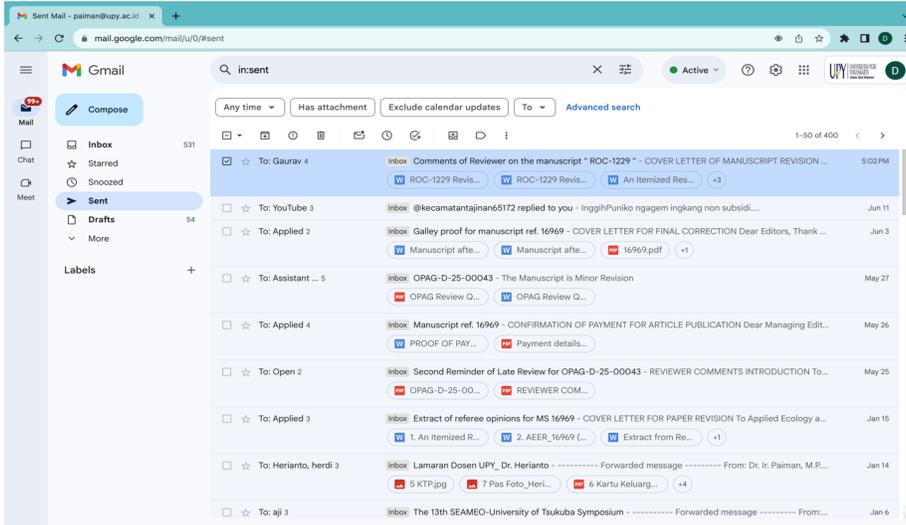
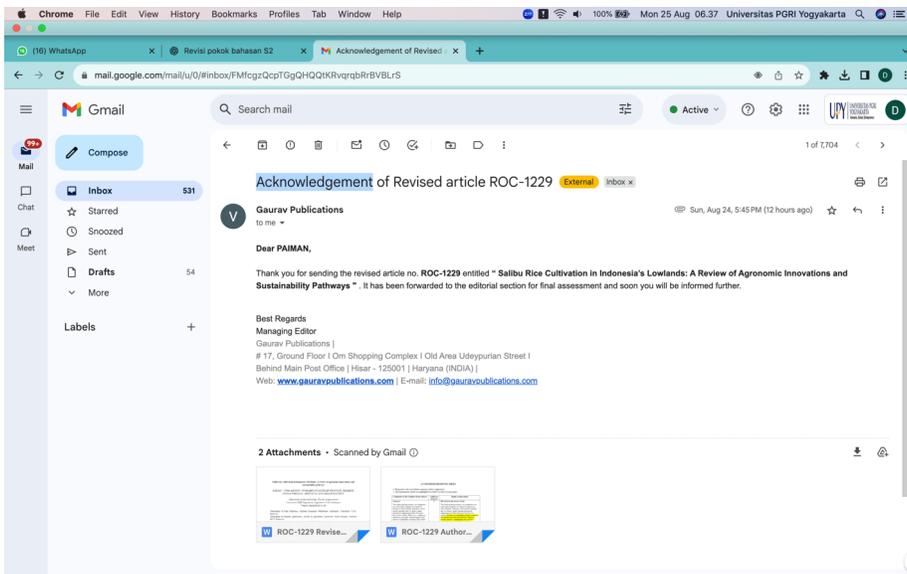
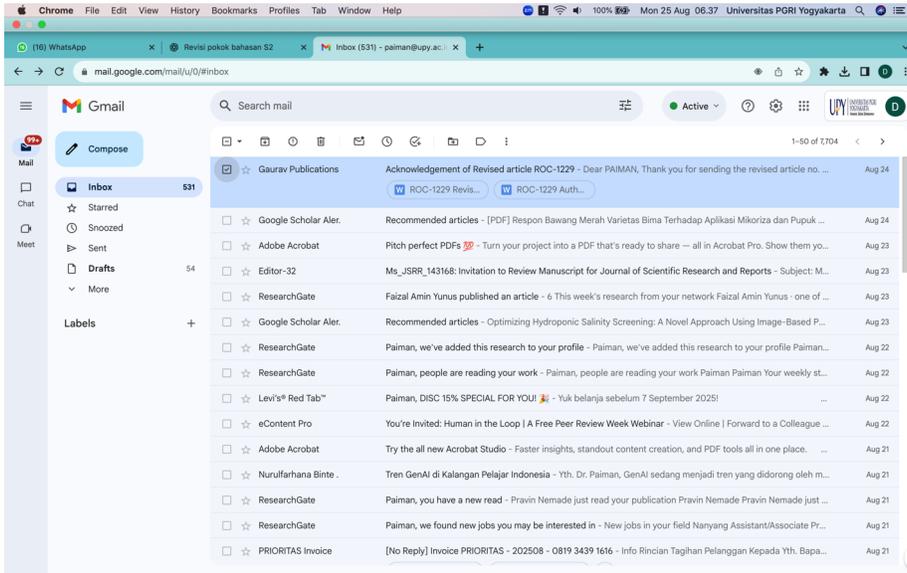


Fig. 1. Flow diagram of the Salibu planting system in lowland rice (one-year cycle).

## MANUSCRIPT RE-SUBMISSION: 24 AGUSTUS 2025



## Tanggapan Perbaikan dari Jurnal: 24 Agustus 2025



## Invoice dan Acceptance Publikasi: 9 September 2025 & 11 September 2025

The screenshot shows a Gmail inbox with the following email list:

- Gaurav Publications** - Acknowledgement of Publication Charges for ROC-1229 - Dear PAIMAN, It is to acknowledge the receipt of L... **Sep 11**
- Kudos: Science need.** - You have not claimed any articles in a while - Start growing your research impact ... **Sep 11**
- Mendeley** - "Weed management in dry directseeded rice A review..." and more articles on Mendeley - Discover rel... **Sep 11**
- Mercer | Mettl** - Students are outsmarting online exams - here's how you can stay ahead - Here are some of the top ta... **Sep 11**
- Priya Jain** - Your valuable manuscript submission towards MC Agriculture & Environmental Sciences - Dear Dr. Pai... **Sep 10**
- ResearchGate** - Paiman, you have a new read - Pooja Negi just read your publication Pooja Negi just read your ... **Sep 10**
- ResearchGate** - Ida Ayu Suci published an article - This week's research from your network Ida Ayu Suci - one of your co-... **Sep 10**
- Maybank\_Notificatio.** - Maybank Debit Card Transaction Notification (do not reply) - Hi Nasabah Maybank, Anda baru saja mela... **Sep 10**
- Google Scholar Aler.** - 1 new citation to your articles - [PDF] Impact of Weed Management Practices on the Growth and Yield of ... **Sep 10**
- Google Scholar Aler.** - Recommended articles - Metabolism and Signalling in Pea (Pisum sativum) Leaves Exposed to Drought and... **Sep 10**
- Gaurav ... Vedpal 5** - Approval of the manuscript ROC-1229 "Salibu rice cultivation in Indonesia's lowlands: A review of agr... **Sep 9**
- eContent Pro** - Achieving Publishing Success: The Role of Professional Copy Editing - View Online | Forward to a Collea... **Sep 9**
- ResearchGate** - Eloisa Vidal and 1 other researcher are waiting for you to read the messages they sent you - Eloisa Vid... **Sep 9**
- AkiNik, AkiNik 2** - Call For book Chapter in Agriculture - Agriculture Banner Image Dear Author, Greetings, We warmly invite ... **Sep 9**

The screenshot shows the content of the email from Gaurav Publications:

**Acknowledgement of Publication Charges for ROC-1229** **External** **Inbox**

**Gaurav Publications** to me • Thu, Sep 11, 12:30 PM (4 days ago)

**Dear PAIMAN,**

It is to acknowledge the receipt of the approval charges of **USD 1080** through Online Payment towards your manuscript **ROC-1229** entitled "**Salibu rice cultivation in Indonesia's lowlands: A review of agronomic innovations and sustainability pathways**" [Approved for publication in **September 2025** issue of **RESEARCH ON CROPS** journal (ISSN: 2348-7542)] for publication in "Research on Crops".

Enclosed is the Acceptance letter of your manuscript. Please feel free to contact if you have any questions or concerns.

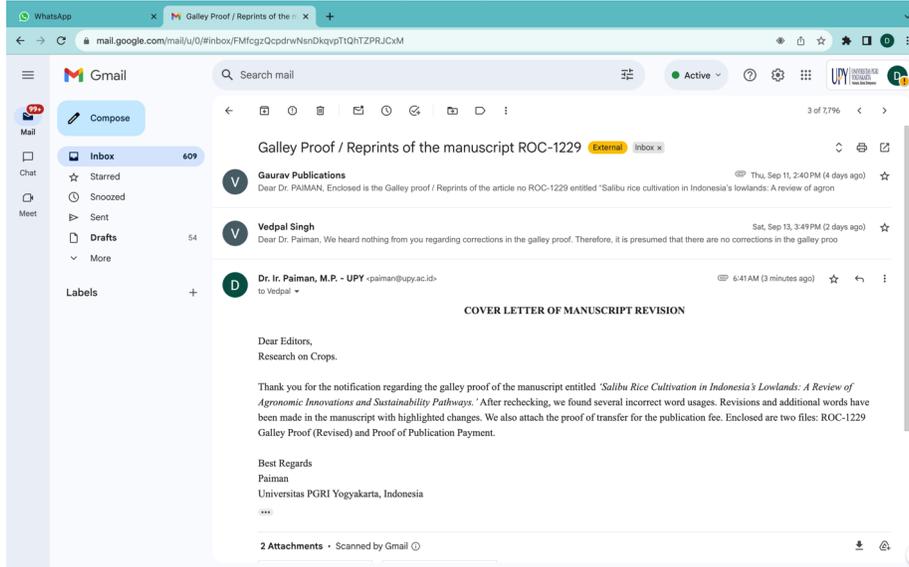
**Best Regards**  
Managing Editor  
Gaurav Publications |  
# 17, Ground Floor | Om Shopping Complex | Old Area Udeyapurian Street I  
Behind Main Post Office | Hissar - 125001 | Haryana (INDIA) |  
Web: [www.gauravpublications.com](http://www.gauravpublications.com) | E-mail: [info@gauravpublications.com](mailto:info@gauravpublications.com)

One attachment - Scanned by Gmail

Acceptance Letter

Thank you for your mail. Thank you for your information. Thank you so much for the great news!

## Perbaikan dan Resubmission Manuskrip: 15 September 2025



## Manuskrip Revision for Submission without Highlighted: 15 September 2025

### *Salibu rice cultivation in Indonesia's lowlands – A review*

*Research on Crops* **26** (3): (2025) ISSN: 0972-3226; eISSN: 2348-7542  
*With one figure* DOI:  
*Printed in India*

### **Salibu rice cultivation in Indonesia's lowlands: A review of agronomic innovations and sustainability pathways**

PAIMAN<sup>1,\*</sup>, NURCAHYONO<sup>2</sup>, NUGRAHINI SUSANTINAH WISNUJATI<sup>3</sup>, DHAREND LINGGA WIBISANA<sup>1</sup>, ARDIYANTA<sup>1</sup> AND ARGAWI KANDITO<sup>1</sup>

<sup>1</sup>Department of Agrotechnology, Faculty of Agriculture  
Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia

\*(email: [paiman@upy.ac.id](mailto:paiman@upy.ac.id))

(Received: July 31, 2025 / Accepted: September 11, 2025)

### ABSTRACT

The *Salibu* system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which allows multiple harvests from a single planting through the regeneration of tillers from post-harvest rice stubble. Despite its promising potential to enhance rice productivity and sustainability, its adoption remains limited, highlighting the need for a comprehensive review of its principles, applications, and constraints. The structure of this review comprises seven main sections, including an overview of Indonesia's lowland rice agroecosystems, the *Salibu* system, innovations, productivity impacts, adoption strategies, challenges, and future development recommendations. This review synthesizes agronomic principles, regional applications, and the sustainability potential of the *Salibu* system within Indonesia's lowland rice agroecosystems, and key innovations such as precision stem cutting, alternate wetting and drying (AWD) irrigation, and the use of biofertilisers. Drawing from scientific literature, field reports, and local practices, this article identifies that these innovations can improve regenerative growth, yield stability, and environmental efficiency. However, broader implementation faces challenges, including incompatible rice varieties, variable soil conditions, limited farmer knowledge, and inadequate institutional support. The findings suggest that successful adoption depends on targeted farmer training, participatory extension models, and supportive agricultural policies. In conclusion, the *Salibu* system offers

---

<sup>2</sup>Department of Palm Plantation, Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta 55281, Indonesia.

<sup>3</sup>Department of Magister Agribusiness, Faculty of Agriculture, Universitas Wijaya Kusuma, Surabaya 60225, Indonesia.

strong potential to increase rice yields, reduce environmental impacts, and support smallholder livelihoods. Coordinated efforts in research, policy, and on-farm implementation are essential to scale its impact and integrate it into national climate-resilient food strategies.

**Key Words:** Agricultural innovation, lowland, rice, *Salibu* system, sustainable intensification

## INTRODUCTION

Rice (*Oryza sativa* L.) is the primary staple food for over 90% of Indonesians, with more than 80% of national production sourced from lowland rice fields due to their stable agro-ecological conditions and well-managed irrigation (Sembiring *et al.*, 2020). However, despite increased use of modern inputs like fertilisers and high-yielding varieties, productivity has stagnated over the past two decades. This is largely due to declining soil fertility, disease-prone

varieties, and inefficient water and fertiliser use (Wassmann *et al.*, 2009). Soil degradation, water stress, and climate-induced disruptions such as erratic rainfall and prolonged droughts have further challenged the resilience of conventional rice cultivation (Lal, 2015; Dou *et al.*, 2016).

In response to these challenges, the *Salibu* system has emerged as a promising indigenous innovation rooted in West Sumatra's farming traditions. It leverages the rice plant's natural ability to regenerate tillers from post-harvest stubble, enabling multiple harvests without reseeded or full land preparation (Abdulrachman *et al.*, 2015). When properly managed, *Salibu* systems can achieve yields comparable to initial plantings while reducing seed, labour, water, and energy inputs (Oda *et al.*, 2020; Shiraki *et al.*, 2020). These features make the *Salibu* approach particularly relevant for sustainable intensification in the face of climate variability, declining input efficiency, and limited land availability.

Over the past decade, growing interest in *Salibu* cultivation among researchers, extension agencies, and policymakers has led to studies on its agronomic performance, cost-effectiveness, and adaptability in rainfed, irrigated, and tidal lowlands (Fitri *et al.*, 2019). Innovations such as precision stem cutting, AWD irrigation, the use of early-maturing varieties, and the application of biofertilisers have further enhanced the system's effectiveness and ecological value (Bouman *et al.*, 2007; Doni *et al.*, 2018). Despite its potential, *Salibu* adoption remains uneven due to knowledge gaps, varietal mismatches, technical constraints, and limited institutional support (Mayly and Syafri, 2018; Yamaoka *et al.*, 2023).

The objective of writing this article is to synthesise current knowledge and field experiences related to *Salibu* rice cultivation in Indonesia's lowlands, with a focus on its agronomic innovations and sustainability potential. The review aims to highlight the key principles and regenerative mechanisms underlying the *Salibu* system, assess its regional implementation and the challenges associated with its adoption, and explore strategic opportunities for integrating *Salibu* into national sustainable intensification frameworks.

This review focuses on *Salibu* practices in Indonesia's lowland rice ecosystems, including irrigated, rainfed, and tidal fields. It excludes ratooning systems in upland or highland areas and hybrid or mechanised rice systems in non-tropical regions, drawing on literature from 2000 to 2024. The structure of this review comprises seven main sections, including an overview of lowland rice agroecosystems in Indonesia, detailed analysis of the *Salibu* system, innovation in the *Salibu* system for lowland rice, impact of the *Salibu* system on lowland rice productivity,

adoption and dissemination of the *Salibu* system in lowland rice, challenges and limitation of the *Salibu* system, and future development directions and recommendations.

### **Lowland Rice Agroecosystems in Indonesia**

The lowland rice agroecosystem refers to rice cultivation on land situated below 400 m above sea level, characterized by a stable water supply and seasonal flooding (Dobermann and Fairhurst, 2000). These areas, predominantly comprising clay or silty clay soils, are ideal for irrigated rice due to their water retention capacity and the formation of an impermeable plow pan (Fageria *et al.*, 2011). Such soil properties facilitate higher yields and improved water productivity, particularly under prolonged waterlogged conditions (Dou *et al.*, 2016). Indonesia's rice-growing areas span irrigated, rainfed, tidal, and swampy lowlands, totalling 8.1 million hectares.

The *Salibu* system, which enables regrowth from harvested stems, relies on precise harvest timing, accurate stem cutting, and careful management of water, fertilisers, and suitable rice varieties. However, productivity in lowland rice systems is often limited by cultivars that struggle with abiotic stresses such as drought, flooding, and temperature fluctuations. Long-duration varieties tend to underperform under erratic weather or delayed planting. In contrast, local genotypes like *Sironda Putih* and varieties with the *Sub1* gene offer greater resilience (Wassmann *et al.*, 2009).

Climate resilience can also be enhanced through the application of biofertilisers like *Azolla* and the use of salt-tolerant rice varieties. In contrast, the continued reliance on high-input farming marked by excessive use of chemical fertilisers and pesticides has led to soil degradation and reduced biodiversity. These practices compromise soil physical, chemical, and biological properties, ultimately hindering plant growth (Lal, 2015).

Furthermore, unreliable irrigation due to infrastructure damage or water shortages remains a critical challenge. Adjusting planting schedules has proven to be a practical strategy; studies show yield increases of up to 7.8% during the rainy season and 5.6% during the dry season (Tuong *et al.*, 2005). This adaptive measure not only stabilizes harvests but also reduces dependency on irrigation and enhances water use efficiency.

### **Analyses of the *Salibu* System**

The *Salibu* system is a rice cultivation technique that utilizes the plant's natural ability to regenerate. After the main harvest, the plants are not immediately uprooted but are left to regrow from the remaining stems (stubble) that are cut precisely. Interestingly, the term "*Salibu*"

originates from the Minangkabau dialect in West Sumatra, meaning “*once planted, can be harvested many times*”, as illustrated in Fig. 1.

Unlike traditional systems that require farmers to replant each season, this method allows for one to two additional harvests without the need to resow seeds. Research has shown that the double-cutting technique in the *Salibu* system can reduce the need for seeds and labour, while still producing around 6–7 tons of grain per hectare over six consecutive harvests (Shiraki *et al.*, 2020).

Initially developed by farmers in Solok Regency, West Sumatra, in the early 2000s, the system was based on observations that rice plants harvested at the right age could produce productive new shoots. After receiving support from the Department of Agriculture and the Agricultural Technology Assessment Institute, it began to be introduced in other provinces such as North Sumatra, West Java and West Nusa Tenggara (Fitri *et al.*, 2019).

Cropping systems that include ratooning improve energy efficiency and reduce both greenhouse gas emissions and production costs by 32–42% (Yuan *et al.*, 2019). When agronomic practices are well-managed, the ratoon crop can be produced with just 50% of the labour and resources, while yielding about 60% of the main crop (Alekhya *et al.*, 2024). Additionally, this system significantly reduces production costs while saving time, water, and seeds (Zipporah *et al.*, 2023).

Excess soil moisture, especially from stagnant water, can prevent shoot development and lower yields. This is commonly seen in rainfed fields or water-saving systems where moisture availability fluctuates (Deshabandu *et al.*, 2024). Drought, plant lodging, and post-harvest mismanagement may also reduce the success of regrowth (Shiraki *et al.*, 2020). A brief comparison of the *Salibu* and conventional planting systems is shown in Table 1.

#### **Innovation in the *Salibu* System for Lowland Rice**

Current innovations in applying the *Salibu* system in lowland rice focus on improving basic agronomic practices, especially stem cutting techniques and the timing of early regrowth. These factors are crucial for maximising shoot regeneration and yield. Research shows that an optimal cutting height of 20–25 cm above the soil surface preserves active lower stem nodes capable of producing new tillers (Dobermann and Fairhurst, 2000). Cutting too high reduces regenerative efficiency, while cutting too low may damage the plant’s growing point. Although efficacy depends on soil moisture, the double-cutting technique, first at 20–40 cm, then at 5 cm, has been shown to improve grain yield (Shiraki *et al.*, 2020).

Increased plant height, number of productive tillers, and grain yield have been reported with 10 cm cutting combined with the application of Seprint liquid organic fertiliser (Alridiwersah *et al.*, 2021). Planting time is also a key factor. Depending on the variety, the first harvest should occur between 105 and 110 days after planting or when grains reach physiological maturity. Ensuring that the remaining stem tissues are still physiologically active supports rapid shoot regeneration (Abdulrachman *et al.*, 2015). Although lower cutting heights (*e.g.*, 3 cm) may delay the generative phase, they can improve yield components and ratoon yield. Cutting at 10–15 cm promotes better shoot development than at 20–25 cm (Setiawan *et al.*, 2014).

The AWD irrigation technique, which maintains ideal soil moisture without prolonged flooding, has revolutionised water management practices. AWD enhances root and shoot development and increases water-use efficiency by up to 30% (Bouman *et al.*, 2007). It also improves phosphorus availability and raises yields, increasing water efficiency by up to 35% compared to continuous flooding (Xu *et al.*, 2020). Additionally, AWD increases soil macroporosity by 46% and pore connectivity by 20%, enabling more effective root water uptake (Islam *et al.*, 2024). Maintaining a water depth of 5–10 cm has also been shown to reduce water usage by up to 45% without negatively impacting yield or income (Atwill *et al.*, 2023).

The integration of environmentally friendly inputs is another critical component in developing the *Salibu* system. Organic and biological fertilisers increase nutrient availability and plant resistance to soil-borne pathogens. Biofertilisers such as *Azospirillum*, *Rhizobium*, and *Trichoderma* significantly stimulate tiller growth (Mthiyane *et al.*, 2024). The combination of *Trichoderma* and *Aspergillus* has been found to improve plant height, panicle number, and 100-grain weight, while reducing disease symptoms by up to 64.7% (Sutarman *et al.*, 2023). *Trichoderma*-based biofertilisers have further been shown to enhance photosynthesis rate, chlorophyll content, tiller number, and grain weight by up to 30% compared to untreated controls (Doni *et al.*, 2018).

Selecting high-performing cultivars compatible with the *Salibu* system is essential. Varieties like Cihorang, Inpari 32, and Mekongga have strong regenerative traits, such as vigorous tillering, sturdy stems, and good response to re-fertilisation. Research is increasingly focused on breeding for regenerative rice systems with improved yield components. Inpari 42 responds well to 300 kg/ha of NPK, while Inpari 32 performs effectively in the Jajar Legowo system, which enhances light and air penetration (Khairullah *et al.*, 2021).

Several mechanization have been introduced to improve efficiency in *Salibu* implementation. One major challenge is achieving accurate and consistent stem cutting, which is labour-intensive if done manually. To address this, portable motorised stem cutters have been developed, enabling precise cutting at the ideal height (Dixit *et al.*, 2022). The use of double-blade headers during harvest also supports accurate cutting and grain preservation, both essential for healthy ratoon growth (Huang *et al.*, 2020). Recent innovations in mechanical harvesting tools, including energy-efficient stem cutters, have further supported the success of the first ratoon period (Fu *et al.*, 2022).

In terms of irrigation, micro-irrigation systems such as small channels and micro-sprinklers have been introduced to ensure uniform soil moisture, especially in poorly drained areas. These systems facilitate more practical AWD applications (Tuong *et al.*, 2005). Micro-sprinklers with an evapotranspiration rate (ETc) of 1.25 have been shown to increase plant height, biomass, leaf area, and grain yield, while improving water use efficiency. In just 1–2 hours, with a discharge of 91 L/hour, they can distribute moisture up to 3 meters, achieving 76–100% field capacity (Arulkar *et al.*, 2008).

#### **Impact of *Salibu* System on Lowland Rice Productivity**

One of the main advantages of the *Salibu* system is its ability to maintain competitive yields compared to conventional replanting methods. Numerous studies have shown that *Salibu* yields can reach 80–95% of the main harvest, depending on the rice variety, agronomic practices, and environmental conditions (Yamaoka *et al.*, 2023). Notably, the double-cutting technique used in this system has achieved yields of 6–7 tons/ha across six consecutive cropping cycles, comparable to initial planting yields and indicative of high production efficiency (Oda *et al.*, 2020; Shiraki *et al.*, 2020). Additionally, *Salibu* increases straw production, which plays a key role in stimulating tillering and enhancing nutrient cycling (Oda *et al.*, 2020).

The performance of the *Salibu* system depends heavily on several critical factors, including cutting height, soil moisture levels, and harvesting time (Awalina *et al.*, 2021). With proper stem cutting, supplemental fertilisation, and AWD irrigation, the *Salibu* system can maintain stable productivity. Compared to conventional replanting, it enables two harvests within 180–200 days, and with optimal water management and double-cutting, yields can increase by up to 69% (Shiraki *et al.*, 2020). These findings affirm that *Salibu* is a viable and efficient method to sustain rice production amid climate challenges (Yamaoka *et al.*, 2023; Hong and Huang, 2024).

The *Salibu* system significantly reduces input requirements. By eliminating the need for land tillage, seed preparation, and transplanting, farmers can save 30–40% on labour costs (Paman *et al.*, 2014; Fitri *et al.*, 2019). By regenerating from existing stubble, the *Salibu* system reduces seed use by nearly 100% and improves labour and seed efficiency by 29% and 52% compared to double replanting (Shiraki *et al.*, 2020). By enabling multiple harvests from a single planting, *Salibu* saves time, water, seed, and labour (Fitri *et al.*, 2019). Furthermore, moderate AWD irrigation can reduce methane (CH<sub>4</sub>) emissions by 45–90% and irrigation water use by up to 23% without compromising yield (Ishfaq *et al.*, 2020). The AWD can reduce greenhouse gas emissions and global warming potential by up to 73%, with minimal yield loss, depending on the drying cycle's intensity and duration (Gao *et al.*, 2024). In Arkansas, USA, AWD even improved nitrogen uptake and increased rice yields by up to 11% compared to continuous flooding (Atwill *et al.*, 2020).

Environmental efficiency in the *Salibu* system is also supported by the use of organic and microbial fertilisers. Biofertilisers such as *Azospirillum* and *Trichoderma* enhance plant resilience to drought and improve nutrient absorption (Lal, 2015). *Azospirillum* inoculation significantly improves rice growth and yield, offering a sustainable alternative to synthetic nitrogen fertilisers. *Trichoderma*-based biofertilisers can increase yields by up to 30% and reduce the harmful effects of excessive chemical use (Razie and Anas, 2008).

From an economic perspective, the *Salibu* system can increase farmers' profits by up to IDR 4.5 million per hectare per season through savings in labour, seed, and land preparation (Abdulrachman *et al.*, 2015). Additionally, the revenue-to-cost (R/C) and Benefit-cost (B/C) ratios of *Salibu* are higher than those of conventional systems, indicating greater farming feasibility (Fitri *et al.*, 2019). With two or more harvests per year and reduced risk of crop failure, especially in climate-vulnerable regions, *Salibu* contributes to household food security and income stability (Wassmann *et al.*, 2009). Some studies even report up to four harvests from a single planting within a year, an impressive feat in the context of intensified agriculture (Sakti *et al.*, 2021).

From a social perspective, increased productivity from the *Salibu* system boosts local labour participation in key tasks like pruning, fertilising, and irrigation. It also encourages resource-efficient farming, reduces reliance on external inputs, and strengthens community resilience. In Percut Sei Tuan District, *Salibu* improved farmer incomes, prevented land

conversion, and empowered farmers to produce organic pesticides and bokashi compost, supporting sustainable agriculture (Mayly and Syafri, 2018).

Overall, the *Salibu* system can reduce water usage by up to 60%, lower labour requirements by up to 50%, and significantly cut production costs all without reducing yields (Paiman *et al.*, 2022). From economic, environmental, and social perspectives, *Salibu* represents an agricultural innovation that is efficient, profitable, climate-resilient, and farmer-friendly.

#### **Adoption and Dissemination of *Salibu* System in Lowland Rice**

The successful adoption of the *Salibu* system depends on social, technical, and institutional factors, especially farmers' skills in post-harvest fertilisation, water management, and precise stubble cutting. Without proper knowledge and training, many farmers fail to regenerate tillers effectively, causing discouragement and abandonment of the practice (Mayly and Syafri, 2018; Effendy *et al.*, 2021; Paiman *et al.*, 2022). Thus, technical competencies, effective communication, and institutional support form the foundation for the effective and sustainable implementation of the *Salibu* system.

To achieve the intended outcomes, key agronomic practices such as maintaining optimal cutting height and implementing consistent water management, especially through techniques like AWD, must be consistently applied (Yamaoka *et al.*, 2023). The lack of structured technical assistance in many regions often blocks successful implementation. Additionally, the *Salibu* system performs best on sandy loam soils with good water supply and drainage, while heavy clay or poorly drained soils hinder shoot regeneration and overall performance (Shiraki *et al.*, 2020). Nonetheless, with appropriate water management, this method has also demonstrated improvements in soil porosity and organic carbon content, benefiting tiller growth even in marginal environments such as type C tidal lands (Sakti *et al.*, 2021).

Institutional support, particularly from pioneer farmers and agricultural extension officers, serves as a key driver of *Salibu* adoption. Farmers who have successfully implemented the system often become role models through demonstration plots or Farmer Field Schools (FFS), both of which are highly effective platforms for disseminating agricultural innovations at the local level (Mapiye *et al.*, 2021; Yitayew *et al.*, 2021). Through the participatory learning approach employed in FFS, farmers' capacity and confidence to implement new techniques increase significantly (Ilar, 2015).

Solok Regency in West Sumatra, the birthplace of the *Salibu* system, serves as a model for its development and dissemination. Since the early 2000s, collaboration between the Agricultural Technology Institute and local authorities has supported technical assistance and innovation, with pioneer farmers developing site-specific fertilisation and cutting techniques (Abdulrachman *et al.*, 2015). Consequently, rice productivity in this region increased by approximately 35%, with yields reaching 4.5–5.0 tons/ha without requiring replanting each season (Shiraki *et al.*, 2020; Sakti *et al.*, 2021).

### **Challenges and Limitations of *Salibu* System**

Despite its potential, the *Salibu* system faces biophysical and socio-institutional challenges. A key limitation is varietal suitability, as not all rice cultivars regenerate well after stubble cutting. Early-maturing varieties like Ciherang and Inpari 32 are compatible, while late-maturing or soft-stemmed cultivars often underperform (Khaerana *et al.*, 2023).

Soil characteristics, including stable moisture, good drainage, and moderate texture, are crucial for *Salibu* success, while overly dry or waterlogged soils hinder tiller regeneration and increase stress vulnerability (Shiraki *et al.*, 2020; Agustina *et al.*, 2022). Moreover, untimely stubble cutting and poor field sanitation practices can elevate the risk of pest and disease outbreaks, such as bacterial leaf blight (*Xanthomonas oryzae*) and brown spot (*Rhizoctonia solani*) (Khaerana *et al.*, 2023).

A major technical challenge is the limited knowledge and training of both farmers and extension workers. Many lack understanding of shoot regeneration, pruning, and water management, while extension agents often have no formal *Salibu* training, causing inconsistent adoption and results (Abdulrachman *et al.*, 2015). The impact of climate change, particularly shifts in pest and disease dynamics, further complicates management, underscoring the need for integrated pest surveillance and predictive modelling to support adaptive, ecosystem-based control strategies (Subedi *et al.*, 2023).

In addition, more research is needed to develop or identify rice varieties that are better adapted to rainfed lowland ecosystems, which are inherently more vulnerable to water stress and soil degradation (Erythrina *et al.*, 2021; Zarwazi *et al.*, 2022). Without adequate investments in varietal development, structured capacity-building programs, and sustained technical support, the broader scalability of the *Salibu* system across diverse agroecosystems remains constrained.

From a socio-economic perspective, adoption of the *Salibu* system has largely been driven by smallholder pioneers operating at the community level. However, resistance to change remains high, particularly in areas with strong traditions of conventional replanting using certified hybrid seeds. Scepticism about ratoon yield performance and a lack of locally visible success stories continue to hinder broader acceptance (Yamaoka *et al.*, 2023).

#### **Future Development Directions and Recommendations**

- The sustainable development of the *Salibu* system requires a comprehensive, interdisciplinary research and policy approach. Key priorities include adapting *Salibu* practices and rice cultivars to Indonesia's diverse lowland agroecosystems, with site-specific management of soil water, cutting height, and fertilisation timing (Paiman *et al.*, 2022).
- The system has demonstrated adaptability to elevated temperature conditions, as evidenced by its successful application in Central Java, highlighting its potential for climate-resilient rice production (Oda *et al.*, 2020). However, yield outcomes remain variable across regions; in some locations, *Salibu* yields still lag behind those of conventional replanting systems (Sakti *et al.*, 2021; Yamaoka *et al.*, 2023).
- Future research should investigate the long-term environmental impacts of *Salibu*, including greenhouse gas emissions, soil quality, and water-use efficiency. Using life cycle assessment (LCA) frameworks is essential for evaluating its sustainability, with initial Solok studies showing reduced pollution and emissions alongside improved environmental performance (Aswin *et al.*, 2023; Qiao *et al.*, 2024).
- Effective scaling of the *Salibu* system requires context-specific, evidence-based extension using practical materials like visual guides, mobile videos, and hands-on training to empower farmers and workers (Mayly and Syafri, 2018). Combining local wisdom with scientific agronomy enhances knowledge retention and practical application, especially when supported by participatory learning models (Limpo *et al.*, 2022).
- Digital platforms like WhatsApp and Facebook aid peer-to-peer learning but have limited reach in low digital literacy areas. Thus, hybrid strategies combining ICT and traditional outreach are recommended (Agnese *et al.*, 2024). Participation in

digital farming communities has been positively correlated with increased productivity and improved decision-making (Elkassim *et al.*, 2024; Mendes *et al.*, 2024). In this regard, involving lead farmers as local mentors and organising farmer groups or cooperatives can accelerate innovation diffusion at the grassroots level.

- To broaden its application, the *Salibu* system must be strategically integrated into national agricultural development programs, such as the Food Estate initiative and the IP400 intensification program. *Salibu* aligns well with IP400's goal of achieving four rice harvests per year, as it enables two harvests from a single planting, thereby saving labour, water, and time (Mayly and Syafri, 2018; Yusup and Sonia, 2024).

### CONCLUSION

This review highlights the *Salibu* system as a sustainable alternative to conventional rice replanting in Indonesia's lowland agroecosystems. By using the rice plant's natural regenerative ability, *Salibu* allows multiple harvests from a single planting, reducing seed, labour, and water use while maintaining competitive yields. Agronomic innovations like stem cutting, AWD irrigation, and biofertilisers improve efficiency and adaptability. However, adoption is limited by unsuitable rice varieties, soil variability, low farmer technical skills, and weak institutional support. Successful implementation depends on targeted training, participatory extension, and supportive policies. Integrating *Salibu* into national strategies and climate-resilient programs can expand its impact. Overall, the system offers great potential to boost productivity, reduce environmental impact, and support smallholders, but requires coordinated efforts in research, policy, and on-farm practice to realise this promise.

### ACKNOWLEDGMENTS

We would like to express our deepest gratitude to Universitas PGRI Yogyakarta, Indonesia, for its valuable support, and to the proofreading team for their careful assistance in preparing this manuscript.

### REFERENCES

Abdulrachman, S., Suhartatik, E., Erdiman, Susilawati, Zaini, Z., Jamil, A., Mejaya, M. J., Sasmita, P., Abdulah, B., Suwarno, Baliadi, Y., Dhalimi, A., Sujinah, Suharna and Ningrum, E. S. (2015). *Panduan teknologi budidaya padi Salibu*. Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian, Jakarta. pp: 26 (In Indonesian)

Agnese, F., Othman, Z., Mitin, A. and Yahaya, W. A. J. W. (2024). Participatory monitoring in farmer field school program through Whatsapp among indigenous farmers in rural Sarawak, Malaysia. *Interact. Learn. Environ.* **32**: 5699–710.

Agustina, H., Setiawan, B. I., Sugiyanta, Solahudin, M. and Dewi, V. A. K. (2022). Subsurface evapotranspiration irrigation system design in system of rice intensification (SRI) *Salibu* paddy cultivation. *Asian J. Appl. Sci.* **10**: 1–8.

Alekhya, G., Rajareddy, G., Darjee, S., Kumar, A. A. and Kumar, A. S. T. (2024). Rice ratooning: A revolutionary approach for resource-efficient and sustainable practice for promising future of rice. *Int. J. Environ. Clim. Chang.* **14**: 424–36.

Alridiwersah, A., Tampubolon, K., Sihombing, F. N., Suprianto, A. A. and Purba, Z. (2021). Agronomic character of ratoon rice: Stem cutting sizes and seprint liquid organic fertilizer. *Acta Agrobot.* **74**: 1–12.

Arulkar, K. P., Sarode, S. C. and Bhuyar, R. C. (2008). Wetting pattern and salt distribution in drip and micro sprinkler irrigation. *Agri. Sci. Dig.* **28**: 124–26.

Aswin, S. N., Asben, A. and Nazir, N. (2023). Life cycle assessment of the Solok rice production system in the Gunung Talang District, Solok Regency, West Sumatra. *Asian J. Appl. Res. Community Dev. Empower.* **7**: 160–9.

Atwill, R. L., Krutz, L. J., Bond, J. A., Golden, B. R., Spencer, G. D., Bryant, C. J., Mills, B. E. and Gore, J. (2020). Alternate wetting and drying reduces aquifer withdrawal in Mississippi rice production systems. *Agron. J.*, **112**: 5115–24.

Atwill, Richard L., Spencer, G. D., Bond, J. A., Walker, T. W., Phillips, J. M., Mills, B. E. and Krutz, L. J. (2023). Establishment of thresholds for alternate wetting and drying irrigation management in rice. *Agron. J.* **115**: 1735–45.

Awalina, R., Yanti, D. and Irsyad, F. (2021). Analisis faktor yang mempengaruhi produksi padi *Salibu* daerah Sumatera Barat. *J. Tek. Pert. Andalas* **25**: 90–95. (in Indonesian)

Bouman, B. A. M., Lampayan, R. M. and Tuong, T. P. (2007). Water management in irrigated rice: Coping with water scarcity. International Rice Research Institute, Los Baños, Philippines. pp: 54.

Deshabandu, K. H. S. T., Noda, Y., Marcelo, V. A. C., Ehara, H., Inukai, Y. and Kano-Nakata, M. (2024). Rice yield and grain quality under fluctuating soil moisture stress. *Agronomy* **14**: [doi:10.3390/agronomy14091926](https://doi.org/10.3390/agronomy14091926).

- Dixit, J., Hakak, F. A. and Saxena, A. (2022). Adaption of modified brush cutter for rice harvesting. *Agric. Eng. Int.* **24**: 90–101.
- Dobermann, A. and Fairhurst, T. (2000). *Rice: Nutrient disorders & nutrient management*. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute (IRRI), Makati, Philippines. **pp**: 193.
- Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. W., Yusoff, W. M. W. and Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Org. Agric.* **8**: 207–23.
- Dou, F., Soriano, J., Tabien, R. E. and Chen, K. (2016). Soil texture and cultivar effects on rice (*Oryza sativa* L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE* **11**: [doi:10.1371/journal.pone.0150549](https://doi.org/10.1371/journal.pone.0150549).
- Effendy, L., Hanan, A., Haryanto, Y. and Putri, K. (2021). Farmers' preference for innovation of *Salibu* rice technology in Garut Regency, West Java-Indonesia. *Int. J. Innov. Sci. Res. Technol.* **6**: 644–49.
- Elkassim, M., Ibrahim, I. M. and Bala, B. (2024). Exploring the role of social media in agricultural practices among rice farmers: Evidence from Kaduna State, Nigeria. *Int. J. Intellect. Discourse (IJID)* **7**: 44–57.
- Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V. and Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy* **11**: [doi:10.3390/agronomy11040777](https://doi.org/10.3390/agronomy11040777).
- Fageria, N. K., Carvalho, G. D., Santos, A. B., Ferreira, E. P. B. and Knupp, A. M. (2011). Chemistry of lowland rice soils and nutrient availability. *Commun. Soil Sci. Plant Anal.* **42**: 1913–33.
- Fitri, R., Erdiman, Kusnadi, N. and Yamaoka, K. (2019). *Salibu* technology in Indonesia: An alternative for efficient use of agricultural resources to achieve sustainable food security. *Paddy Water Environ.* **17**: 403–10.
- Fu, J., Ji, C., Liu, H., Wang, W., Zhang, G., Gao, Y., Zhou, Y. and Abdeen, M. A. (2022). Research progress and prospect of mechanized harvesting technology in the first season of ratoon rice. *Agric.* **12**: [doi:10.3390/agriculture12050620](https://doi.org/10.3390/agriculture12050620).

Gao, R., Zhuo, L., Duan, Y., Yan, C., Yue, Z., Zhao, Z. and Wu, P. (2024). Effects of alternate wetting and drying irrigation on yield, water-saving, and emission reduction in rice fields: A global meta-analysis. *Agric. For. Meteorol.* **353**: [doi:10.1016/j.agrformet.2024.110075](https://doi.org/10.1016/j.agrformet.2024.110075).

Hong, Y. and Huang, H. (2024). The role of soil microbiota in rice cultivation and its implications for agricultural sustainability. *Mol. Soil Biol.* **15**: 87–98.

Huang, M., Li, Y., Chen, A. and Xu, L. (2020). Design and test of double-cutterbar structure on wide header for main crop rice harvesting. *Appl. Sci.* **10**: [doi:10.3390/app10134432](https://doi.org/10.3390/app10134432).

Ilar, G. Y. (2015). Farmer field school as an effective approach in increasing farmers' knowledge, skills, and practices, and in enhancing diffusion of innovations: Evidences from selected rice farmers in Masalasa, Victoria, Tarlac, Philippines. *J. Public. Aff. Dev.* **2**: 107–42.

Ishfaq, M., Farooq, M., Zulfiqar, U., Hussain, S., Akbar, N., Nawaz, A. and Anjum, S. A. (2020). Alternate wetting and drying: A water-saving and ecofriendly rice production system. *Agric. Water Manag.* **241**: [doi:10.1016/j.agwat.2020.106363](https://doi.org/10.1016/j.agwat.2020.106363).

Islam, M. D., Price, A. H. and Hallett, P. D. (2024). Rhizosphere development under alternate wetting and drying in puddled paddy rice. *Eur. J. Soil Sci.* **75**: [doi:10.1111/ejss.13533](https://doi.org/10.1111/ejss.13533).

Khaerana, K., Widiarta, I. N., Gunawan, A. and Muazzam, A. (2023). *Salibu* rice cultivation in tungro endemis region. *J. Tek. Pertan. Lampung* **12**: 338–49.

Khairullah, I., Annisa, W., Subagio, H. and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland. *Ilmu Pertan.* **6**: 163–74.

Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustain.* **7**: 5875–95.

Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H. and Andri, K. B. (2022). Integrating indigenous and scientific knowledge for decision making of rice farming in South Sulawesi, Indonesia. *Sustain.* **14**: [doi:10.3390/su14052952](https://doi.org/10.3390/su14052952).

Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. and Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of ICTS. *Sustain.* **13**: [doi:10.3390/su13115868](https://doi.org/10.3390/su13115868).

Mayly, S. and Syafri, A. (2018). Implementation of *Salibu* rice cultivation technology in Percut Sei Tuan Sub-District. *J. Saintech Transf.* **1**: 33–40.

Mendes, J. D. J., Carrer, M. J., Vinholis, M. D. M. B. and Filho, H. M. D. S. (2024). Adoption and impacts of messaging applications and participation in agricultural information-sharing groups: an empirical analysis with Brazilian farmers. *J. Agribus. Dev. Emerg. Econ.* **14**: 676–93.

Mthiyane, P., Aycan, M. and Mitsui, T. (2024). Integrating biofertilizers with organic fertilizers enhances photosynthetic efficiency and upregulates chlorophyll-related gene expression in rice. *Sustain.* **16**: [doi:10.3390/su16219297](https://doi.org/10.3390/su16219297).

Oda, M., Nguyen, H. C. and Huynh, V. T. (2020). Evaluation of cropping method for perennial ratoon rice: Adaptation of *SALIBU* to triple-cropping in Vietnam. *F1000Research*, **8**: [doi:10.12688/f1000research.20890.3](https://doi.org/10.12688/f1000research.20890.3).

Paiman, Isnawan, B., Aziez, A., Subeni. and Salisu, M. A. (2022). The role of agronomic factors in *Salibu* rice cultivation. *Open Agric. J.* **16**: 1–7.

Paman, U., Inaba, S. and Uchida, S. (2014). The mechanization of small-scale rice farming: Labor requirements and costs. *Eng. Agric. Environ. Food* **7**: 122–6.

Qiao, H., Pu, M., Wang, R. and Zheng, F. (2024). Is the ratoon rice system more sustainable? An environmental efficiency evaluation considering carbon emissions and non-point source pollution. *Sustain.* **16**: [doi:10.3390/su16229920](https://doi.org/10.3390/su16229920).

Razie, F. and Anas, I. (2008). Effect of azotobacter and azospirillum on growth and yield of rice grown on tidal swamp rice field in South Kalimantan. *J. Ilmu Tanah dan Lingkungan.* **10**: 41–5.

Sakti, M. B. G., Komariah, Ariyanto, D. P., Sumani, Zaki, M. K. and Noda, K. (2021). The comparison between conventional and rice ratoon system on soil properties, rice productivity and nutrient status. *Sains Tanah* **18**: 65–72.

Sembiring, H., Subekti, N. A., Erythrina, Nugraha, D., Priatmojo, B. and Stuart, A. M. (2020). Yield gap management under seawater intrusion areas of Indonesia to improve rice productivity and resilience to climate change. *Agriculture* **10**: 1–13.

Setiawan, A., Tyasmoro, S. Y. and Nugroho, A. (2014). Intermittent irrigation and cutting height on growth and yield ratoon rice (*Oryza sativa* L.). *Agrivita* **36**: 72–80.

Shiraki, S., Cho, T. M., Htay, K. M. and Yamaoka, K. (2020). Effects of the double-cutting method for ratooning rice in the *Salibu* system under different soil moisture conditions on grain yield and regeneration rate. *Agronomy* **10**: [doi:10.3390/agronomy10111621](https://doi.org/10.3390/agronomy10111621).

Subedi, B., Poudel, A. and Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *J. Agric. Food Res.* **14**: [doi:10.1016/j.jafr.2023.100733](https://doi.org/10.1016/j.jafr.2023.100733).

Sutarman, Prihatiningrum, A. E. and Miftahurrohmat, A. (2023). Application of trichoderma and aspergillus as biofertilizers in eco-friendly ratoon rice cultivation. *Asian J. Agric. Rural Dev.* **13**: 277–87.

Tuong, T. P., Bouman, B. A. M. and Mortimer, M. (2005). More rice, less water-integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. New Directions for a Diverse Planet. In: Proc. of the 4th International Crop Science Congress, 26 Sep – 1 Oct 2004, Brisbane, Australia. **pp**: 231–41.

Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K. and Heuer, S. (2009). Regional vulnerability of climate change impacts on asian rice production and scope for adaptation. In: Advances in Agronomy, Academic Press, Burlington. **pp**: 91–133.

Xu, F., Song, T., Wang, K., Xu, W., Chen, G., Xu, M., Zhang, Q., Liu, J., Zhu, Y., Rensing, C., Zhang, J. and Yuan, W. (2020). Frequent alternate wetting and drying irrigation mitigates the effect of low phosphorus on rice grain yield in a 4-year field trial by increasing soil phosphorus release and rice root growth. *Food Energy Secur.* **9**: [doi:10.1002/fes3.206](https://doi.org/10.1002/fes3.206).

Yamaoka, K., Htay, K. M., Ofori, J., Fitri, R., Myaing, K., Win, N. K., Kutame, K. and Owusu, G. (2023). Salibu rice ratoon cropping system. JIRCAS, Japan International Agriculture Series No. 26. **pp**: 166.

Yitayew, A., Abdulai, A., Yigezu, Y. A., Deneke, T. T. and Kassie, G. T. (2021). Impact of agricultural extension services on the adoption of improved wheat variety in Ethiopia: A cluster randomized controlled trial. *World Dev.* **146**: [doi:10.1016/j.worlddev.2021.105605](https://doi.org/10.1016/j.worlddev.2021.105605).

Yuan, S., Cassman, K. G., Huang, J., Peng, S. and Grassini, P. (2019). Can ratoon cropping improve resource use efficiencies and profitability of rice in central China? *Field Crop. Res.* **234**: 66–72.

Yusup, S. and Sonia, Y. (2024). Can rice farming through the national strategy food estate increase regional production? *J. Lahan Suboptimal J. Suboptimal Lands* **13**: 186–97.

Zarwazi, L. M., Junaedi, A., Sopandie, D., Sugiyanta, Purwono and Sakagami, J. (2022). Prospective rice varieties for high yield performance on modified ratoon *Salibu* cultivation. *Biodiversitas* **23**: 1065–71.

Zipporah, P., Inoussab, A., Ahouansou, R., Bolorunduro, P. and Ziama, R. Z. (2023). Rice ratooning as a sustainable climate smart adaptation for agriculture in Liberia. *Afr. J. Agric. Res.* **19**: 20–23.

Table 1. *Salibu* vs. conventional planting system (lowland rice)

No.	Aspect	Conventional System	Salibu System
1	Plant source	New seeds	Shoots from cut stubble
2	Seed use	High	Low
3	Land preparation	Repeated each season	Once only
4	Planting method	Transplanting each time	No replanting after main crop
5	Labor requirement	High	Lower
6	Growth duration	±105–115 days	105 days (main), 80 days ( <i>Salibu</i> )
7	Harvest frequency	1–2 times/year	Up to 4 times/year
8	Yield trend	Stable	Gradually decreasing
9	Fertilizer need	Full dose every season	Reduced, adjusted
10	Cost efficiency	Low	High
11	Soil disturbance	Frequent	Minimal
12	Water requirement	Seasonal irrigation	Continuous irrigation needed
13	Environmental impact	Higher	Lower
14	Residue management	Often discarded	Used for regrowth
15	Best land suitability	All lowland types	Irrigated lowlands

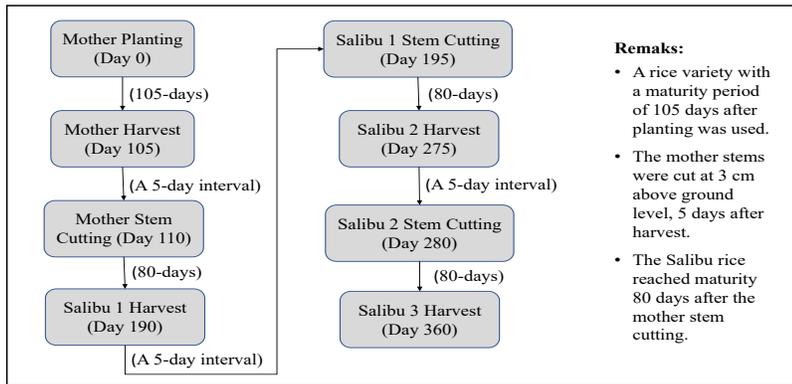
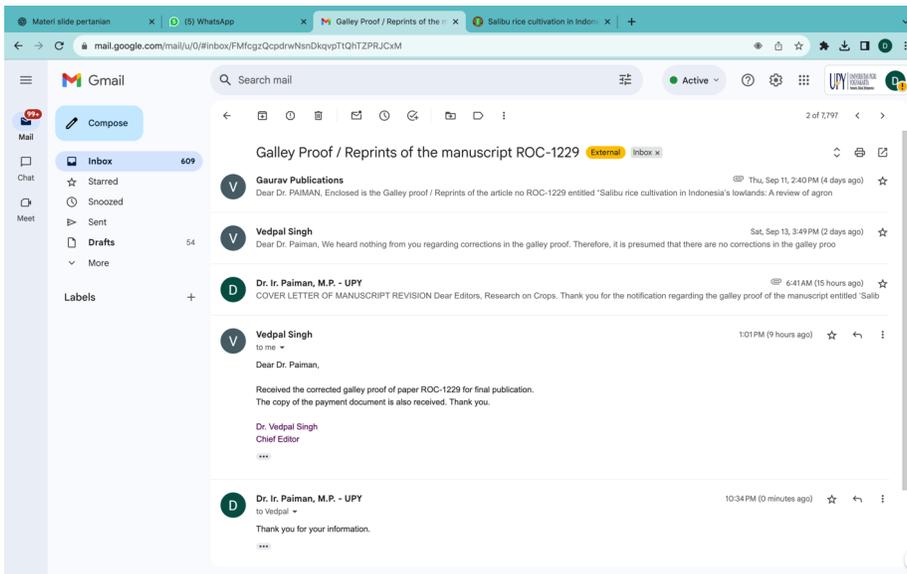
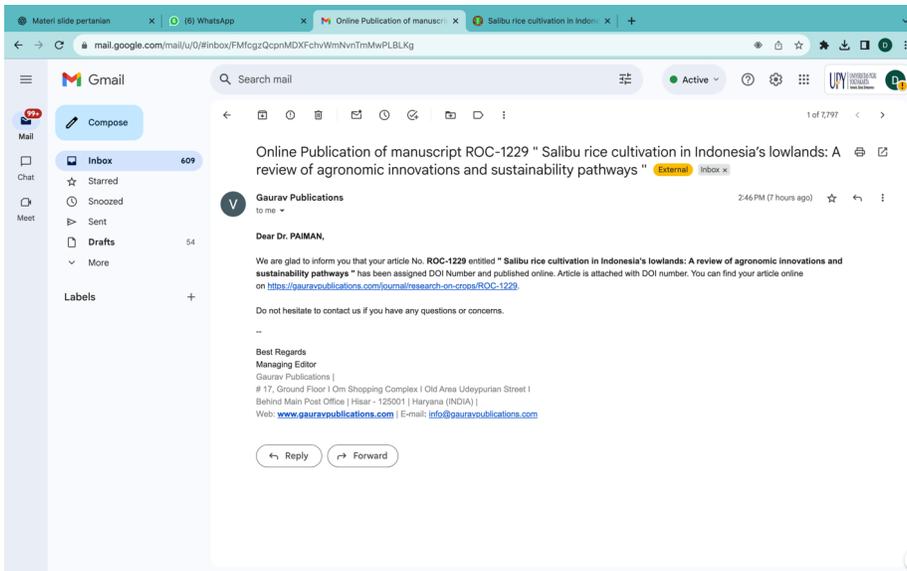
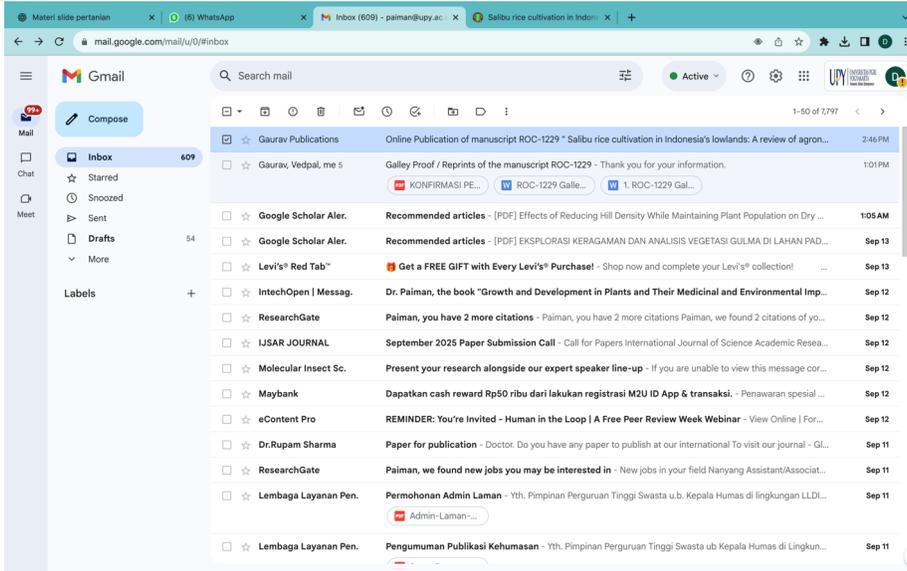


Fig. 1. Flow diagram of the *Salibu* system in lowland rice (one-year cycle).

### Final Publication: 15 September 2025



## Online Publication: 15 September 2025



Materi slide pertanian x (6) WhatsApp x Online Publication of manuscript: x Salibu rice cultivation in Indonesia x

gauravpublications.com/journal/research-on-crops/ROC-1229

Gaurav Publications Journals Services Policies LOGIN

Research On Crops  
Home > Research on Crops > VOLUME 26 > ISSUE 3 (SEPTEMBER) 2025 > ROC-1229

## Salibu rice cultivation in Indonesia's lowlands: A review of agronomic innovations and sustainability pathways

DOI: 10.31830/2348-7542.2025.ROC-1229 | Article Id: ROC-1229

Authors and affiliations

PAIMAN, NURCAHYONO, NUGRAHINI SUSANTINAH, WISNUJATI, DHAREND LINGGA WIBISANA, ARDIYANTA AND ARGAWI KANDITO  
paiman@uyy.ac.id

Address : Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia

Submitted Date : 31-07-2025 | Accepted Date : 11-09-2025 | Online Published : 15-09-2025

### Abstract

The *Salibu* system is an indigenous rice cultivation technique developed by farmers in West Sumatra, Indonesia, which allows multiple harvests from a single planting through the regeneration of tillers from post-harvest rice stubble. Despite its promising potential to enhance rice productivity and sustainability, its adoption remains limited, highlighting the need for a comprehensive review of its principles, applications, and constraints. The structure of this review comprises seven main sections, including an overview of Indonesia's lowland rice agroecosystems, the *Salibu* system, innovations, productivity impacts, adoption strategies, challenges, and future development recommendations. This review synthesizes agronomic principles, regional applications, and the sustainability potential of the *Salibu* system within Indonesia's lowland rice agroecosystems, and key innovations such as precision stem cutting, alternate wetting and drying (AWD) irrigation, and the use of biofertilizers. Drawing from scientific literature, field reports, and local practices, this article identifies that these innovations can improve regenerative growth, yield stability, and environmental efficiency. However, broader implementation faces challenges, including incompatible rice varieties, variable soil conditions, limited farmer knowledge, and inadequate institutional support. The findings suggest that successful adoption depends on targeted farmer training, participatory extension models, and supportive agricultural policies. In conclusion, the *Salibu* system offers strong potential to increase rice yields, reduce environmental impacts, and



- Editorial Board
- Author guidelines
- Aims and Scope
- Role of Reviewers
- Editorial Policy
- Role of Authors
- Peer-Review Article Process

## Complete Publications: 21 September 2025

(6) WhatsApp x Inbox (591) - paiman@uyy.ac... x

mail.google.com/mail/u/0/#inbox

Search mail

Active

1-50 of 7849

Compose

Inbox 591

Starred

Snoozed

Sent

Drafts 54

More

Labels +

☆	Gaurav Publications	Complete Publication of manuscript no. ROC-1229 entitled Salibu rice cultivation in Indonesia's lowlands: A re...	Sep 21
☆	PRIORITAS Invoice	[No Reply] Invoice PRIORITAS - 202509 - 0819 3439 1616 - Info Rincian Tagihan Pelanggan Kepada Yth. Bapa...	Sep 21
☆	AVS Quantum Science	The latest research in AVS Quantum Science - Discover highlighted research from the editors. View in Brows...	Sep 20
☆	Adobe Acrobat	Bring your files to order - Combine and organise all your important documents into a PDF. Keep it togethe...	Sep 20
☆	ResearchGate	Paiman, your co-author Ardiyanta can help your article gain visibility - Paiman, your co-author Ardiyanta can ...	Sep 20
☆	Google Scholar Alert	Recommended articles - Integration of Gamma Irradiation Breeding from Doubled haploid and Systematic Sc...	Sep 19
☆	Cell Press	Visit the Cell Press events hub - Discover, connect, and advance scientific discourse Introducing our events h...	Sep 19
☆	ResearchGate	Paiman, a recent article cited your research - Paiman, a recent article cited your research Paiman, we found ...	Sep 19
☆	ARCC Journals GARCX	Invitation to Publish with ARCC Journals - GARCX Registration Benefit - Dear Dr. G. Uma Devi, We are pleas...	Sep 19
☆	ResearchGate	Paiman, people are reading your work - Paiman, people are reading your work Paiman Paiman Your weekly st...	Sep 19
☆	eContent Pro	eContent Pro Supports Peer Review Week - View Online   Forward to a Colleague Facebook   X   LinkedIn In a...	Sep 19
☆	ResearchGate	Paiman, we found new jobs you may be interested in - New jobs in your field Recruit Phds with Salary 90000...	Sep 18
☆	Kudos: Science need.	Our support team can help - Download our welcome pack or contact support to get started with Kudos ...	Sep 18
☆	Maybank	Registrasi MZU ID App & transaksi, bisa dapat cash reward Rp50 ribul - Penawaran spesial untuk Andal Penu...	Sep 18
☆	Mendeley	"Weed management in dry directseeded rice A review..." and more articles on Mendeley - Discover relevant r...	Sep 18
☆	Aanchal Mercer   Me.	Elevate education with smarter, data-driven decisions - Explore how online assessments provide the insights...	Sep 18

Browser tabs: (6) WhatsApp, Complete Publication of manu...  
Address bar: mail.google.com/mail/u/0/#inbox/FMfcgZQcpnSzkLRztpPvVrZTq2kgPZDw

**Gmail** Search mail [Active] [Settings] [Profile]

Compose | Mail (591) | Chat | Starred | Snoozed | Sent | Drafts (54) | More | Labels (+)

---

**Complete Publication of manuscript no. ROC-1229 entitled Salibu rice cultivation in Indonesia's lowlands: A review of agronomic innovations and sustainability pathways**  
External | Inbox x

**Gaurav Publications** to me | Sun, Sep 21, 8:07 PM (7 days ago) | Star | Reply | More

**Dear Dr. PAIMAN,**

We are glad to inform you that your Manuscript No. **ROC-1229** entitled **Salibu rice cultivation in Indonesia's lowlands: A review of agronomic innovations and sustainability pathways** has been published in **VOLUME 26 ISSUE 3 (SEPTEMBER) 2025**, page range **389-399** in **Research on Crops**. Enclosed is the Final article. You can find your manuscript online on <https://gauravpublications.com/journal/research-on-crops/ROC-1229>.

Congratulations to you once again on your manuscript publication in Gaurav Publications and we look forward to receiving more of your good submissions.

Best Regards  
Managing Editor  
Gaurav Publications |  
# 17, Ground Floor I Om Shopping Complex I Old Area Udeyपुरian Street I  
Behind Main Post Office | Hisar - 125001 | Haryana (INDIA) |  
Web: [www.gauravpublications.com](http://www.gauravpublications.com) | E-mail: [info@gauravpublications.com](mailto:info@gauravpublications.com)

3 Attachments - Scanned by Gmail

- Research on Crops
- 1\_389-399.pdf
- Contents ROC Vol...

**Page 68: [1] Formatted Microsoft Office User 8/24/25 5:48:00 PM**

Font: (Default) Times New Roman, Font color: Auto

**Page 68: [2] Formatted Microsoft Office User 8/24/25 5:48:00 PM**

Font: (Default) Times New Roman, Font color: Auto