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Farming Practices, Financing Constraints, and Trust Barriers in Indonesia's Rice Sector

A Survey Report

Hiswaty Hafid | Asda J Pandiangan | Johan Sulaeman

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Abstract

This paper provides a detailed examination of the financial vulnerabilities faced by smallholder rice farmers in Indonesia. This paper presents findings from a large-scale survey of 3,030 rice-farming households, highlighting the underlying barriers to productivity, financial inclusion, and climate resilience.

Findings indicate that income from paddy farming alone is insufficient to sustain households, making diversification a necessity rather than a choice. Households with four to five income sources, primarily from non-farming activities, exhibit the highest financial security, with diversification serving as a key resilience strategy against shocks such as harvest failure, which led to an average gross profit loss of 76% in 2023.

Despite a clear need for external capital, access to formal financial services remains limited: only half of respondents own a bank account, while 80% rely on informal loans. These loans, favoured for their flexibility and trust-based nature, are predominantly used for daily consumption and financing the next planting season, signalling distress borrowing rather than productive investment. The adoption of government-subsidized crop insurance is slow due to complex procedures and low perceived benefits.

The findings highlight an urgent need for financial instruments tailored to the diverse, risk-sensitive nature of smallholder livelihoods. Expanding access to flexible, accessible, and context-specific credit and insurance products is essential to improving financial resilience in the face of growing climate and market uncertainties.

Keywords:

Rice-farming, agriculture financing, smallholders, access to financing, crop insurance, sustainable farming, agriculture in Indonesia, resilience, water scarcity, climate change

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Foreword

Indonesia's future food security is inextricably linked to the structural integrity of its smallholder farming system. This white paper provides a focused analysis, offering more than statistical data by detailing the socio-economic and human factors that define the operational capacity of farming households. Our analysis identifies several critical pressures on the foundation of national rice output: an increasingly aged farming demographic, pronounced landholding fragmentation, and the relentless, destabilizing effects of climate change.

This white paper calls on policymakers, financial institutions, and agricultural stakeholders to view contract farming and access to finance not merely as a transaction, but as a commitment to social development. Our findings indicate that mitigating financial exclusion necessitates a direct approach to the challenges of generational transition, which is critical for the long-term viability of the agricultural sector.

Achieving long-term stability necessitates strategic investment in social capital and the deployment of community-rooted solutions. This requires a policy pivot away from fragmented subsidies and short-term yield maximization towards the development of comprehensive support systems. By reinforcing farmer group organizations, promoting collaborative resource governance, and enabling shared ownership of productive assets, the sector can collectively mitigate the high costs borne by individual producers and buffer the effects of market failures. These farmer-centric interventions are critical for fostering an agricultural ecosystem that is more equitable, economically viable, and adaptive to escalating climate pressures.

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Managing Director, SGFIN
Low Tuck Kwong Distinguished Professor of Finance at NUS Business School
Professor of Economics and Real Estate
President of Asian Bureau of Finance and Economic Research
8 December 2025

Foreword

Indonesia's rice farming sector, essential to national food security and rural livelihoods, continues to face deep and persistent challenges. Smallholder farmers, who make up the majority of this sector, struggle with limited access to formal credit, low financial literacy, and increasing exposure to climate-related risks. In response, digital technologies have been promoted as solutions to boost productivity, improve market access, and build resilience. Tools such as mobile financial services, satellite-based weather alerts, and digital platforms for credit or insurance hold promise. Yet in practice, many of these remain out of reach for rural farmers due to barriers like low digital literacy and weak infrastructure. As a result, the potential of digital transformation often fails to deliver real, day-to-day benefits for smallholders.

This white paper explores the gap between innovation and implementation in the context of Indonesia's rice smallholders. It emphasizes that technology alone cannot resolve the systemic issues that hold the sector back. In particular, dependency on informal intermediaries, inadequate rural infrastructure, and short-term policy measures, such as subsidies for chemical inputs, continue to undermine long-term resilience.

Moving forward, the focus must shift toward designing simple, accessible, and culturally relevant tools that are rooted in farmers' realities. Technology can help improve yields, increase efficiency, support sustainable farming practices, expand access to knowledge, and reduce reliance on state support and expensive external inputs. While digital solutions are not a silver bullet, they can support meaningful change if developed and deployed with a clear understanding of the constraints smallholders face.

Associate Prof. Huang Ke Wei
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8 December 2025

Executive Summary

Smallholder farmers are the backbone of global rice production, yet they remain among the most financially underserved groups in most economies. Despite their central role in safeguarding food security, many continue to face exclusion from formal financial systems due to limited collateral, stringent lending requirements, and low levels of financial literacy.

This white paper draws on a large-scale survey of 3,030 rice-farming households across five provinces in Indonesia, complemented by focus group discussions, to provide a detailed picture of the financial realities, constraints, and opportunities shaping farmers' lives. The findings highlight a sector under growing strain. More than sixty percent of farmers are over the age of fifty, and younger generations are increasingly leaving agriculture for urban employment, slowing the adoption of digital tools, sustainable practices, and climate adaptation strategies. Farms remain small and fragmented, with nearly one-third cultivating less than 0.1 hectares. This lack of scale limits productivity and heightens vulnerability to crop failures, which are becoming more frequent due to climate variability and acute water scarcity. Production costs are high, dominated by fertilizers and pesticides, and their excessive use is undermining both farm profitability and long-term soil health.

Farmers are acutely aware of mounting risks from climate change, particularly irregular rainfall, pest outbreaks, and the depletion of water resources, but lack the financial means to invest in resilience. Most farmers also rely on a mix of other crops, livestock, casual labour, or remittances to stabilize income. Access to finance remains severely constrained: just half of farmers hold a bank account and fewer than 10 percent have formal loans. Trust-based informal borrowing from relatives, neighbours, or local traders dominates external financing, but these channels provide limited capital and often come with hidden costs. Government-subsidized paddy insurance schemes have failed to attract broad adoption due to perceptions of complex procedures and low benefits.

Addressing these challenges requires bridging the gap between financial institutions and smallholder realities. This includes strengthening cooperatives and intermediary organizations to channel formal credit more effectively, designing financial products that align with agricultural cycles and diverse household income streams, and leveraging digital finance and fintech innovations to lower costs and expand access. Embedding sustainability incentives into loans and insurance products can further encourage climate-robust practices and resource efficiency.

Expanding access to inclusive, tailored financial services is therefore central to unlocking the potential of smallholder farmers. By aligning financial tools with the needs and risks of smallholders, Indonesia can strengthen its food security, enhance rural prosperity, and foster a more sustainable agricultural future.

About the Authors

Hiswaty Hafid was a Research Fellow at NUS Asian Institute of Digital Finance. She holds a Ph.D. in Human Geography from the University of Sydney and experienced development professional with over a decade of expertise in project monitoring and evaluation, knowledge management, and sustainability research. She has extensive experience working with international organizations including GIZ, Swisscontact, ACIAR, and USAID, focusing on sustainable agriculture, traceability systems, climate adaptation, and gender empowerment across palm oil, cocoa, coffee, and natural rubber value chains.

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Johan Sulaeman is the Director of SGFIN. He is also a Dean's Chair and a Professor in the Department of Finance at the NUS Business School. He currently serves as one of the Scientists at AIDF (Asian Institute of Digital Finance). He has been involved in designing and delivering executive programmes for large companies and financial institutions in the region, primarily on topics related to sustainability, finance, and technology. His current research focuses on corporate social and environmental performance. His research has appeared in top economics and business journals, and been covered in various international publications, including The Wall Street Journal and The New York Times. He also contributes opinion pieces to the Straits Times and Channel News Asia.

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1. Introduction

Many smallholder farmers in Southeast Asia are financially underserved and often excluded from the formal market system. Providing access to financial products and services closes the financial gap and enables investments in the agricultural sector. Such financial support allows farmers to adapt to the impacts of climate change and offers opportunities to alleviate poverty. However, delivering sustainable financial services to rural areas remains a major challenge due to the stringent requirements imposed by formal financial institutions and the lack of creditworthiness among smallholder farmers.

The need for surveys in Indonesian rice farming stems from the fact that the majority of Indonesian farmers operate on a small scale and are financially excluded, requiring access to financial services to bolster their agricultural activities and livelihoods (Loukos and Tricarico, 2019; Mariyono, 2019). Understanding the multifaceted challenges in rice farming, such as inadequate capital, high labour costs, and the high costs associated with essential inputs like pesticides and fertilizers, is crucial for devising effective strategies to enhance the sustainability and productivity of rice cultivation (Hou et al., 2019).

1.1 Why Agriculture Finance for Farming Communities?

Agriculture is the backbone of the Indonesian economy, with a substantial segment of the population engaged in agricultural activities for the nation's economic sustenance and livelihood. The sector requires robust financial support to ensure sustainable growth and development. Agricultural finance plays a pivotal role in facilitating the modernization and commercialization of farming practices and bolstering global food security (Khan et al., 2024). The credit enables farmers to adopt new technologies, invest in essential inputs, and expand their operations, contributing to increased productivity and sustainable agricultural practices.

Generally, agriculture financing has direct impacts on:

1. Food security: By providing the necessary capital for quality seeds, fertilizers, technology, and other inputs, financing enables farmers to diversify crop choices in response to market demand, enhance productivity, and strengthen resilience. These improvements ensure a more reliable and sufficient food supply for the population.

2. Rural development: Agriculture financing supports the growth of a financial ecosystem and complementary infrastructure, which in turn fosters job creation, strengthens trade and export opportunities, and attracts further investment. A thriving agricultural sector generates income for rural communities, stimulates local economies, and contributes to national economic growth (Mariyono, 2018).

3. Economic stability: Access to credit and insurance services helps farmers manage risks, stabilise incomes, and avoid debt traps, thereby reinforcing the resilience of both the agricultural sector and the broader economy. The expansion of rural economies creates employment opportunities, raises farming incomes, and improves access to essential services such as education, healthcare, and transportation. These ripple effects play a key role in alleviating poverty and reducing unemployment in rural areas (Mariyono, 2018, 2019).

1.2 Literature Review of Indonesian Agricultural Financing

A study by the World Bank Group, titled "Indonesia Agro-Value Chain Assessment," revealed that total credit disbursements to the Agriculture, Hunting and Forestry (AHF) sector amounted to approximately USD 26 billion, representing around 6.5% of the total bank lending in Indonesia. However, the bulk of this financing is directed towards the palm oil industry, leaving limited credit available for non-palm smallholder farmers. In Indonesia, around 50 million individuals are engaged in agricultural activities, with two-thirds being smallholder farmers who face challenges in accessing funding (Indonesia Agro-Value Chain Assessment: An Exploratory Overview of Agriculture Finance in Indonesia, 2020).

Commercial banks, particularly the top 10 institutions that control nearly 60% of total commercial bank assets, charge an average interest rate of 10% for lending to the AHF sector. This is about 5% higher than the Indonesian government's key policy rate and 3% above the yield on 10-year Indonesian sovereign bonds Despite this premium, these banks maintain an average net interest margin of roughly 5%, suggesting relatively low operating costs. The AHF sector's non-performing loans (NPL) ratio stands at 1.5%, lower than the 2.8% average NPL ratio for Indonesian commercial banks (Indonesia Agro-Value Chain Assessment: An Exploratory Overview of Agriculture Finance in Indonesia, 2020). This relatively strong performance is largely attributable to commercial banks' preference for extending credit to cooperatives and large plantations, which benefit from economies of scale and diversified operations. However, expanding credit to smallholder farmers would likely increase NPL contributions from the sector.

Specialized rural banks, comprising small rural institutions and People's Credit Banks (Bank Perkreditan Rakyat, or BPR), are the primary lenders to smallholder farmers. These banks charge a much higher average interest rate of 29% and face a significantly higher NPL ratio, with AHF loans accounting for 6.8% of their total NPLs. Their limited capacity is also evident in their modest average asset size of approximately USD 7 million (World Bank, 2020).

Rural credit cooperatives play an equally critical role in extending credit to Indonesian farmers. In 2019, more than 123,000 cooperatives served over 22.5 million smallholder farmers, often offering more flexible interest rates than commercial banks and providing accessible financing channels. Leveraging cooperatives as intermediaries, through loan disbursement funded by commercial banks, offers a promising solution to strengthen agricultural financing. Specialised, covenant-based agreements between banks and cooperatives could lower operating costs, improve credit collection, and reduce information asymmetries. By improving recovery rates on non-performing loans, this approach could lower the risk premium applied to the AHF sector, ultimately expanding access to more affordable credit for smallholder farmers.

Credit Facilitation

A study of digital microfinance in Indonesia revealed that 60% of loan access originated from semi-formal sources (cooperatives) and informal channels (supply chain actors and moneylenders), while only 32% came from commercial or rural banks[1]. By 2018 nearly half of rural households held bank accounts. However, despite

[1] Mercycorps and Rabo Foundation. 2020. Landscaping of Digital Agricultural System in Indonesia. https://www.mercycorpsagrifin.org/wp-content/uploads/2021/02/Landscaping-Indonesia-Exec-Summary.pdf

this progress toward financial inclusion, most bank accounts were used mainly to receive payments, which were quickly withdrawn for consumption rather than for savings or investment.

Further research on agricultural finance highlighted that the top five commercial banks by assets are state-owned, with the exception of Bank Central Asia (BCA). Among them, Bank Rakyat Indonesia (BRI) stands out for its extensive branch network, offering broader rural financial services than other state-owned peers (World Bank, 2020). Additionally, 1,545 smaller rural banks (BPRs) provide credit services but remain limited in functions such as credit transfers, foreign currency transactions, and insurance.

By 2022, 68% of Indonesians actively used mobile phones, with higher penetration in urban areas. This widespread usage spurred the rapid growth of fintech. While 160 fintech companies were registered with the Financial Services Authority (Otoritas Jasa Keuangan, OJK) in 2019, only 97 remained operational by December 2024[2]. These fintech companies typically offer short-term credit, relying on borrower payment histories, savings behaviour, and mobile money usage to build credit scores and assess creditworthiness.

Land ownership among smallholder farmers has remained limited, particularly since 2008, as corporate and state-owned companies' interests have increasingly focused on expanding corporate-based farming, especially in the palm oil sector in Kalimantan (Habibi, 2025) primarily through the Nucleus Plasma Scheme[3]. For rice farming, the absence of formal land titles restricts smallholders' ability to use land as collateral, limiting long-term investments in sustainable practices. For instance, in Aceh province, rice farm ownership often averages less than 0.5 hectares and is characterised by fragmented arrangements, owners, tenants, those with use rights, mixed owner-tenants, and landless farmers (McCarthy, 2019). This uncertainty discourages banks and lending institutions from extending credit, given concerns over asset security.

In response, small privately funded companies have emerged to fill the financing gap left by traditional banks. These firms typically create integrated supply chain models that bundle production, financing, and distribution. Their services often include providing inputs such as seeds and fertilisers, offering agricultural services, collecting harvests, and distributing produce directly to consumers. Credit is extended at below-market rates, secured against future cash flows from harvests. However, the volume of financing available is closely tied to the level of equity investment these companies attract.

Introducing Farm Insurance

In Indonesia, the development of digital agricultural financial services stands in contrasts to the slower progress of agricultural insurance. Insurance provision is dominated by the government through Asuransi Jasa Indonesia (Jasindo), a state-owned company. Since 2015, Jasindo has offered products such as the Paddy

[2] Penyelenggara Fintech Lending Berizin di OJK per 31 Desember 2024 https://www.ojk.go.id/id/kanal/iknb/data-dan-statistik/direktori/fintech/Pages/Penyelenggara-Fintech-Lending-Berizin-di-OJK-per-31-Desember-2024.aspx

[3] Nucleus Plasma is a similar scheme to contract farming where the registered plasma farmers (in a designated cooperative) sell their fresh fruit bunch (FFB) kernel to a (designated) nucleus processing company in exchange the company will provide a stable market and access to agri-inputs and extension services.

Farming Business Insurance (AUTP), livestock insurance, and aquaculture insurance, with an 80% premium subsidy. Yet uptake remains limited, covering only 8% of paddy fields and 2.4% of aquaculture areas, despite substantial subsidies. Key barriers include high and unpredictable costs, limited farmer data, and insufficient knowledge and technical capacity, all of which constrain private sector participation.

In parallel, the private sector has introduced pilot schemes. PT Asuransi Central Asia (ACA), a leading commercial insurer, launched Asuransi Mikro Tanaman (Micro Insurance for Crops). Partnering with agribusinesses such as PT Wilmar and Syngenta, ACA piloted Weather Index Insurance and Area Yield Insurance for rice and maize. This model employed a closed-loop ecosystem, combining local NGO support, input suppliers, and bundled services including farm insurance, credit, agri-inputs, technical assistance, and market access. Over four years, the project reached 8,034 rice farmers across six Javanese regencies, yet uptake remained modest at 6%, underscoring the persistent challenges in expanding agricultural insurance coverage in Indonesia, even with innovative partnerships and bundled solutions[4].

1.3 Barriers to Accessing Financial Services

The existing literature highlights a significant gap between the financing needs of farming communities and their actual access to financial services, despite the critical role of agricultural finance. While rural financial institutions and government programs provide credit facilitation and subsidized farm insurance, services remain fragmented, often limited to specific crops or livestock. Even with substantial subsidies and bundled services, the penetration of farm insurance remains low. This disparity reflects constraints on both the demand and supply sides.

Agriculture operates within a complex ecosystem and dynamic supply chains, making it difficult for financial institutions to design products that meet farmers' needs. The high perceived risk of agricultural credit is a primary reason for limited lending to small-holder farmers, and it stems from several common challenges:

a. **Low financial literacy**. Many farmers are unbanked and lack the knowledge to manage business finances effectively, including bookkeeping, cash flow management, and reinvestment (Kloeppinger-Todd & Sharma, 2010). The absence of credit histories and limited repayment capacity leads financial providers to impose higher interest rates, which further burden low-margin farmers.

b. **Collateral constraints**: Farming assets and agricultural production are rarely accepted as collateral due to difficulties in valuation and liquidation risks (World Bank, Indonesia Agro-Value Chain Assessment, 2020).

c. **Weak market linkages:** Farmers limited bargaining power and poor supply chain coordination hinder their access to financial and insurance services. This leaves them less informed about price volatility and more exposed to market risks (Loukos & Tricarico, 2019).

d. **Infrastructure disparities:** Limited road access discourages financial institutions from serving remote areas, while gaps in digital infrastructure constrain the ability to lower transaction costs and scale efficient financing solutions (Das & Patnaik, 2020).

[4] https://www.syngentafoundation.org/agricultural-insurance-solutions

e. **Unfavourable policy framework:** Agricultural policies often prioritize short-term goals, resulting in inconsistent implementation of subsidies and price controls that distort market dynamics. In archipelagic countries like Indonesia, reaching dispersed farmer populations is especially challenging, with marginal farmers frequently excluded from government programs (Levi et al., 2020).

f. **Limited sustainability consideration:** A focus on short-term productivity has encouraged intensive farming practices that deplete soil nutrients and degrade ecosystems, including over-extraction of water resources and excessive use of fertilisers and pesticides (Tripathi et al., 2020).

On the supply side, conventional financial institutions are often reluctant to lend to farmers due to perceived risks such as information asymmetries, volatile commodity prices, and climate-related disasters. While financing demand in agriculture is high, the risks are equally significant. Common supply-side constraints include:

a. Formal requirements that exclude smallholders
Formal banking criteria, such as proof of regular income, formal business registration, or official statements of farming activities, are often difficult for smallholder rice farmers to meet. This mismatch discourages their access to formal financial services.

b. Inflexible contract schemes

Agricultural production follows cyclical patterns that vary by crop type and farming system (Manivong, Cramb, & Newby, 2014). For example, paddy cycles typically range from 3–6 months, with shorter cycles in wet systems compared to dry systems. Factors such as geographic location, infrastructure, and ecosystem services (e.g., water availability and fertile soil) shape these cycles, influencing the number of harvests, income stability, input usage, and supply chain activities (Becker et al., 2024). Standardized loan contracts often fail to accommodate these variations.

c. Unpredictable harvests and irregular income

Rice farming business is highly dependent on the ecosystem services and weather conditions. Climate variability, such as reduced rainfall, warmer temperatures during El Niño (Iizumi et al., 2014; Ismail & Chan, 2019), or the spread of invasive pest species under global warming (Skendžić et al., 2021), can severely affect yields. Minimising harvest losses increasingly requires climate monitoring systems and adaptive pest management strategies, investments that many smallholders cannot afford.

d. High transaction costs

Serving dispersed rural farmers raises operational costs for financial providers. Small loans are less profitable compared to larger commercial loans yet require the same or even higher costs for screening, monitoring, and contract design. Additional risk-related costs arise from the need for collateral to mitigate uncertainty linked to harvest losses and defaults (Brauw et al., 2021).

e. Systemic uncertainty across the value chain

Risks in agriculture can cascade across the entire supply chain. For example, fertilizer distribution disruptions may cause harvest failure; oversupply of crops may trigger price collapses and discourage future planting; and logistics

bottlenecks may reduce post-harvest quality and lower selling prices. These uncertainties heighten lenders' reluctance to extend credit to farmers.

1.4 Research Objectives

This survey is designed to examine the financing access of agricultural communities by identifying the key limitations and obstacles that hinder their ability to obtain essential financial resources for agribusiness investment. Recognizing the constraints faced by smallholder farmers, such as the lack of formal fixed-asset collateral, the survey focuses on household income flows (from both farming and non-farming activities) and the expenditure structure of farm management.

To assess the impacts of climate change and the potential for fostering resilience through sustainability-linked incentives, the survey also gathers information on sustainable farming practices, farmers' attitudes toward digital services, and their perceptions of climate change risks. Finally, by analysing both cost structures in current farming practices and farmer attitudes toward climate impacts, the survey aims to better understand farmers' demand for and preferences in financial products and services.

2. Methodology

The survey aims to assess the financing challenges faced by agricultural communities, particularly smallholder farmers, in accessing essential resources for agribusiness investments. It highlights the constraints associated with formal fixed asset collateral while analysing income flows from both farming and non-farming activities, as well as the expenditure structures of farming operations. The survey further examines the impact of climate change and the potential to build resilience through sustainability-linked incentives, including sustainable farming practices. In addition, it explores farmers' attitudes toward digital services and their perceptions of climate-related risks, providing insights into their financial service needs and preferences.

2.1 Research Design

This pilot study is a collaborative effort with Sebelas Maret State University (Universitas Negeri Sebelas Maret, UNS) in Surakarta, Central Java. Adopting a mixed-methods approach, it combines survey and group discussion techniques to gather both quantitative and qualitative data from smallholder farmers. The survey enables generalizable insights from a broad sample of rice farmers but is limited by its standardized questions, which reduce depth and flexibility.

To address the complexity of farming practices and livelihood resilience, and to capture issues that go beyond the survey's scope, the study also employs Focus Group Discussions (FGDs). These discussions are conducted with the same group of farmers surveyed, selected to represent diverse contexts such as geographic location (e.g., flatlands, mountainous areas, coastal regions), access to financial services, infrastructure development (e.g., irrigation), and links with supply chain actors.

Survey development is being carried out jointly by the NUS-AIDF research team and UNS researchers, ensuring questions are context-specific and tailored to local conditions. The survey is translated into Bahasa Indonesia with the integration of local phrases, technical references, region-specific measurement systems, and farming practices, supported by the expertise of the UNS team.

2.2 Survey Implementation

The research survey began with the development of rice farming research tools, including household and group discussion questionnaires, followed by the design of an online data collection system and pilot simulation.

a. Rice Farming Survey and Group Discussion

Cross-sectional surveys provide broad generalizable insights but have limitations in capturing qualitative depth and may be biased by respondents' memory recall. To address this, the survey was complemented by small group discussions, which explored variations in farming environments (e.g., lowland, highland, irrigated areas) and were facilitated by the UNS research team. The survey instruments, discussion guides, and consent forms are provided in the appendix.

The household survey was structured to capture the financial challenges and capacities of rice farmers through the following modules:

1. **Household and Farming Information**: Demographic profile, labour, and financial resources (farming and non-farming income).

2. **Rice Farming Management and Productivity**: Land ownership, management practices, expenditure patterns, crop failures, and market access.
3. **Existing Financial Access**: Current financial practices, sources of credit, assets, and investment opportunities.
4. **Technology and Climate Change**: Perceptions of digital services and climate-related risks.

Group discussions built on these themes, with follow-up inquiries into farming practices, programme support, and financial arrangements. Key areas included:

- Farms and Income: crop varieties, expenditure on practices, pricing, and support services.
- Financial Access and Investment: informal credit, savings practices, and adoption of digital services.

b. Data Collection Tool and Simulation

A pilot was conducted in Soka Village, Klaten District, Central Java, to test the feasibility and clarity of survey tools. The pilot assessed the timing and flow of interviews, sensitivity of certain questions, and overall respondent engagement. Feedback from this exercise informed revisions to question design and framing, after which the tools were digitized using KoboCollect.

Pilot results also revealed overlaps (e.g., "other jobs" vs. "additional income") and difficulties with technical questions requiring agricultural knowledge. To address these challenges, surveyor training and simulations were conducted prior to full implementation. Training took place in three hybrid phases:

1. Survey orientation: Understanding survey content, delivery, and follow-up strategies.
2. KoboCollect training: Setting up, managing, and inputting survey data into the platform.
3. Survey simulation: Enumerators practiced with mock respondents (family or neighbors), including consent procedures and digital data entry.

c. Geographic Distribution of Target Respondents

From 1 November to 31 December 2024, 25 trained enumerators conducted structured interviews with rice farmers across 25 regencies in five provinces of Java (see Table 1). Data was collected using the standardized questionnaire and uploaded daily via KoboTool. The UNS and AIDF-NUS teams monitored data quality in real time, with final verification, cleaning, and translation performed before analysis.

Table 1. Geographic Distribution of Village and Respondent

Provinces	Number of Regencies	Regency	Number of Villages	Number of Respondents
Banten	**3**	Pandeglang, Lebak, Serang	28	400
West Java	**6**	Bogor, Bandung, Cirebon, Cianjur, Sumedang, Subang	15	501
Central Java	**12**	Purworejo, Brebes, Pemalang, Kebumen, Magelang, Sukoharjo, Karanganyar, Boyolali, Klaten, Grobongan, Semarang, Sukoharjo, Sragen	104	1,432
Yogyakarta	**3**	Sleman, Bantul, and Gunung Kidul	13	143
East Java	**4**	Sampang, Jember, Probolinggo, Gresik	47	554
Total	**28**		**207**	**3,030**

3. Data Analysis and Findings

The survey results are presented through descriptive analysis and regression modelling. The descriptive analysis outlines the characteristics and demographics of rice farmers in Java, their management practices, cost structures, productivity levels, assets and investments, financial access, and perceptions of technology and climate change. The regression models examine the relationships between independent variables, such as demographic attributes, farming types, and forms of financial access, and dependent variables, including farm yields, financing needs, and other performance indicators.

3.1 Demographic

Key Findings: Aging Workforce and Human Capital Constraints

- ***Severe Aging Trend:*** *The farming population is critically aging, with 61% of respondents aged over 50 years and only 15% younger than 41.*
- ***Education Gap:*** *A high proportion of managing farmers (61%) have fewer than seven years of formal schooling, which is a primary factor slowing the adoption of new technologies and sustainable practices.*
- ***Youth Exodus:*** *Nearly half of household (43%) have family members working outside the village, reflecting the lack of generational interest in continuing the family farm business.*
- ***Livelihood Diversification:*** *Farmers manage income risks by diversifying income sources: 67% have other income sources, with remittances (29%) being the single largest non-farm source.*

A majority of survey respondents were male (71%) and beyond productive age, with 61% aged over 51 years and only 15% younger than 41 (see Table 2). The ageing trend is not unique to rice farming but extends to other crops, as younger generations show limited interest in agriculture and prefer employment outside the sector. Although most households (71%) consist of 3 - 5 members, farm management typically falls to the parents, while nearly half of household members (43%) work outside the village in cities or larger towns.

Farming is often perceived as less skilled but highly manual work, which has resulted in older and less educated parents, 61% of whom had fewer than seven years of schooling, continuing to manage farms. Aware of the hardships involved, many parents discourage their children from pursuing farming, instead urging them to seek employment elsewhere. Low levels of formal education, combined with an ageing farming population, slow the adoption of new technologies, digital tools, and sustainable practices in rice farming.

Among respondents, 75% owned their rice farms, though many also engaged in other agricultural activities such as cultivating additional crops or raising livestock. Reliance on a single crop creates livelihood vulnerabilities, as farming is highly dependent on ecosystem services like water availability and weather conditions, and is increasingly threatened by pest infestations linked to invasive species. To manage risks, farmers diversify their livelihoods not only through multi-cropping and livestock but also via side jobs (38%) and additional income sources (67%) from both farm and non-farm activities.

Table 2. Demographic Variable and Distribution

Demographic Attributes	Categories	Distribution
Gender	Male	71%
	Female	29%
Age range	< 41	15%
	41 - 50	24%
	51 - 60	34%
	> 60	27%
Marital status	Married	89%
	Single/Divorce/Widow(er)	10%
Number of years of formal education	< 6 years	26%
	6 years	35%
	9-12 years	35%
	16 years	4%
Family size	1-2 person	24%
	3-5 persons	71%
	6-8 persons	5%
Family members working elsewhere (outside the village)	1 person	19%
	2 persons	15%
	3+ persons	9%
Daily activities in the farming business	Paddy field owner	75%
	Paddy farming labour	30%
	Farming other crops	9%
	Rearing livestock	12%
Having side job	Yes	38%
	No	0%
Type of side job	Daily	16%
	Monthly	6%
	During growing season	4%
	By requests	10%
	All in one arrangement	2%
Having other income	1 Source of other income	64%
	> 1 source of other income	4%
Sources of other income	Remittance	29%
	Kiosk/Merchants	15%
	Lending land/machinery tools	4%
	Pension	2%
	Other business	17%

n = 3,030

3.2 Paddy Farming and Management Practices

Key Findings**: **Farm Fragmentation and Unsustainable Input Reliance

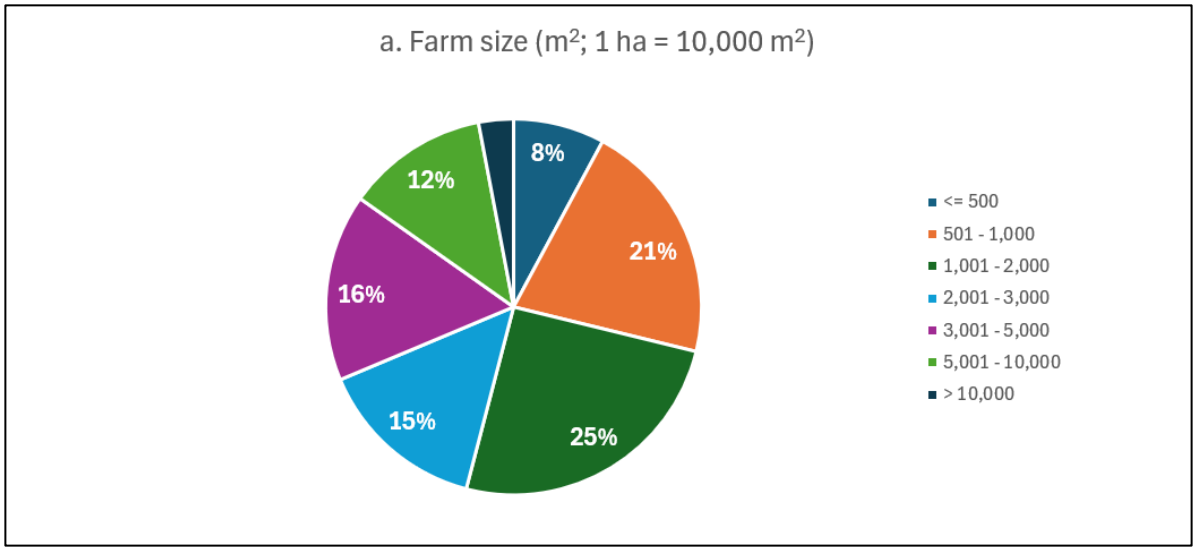
- ***Extreme Fragmentation:** Paddy fields are overwhelmingly small and fragmented: more than half of respondents cultivate less than 0.2 hectares (2,000 m²), with many managing multiple separate plots.*
- ***Irrigation Powers Productivity:** The widespread reliance on irrigation systems is fundamental to the region's productivity, enabling the majority of farmers (over 80%) to achieve 2-3 harvests annually, though this high frequency is increasingly threatened by seasonal water scarcity which forces costly water pumping.*
- ***Unsustainable Resource Needs:** Farmers exhibit heavy reliance on subsidized fertilizers, particularly nitrogen (urea) and NPK, raising significant concerns about soil acidification, nutrient imbalance, and increased greenhouse gas emissions.*
- ***Chemical Dependence:** There is a widespread and often excessive reliance on insecticide–herbicide combinations for pest and weed control, due to limited knowledge of organic methods, contributing to ecological imbalance and resistance.*
- ***Traditional Assets:** Production assets remain traditional, with the most common being manual tools and spraying pumps. Modern assets like mechanical harvesters are typically rented rather than owned, limiting efficiency gains.*

This section presents the survey findings on on-farm paddy cultivation, focusing on field owners and labourers as respondents. Paddy fields were generally small (see Figure 1). Almost one-third of respondents cultivated less than 0.1 ha (1,000 m²), while only 17% managed more than 0.5 ha. In many cases, fields were further fragmented, with respondents managing two or three separate plots.

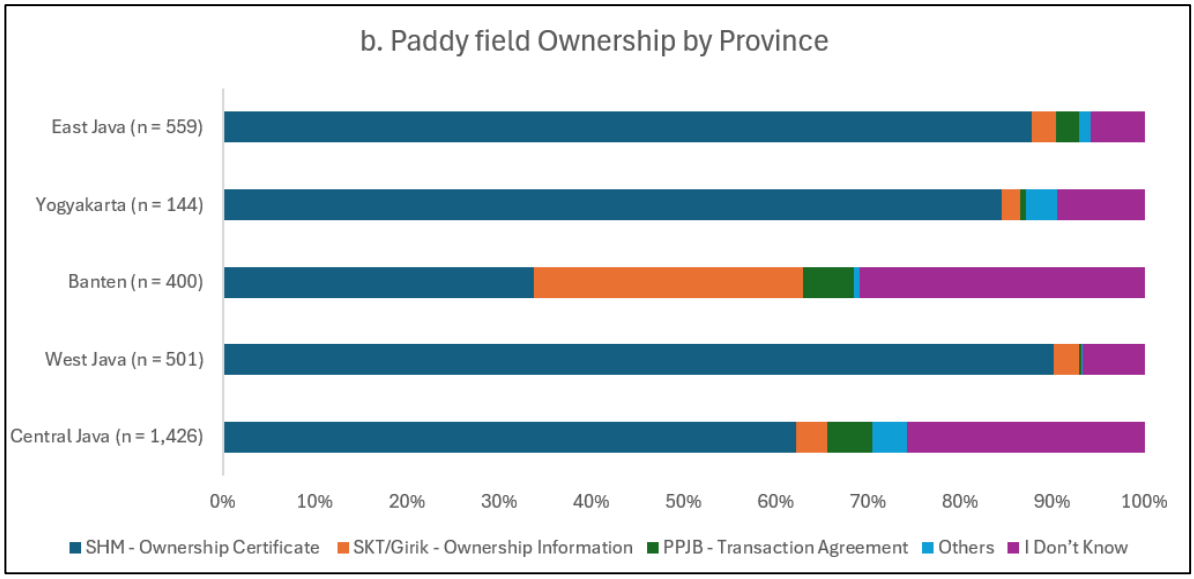
In terms of experience, fewer than one-third of respondents had less than 10 years of paddy farming, while the majority had 11 to 50 years of experience (see Figure 2). This aligns closely with respondents' age distribution, as older farmers tended to have longer histories of cultivation.

Regarding farming practices, the majority relied on irrigation systems, with smaller proportions combining irrigation with rainfed methods or groundwater/river pumping. As a result, over 80% of farmers achieved 2–3 harvests annually (see Figure 3), while fewer than 15% managed only one harvest per year. However, the reliance on water pumping during the dry season indicates seasonal water scarcity, which not only increases production costs but also threatens underground water reserves critical for household use.

Figure 1. Farm Size by Plot and Province

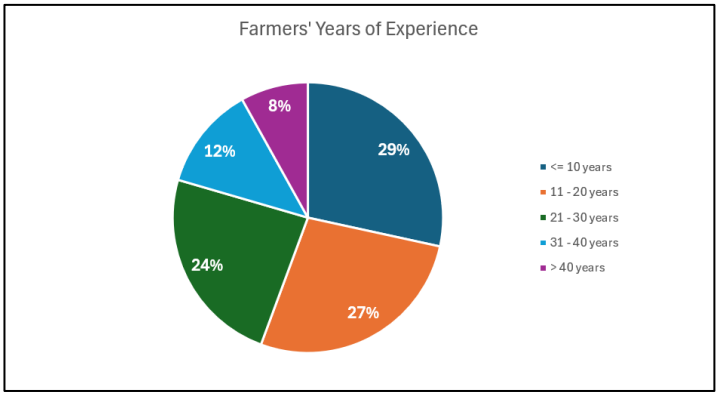


n = 3,030



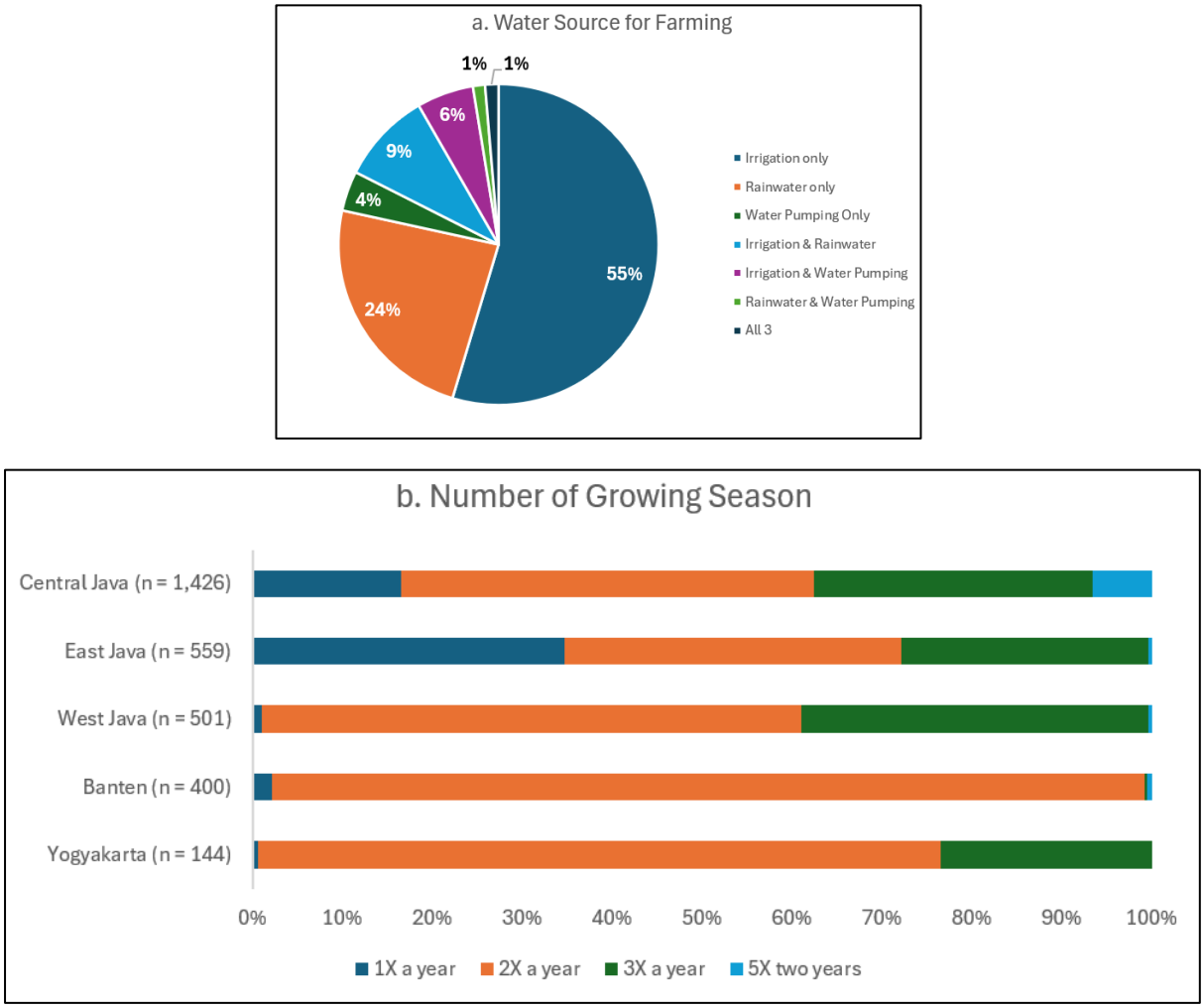
n = 3,030

Figure 2. Years of Experience



n = 3,030

Figure 3. Farming Methods and Time of Harvest



n = 3,030

a. Paddy Farming Calendar in Five Regions

In Java, paddy farming is generally irrigated, allowing for two to three harvests annually. Exceptions are found in hill regencies (e.g., Boyolali, Kebumen, Sukoharjo, Gunung Kidul, Magelang) and coastal regencies (e.g., Lebak, Pandeglang, Gresik, Probolinggo), where farmers rely primarily on rainfall and typically achieve only one or two harvests per year.

The length of the growing cycle varies by farming practice (irrigated vs. rainfed, direct vs. indirect seedling) and by variety (wet-field vs. dry-field rice), ranging from 100 to 160 days. Each cycle follows six main stages: soil preparation, nursery, transplanting seedlings, crop maintenance (fertilization, weed, pest, and disease management), growth and maturation, harvesting. Because of regional differences in seasonal patterns, the start times and cycle durations differ across Java's geographic zones.

Figure 4. Paddy Farming Cycle and Growing Calendar in 2024

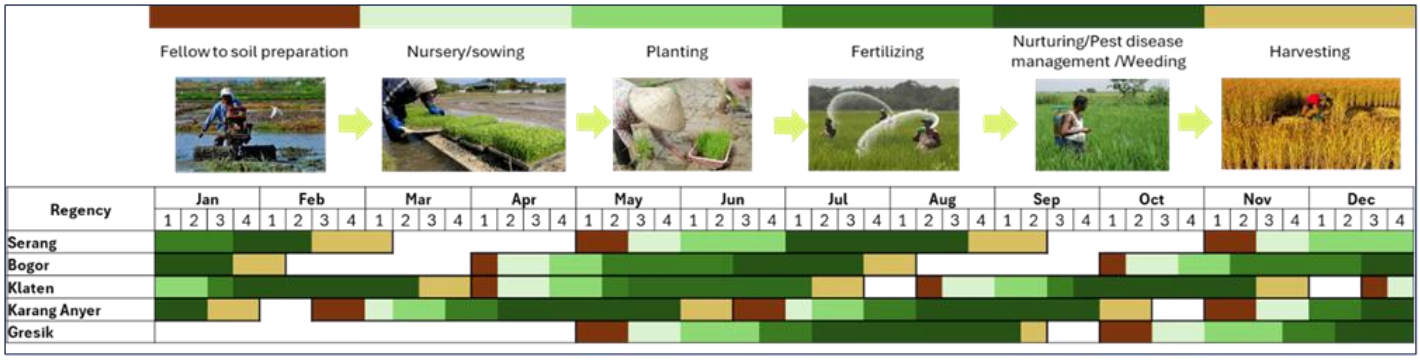


Figure 4 illustrates that the first growing season typically coincides with the rainy season, beginning in November–December and continuing until February - March. The second season generally starts in March or April, while a third season may occur in August. Across the five sampled regions, Serang (Banten), Bogor (West Java), and Gresik (East Java) generally achieve two growing seasons annually, whereas Klaten and Karang Anyar (Central Java) can achieve up to three.

b. Agricultural Inputs

Agricultural inputs are essential resources used to enhance farm production. While machinery and labour are also considered inputs, this section focuses on fertilizers, crop protection agrochemicals (pesticides), and seeds.

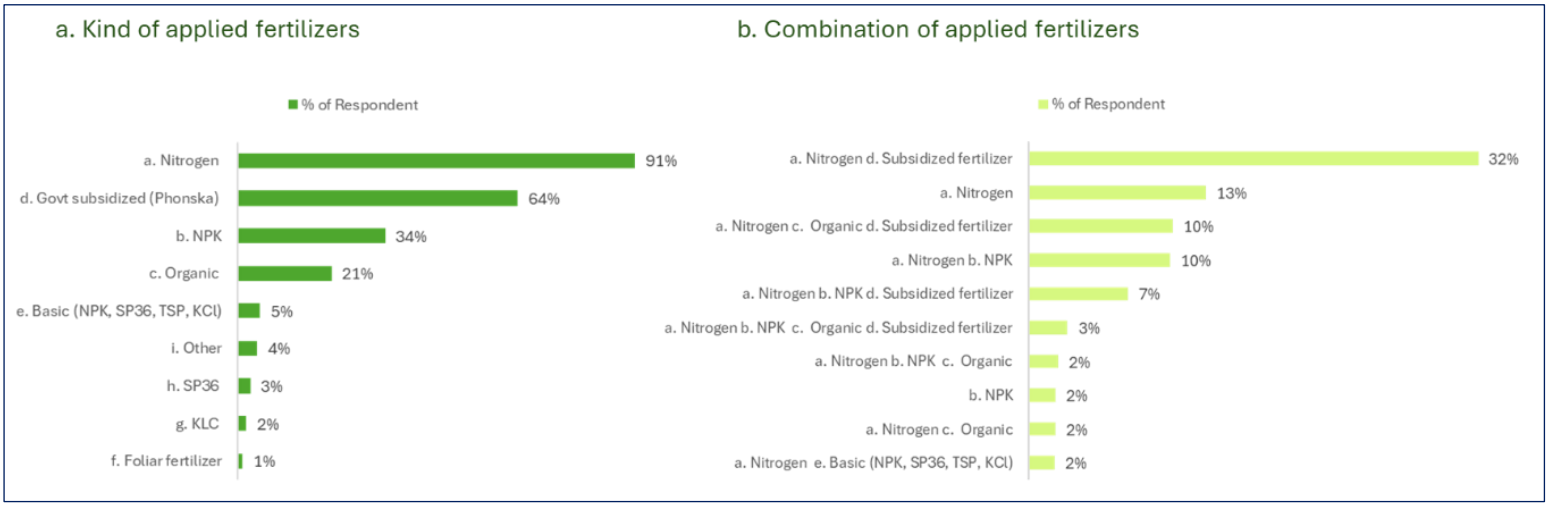
A combination of irrigated paddy fields shows a stronger correlation with higher yields. Comparing practices across provinces (Figure 13), West Java had the largest share of irrigated fields (88%), followed by Central Java (71%), East Java (47%), Banten (42%), and Yogyakarta (40%). By contrast, 54% of farmers in Yogyakarta relied primarily on rainfed practices, while 58% in Banten used a mix of irrigation and rainfed methods. In East Java, 19% of respondents depended on pumping water from nearby rivers, springs, or groundwater sources.

Paddy farmers in Java have relatively high access to government-subsidized fertilizers such as NPK-Phonska and nitrogen-based products. Subsidized nitrogen and NPK are typically priced at 70–80% of commercial market levels, with nitrogen (urea) being the most widely applied due to its low cost. However, the overuse of nitrogen raises significant concerns, including:

- Soil acidification and nutrient imbalance
- Excessive algae growth and oxygen depletion in water systems
- Increased emissions of nitrous oxide (N_2O), a potent greenhouse gas

Figure 5 shows that nitrogen fertilizer is the most widely applied, followed by NPK (both subsidized and non-subsidized). Only 21% of farmers reported using organic fertilizers, while fewer than 10% used other types (see Panel a). In terms of combinations, most farmers applied both nitrogen and NPK, raising concerns about the overuse of nitrogen, since it is present in both fertilizers.

Figure 5. Type of Fertilizers and Fertilizers' Combination

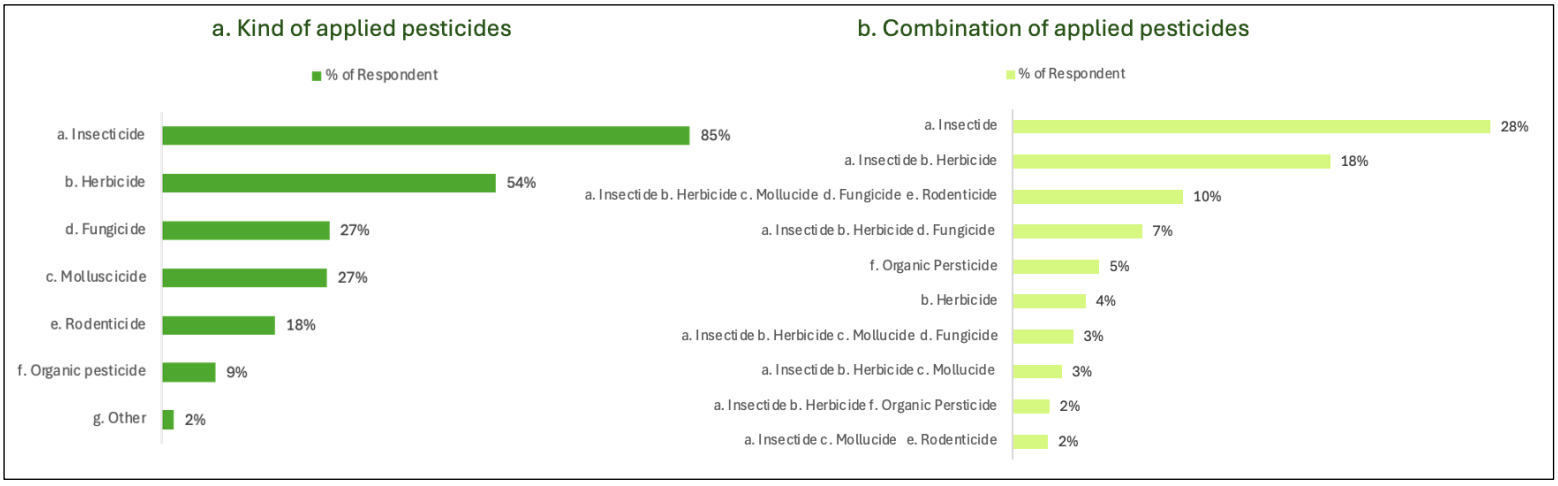


n = 3,030

Figure 6 shows that a large proportion of paddy farmers rely on insecticides to control pests such as planthoppers and stemborers, which threaten yields. However, excessive use can lead to pest resistance, reduce populations of beneficial insects, and further disrupt the ecosystem. Similarly, herbicide application contributes to ecological imbalance, promotes weed resistance, and risks contaminating groundwater and soils through runoff.

Only a small percentage of farmers reported using organic (natural) pesticides, and limited knowledge of biological control methods has reinforced the widespread reliance on insecticide–herbicide combinations. Furthermore, as shown in Figure 3, nearly 27% of farmers harvesting three times per year face rapid soil nutrient depletion, which in turn increases dependence on chemical fertilizers and pesticides.

Figure 6. Type of Pesticides and Top Combination of Applied Pesticides

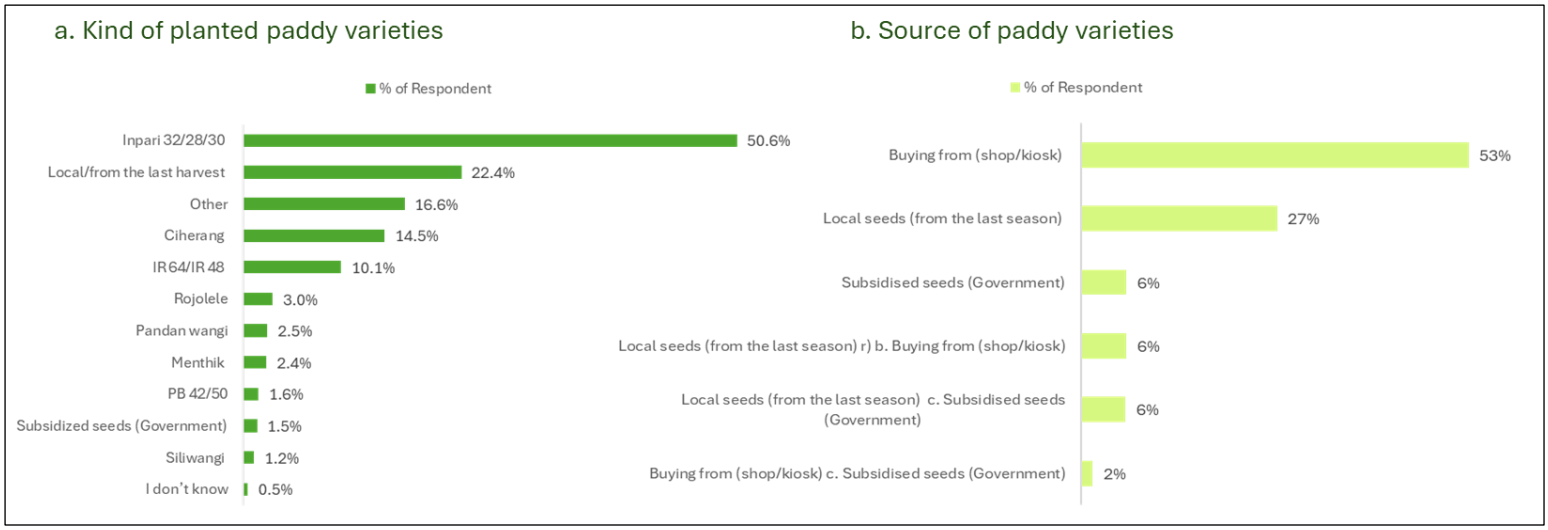


n = 3,030

Figure 7 shows that more than half of respondents purchased seeds from local input kiosks, while about one-quarter reused seeds from the previous harvest season. In terms of varieties, most farmers preferred inbred types (e.g., Inpari 32/28/30, Ciherang, IR64/68) over hybrids. Inbred varieties are less costly, as farmers can reuse harvested seeds for the next cycle, and they generally require fewer fertilizers, reducing dependence on commercial seed suppliers. However, while hybrid varieties offer

higher yields but are more vulnerable to pests, inbred varieties typically produce lower yields but have greater pest resistance.

Figure 7. Type of Varieties Seed and Combination of Source

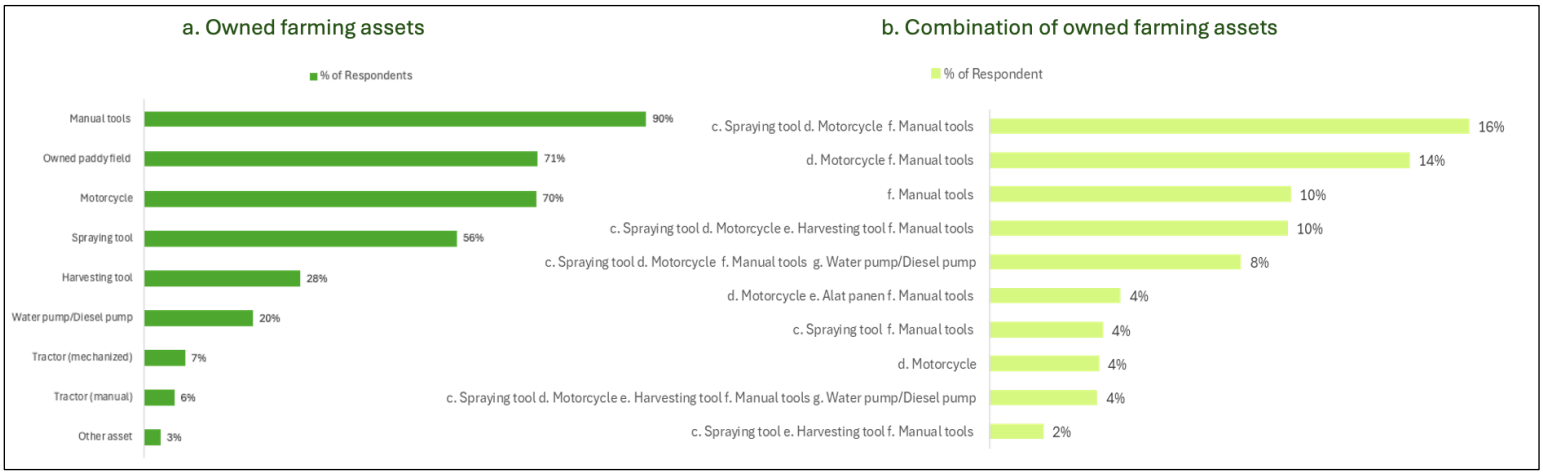


n = 3,030

c. Farm Productive Assets

As shown in Figure 8, the most common productive assets owned by farmers are manual tools, followed by paddy fields, motorcycles (often used to transport crops), and spraying pumps for applying liquid pesticides or fertilizers. Harvesting is still predominantly carried out with manual tools, while mechanical harvesters are typically rented rather than owned. Although electric waterjet pumps are relatively affordable, their use entails additional expenses for generators and electricity or fuel.

Figure 8. Type of Productive Assets and Farming Assets



n = 3,030

3.2.1 Farming Cost and Structure

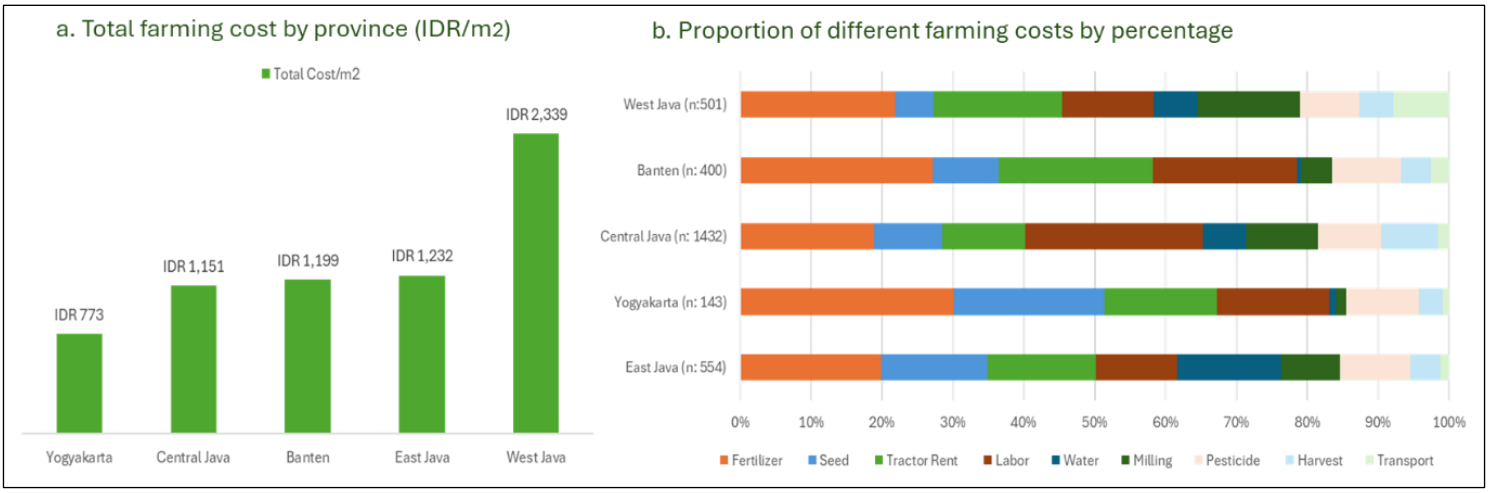
Key Findings: High Production Costs and Regional Disparity

- ***Inputs Dominate:*** *Fertilizers account for the largest cost component (approximately 25% of total spending), followed by labor and machinery rental.*
- ***Extreme Regional Gap:*** *Production costs are highly uneven, with West Java spending nearly three times more than Yogyakarta.*
- ***Water Scarcity Cost:*** *Over half of farmers in Central and East Java incur extra costs for water pumping, highlighting the financial burden of seasonal water deficits.*

Based on responses across five provinces, this section examines the cost structure of the most recent paddy farming season and highlights regional variations. As shown in Figure 9, there is a wide disparity in average production costs: farmers in Yogyakarta reported the lowest spending at IDR 773/m², while those in West Java spent nearly three times more at IDR 2,339/m². The other three provinces reported costs closer to the overall average of IDR 1,194/m².

Breaking down specific cost components (Figure 9b), the largest share was allocated to fertilizers (about one-quarter of total costs), followed by labor, tractor rental, seeds, and pesticides.

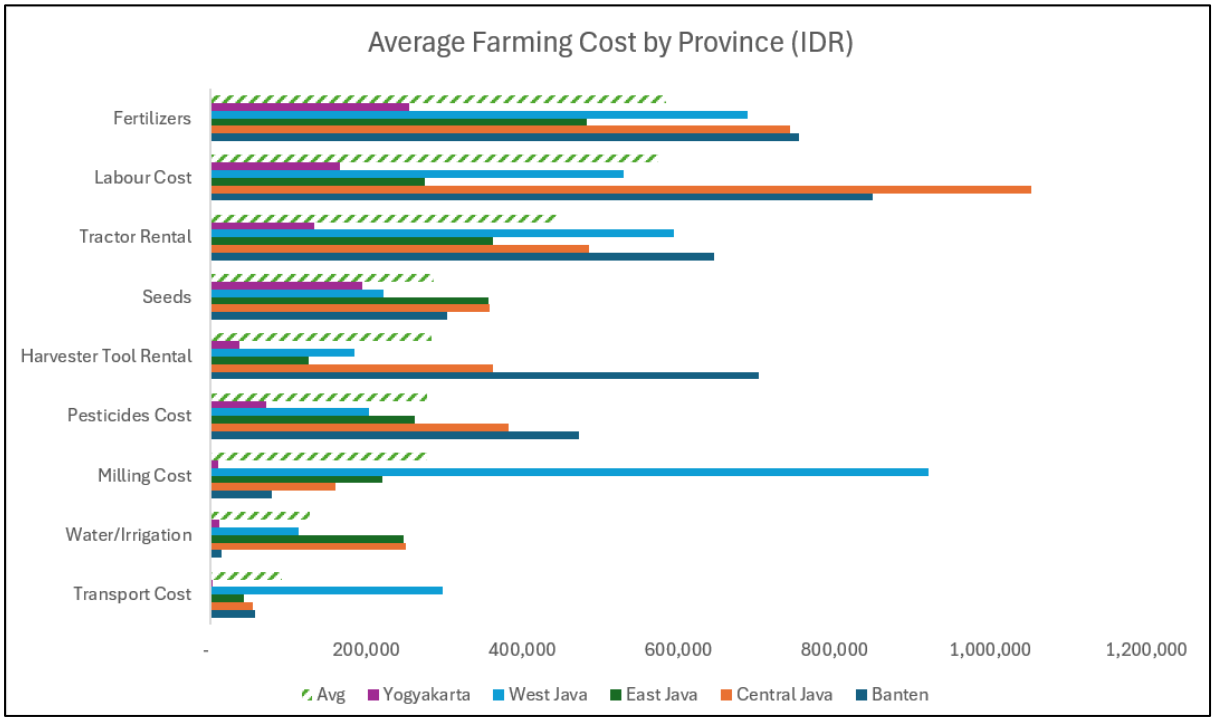
Figure 9. Farming Cost and Type of Cost by Province

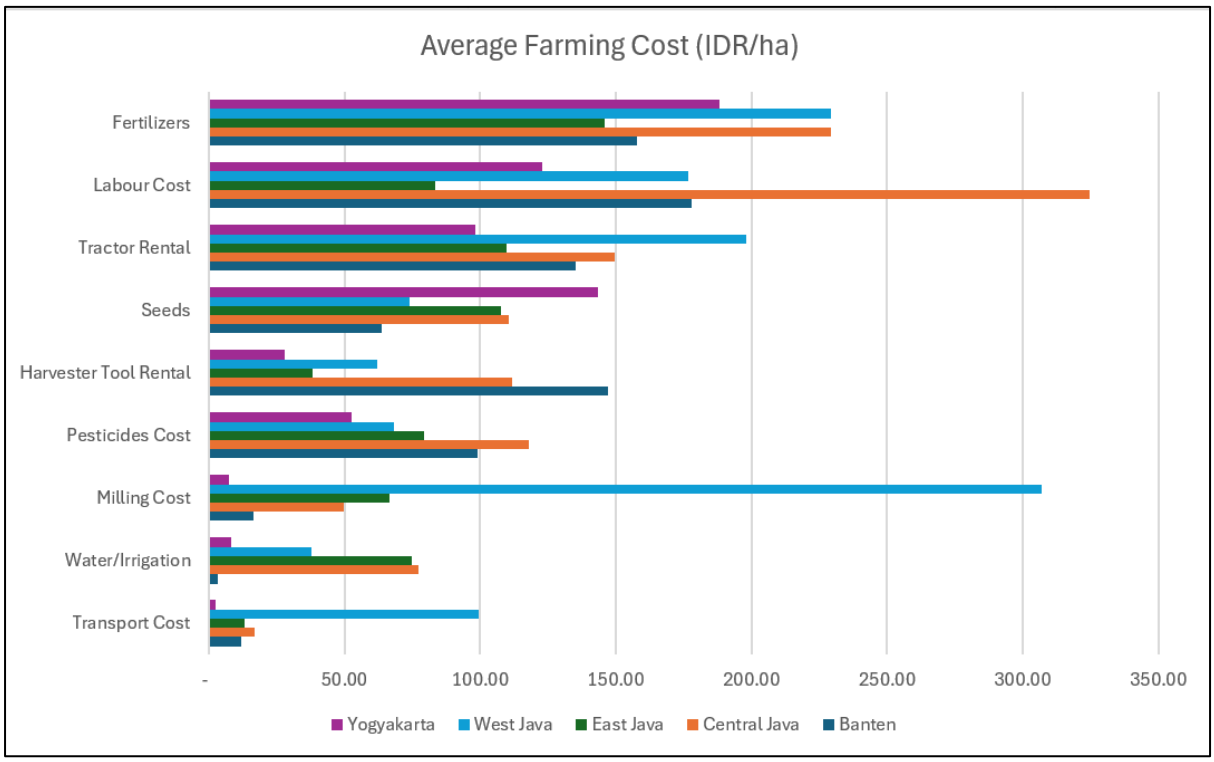


n = 3,030

As shown in Figure 10, all respondents across the five provinces reported paying for fertilizers, followed by high shares paying for seeds, pesticides, tractor rental, and labor. More than half of farmers in Central and East Java also incurred costs for water, largely due to additional pumping from rivers, groundwater, or springs. In West Java, over half of respondents reported expenses for milling and transport, while in Yogyakarta, only about 10% of farmers paid for water, milling, transport, or harvesting services.

Figure 10. Expenditure by Farming Inputs and Services (%)





n = 3,030

3.2.2 Harvest and Yield

Key Findings: Yield, Regional Profit, and Climate Vulnerability

- ***Yield-Land Size Trade-Off:*** *While larger farms achieve higher total harvest volumes, the highest yield per unit area (kg/m²) is achieved by the smallest farmers (plots < 1,000 m²). This suggests that smallholders compensate for lack of scale with more intensive, hands-on management.*
- ***Irrigation plays a crucial role on Higher Yield:*** *Irrigated practices show a strong positive correlation with higher yields in the regression analysis, confirming irrigation as the primary driver of productivity. Conversely, reliance solely on rainfed or pumping methods shows a weaker yield outcome.*
- *West Java recorded the highest costs and the highest yields, indicating that* ***intensive input use (fertilizers/labor) is successfully translating into higher productivity****, though not necessarily the highest profit due to high costs.*
- ***Profit Driven by Cost Control and Size:*** *Regional profit analysis shows that cost control is critical: East Java achieved the highest gross profit (IDR 9.47 million) with lower costs and medium yield, while the low-cost, high-yield structure of Yogyakarta still resulted in the lowest total profit due to its smallest average farm size.*
- ***Catastrophic Climate Impact:*** *Farmers who experienced harvest failure in 2024 saw their gross profits plummet by over 70% compared to those who did not fail (IDR 2.25 million vs. IDR 7.71 million). This highlights the severe and immediate financial devastation caused by climate variability (e.g., El Niño effects).*
- ***Compounding Vulnerability:*** *Farmers relying on only one annual harvest suffered disproportionately large losses (56% loss of total harvest) when failure occurred.*

As shown in Figure 11, larger field sizes were generally associated with higher total harvest volumes. For plots smaller than 1,000 m², the average harvest from the last season was 283 kg of rice, with 75% of the 617 respondents reporting a successful harvest and the remainder experiencing crop failure. Average harvests increased steadily with plot size as shown in Table 3.

Table 3: Plot Size and Average Harvest

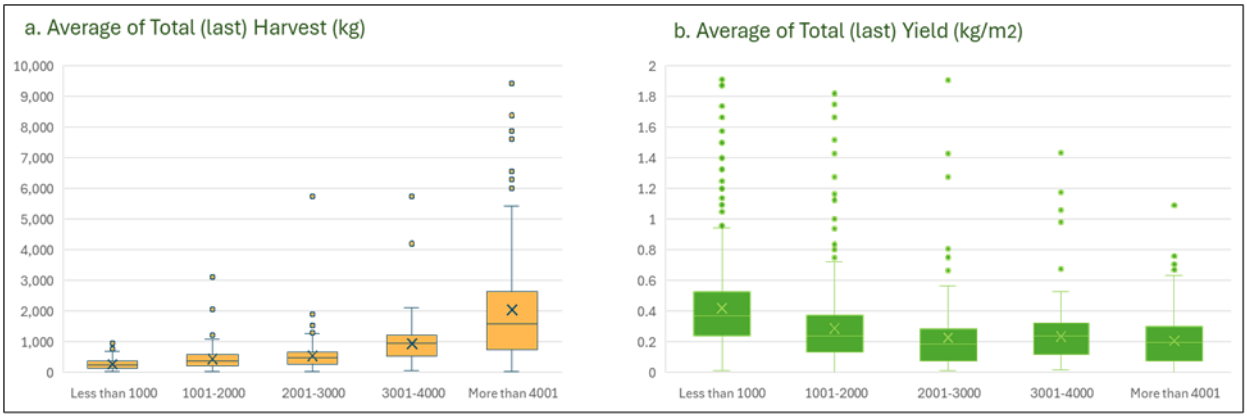
Plot Size	Average harvest increase
1,001-2000 m²	449 kg
2,001-3,000 m²	591 kg
3,001-4,000 m²	858 kg
>4,000 m²	1,812 kg

Crop failure rates declined with larger field sizes, suggesting that larger farms are less prone to total loss and able to produce greater harvest volumes.

However, yield per unit area (kg/m²) tells a different story. Farmers with plots smaller than 1,000 m² achieved the highest yield (0.42 kg/m²), while those with plots larger than 4,001 m² recorded the lowest (0.20 kg/m²). This pattern may reflect the ability of

smallholders to manage soil quality more intensively, as their higher vulnerability to harvest failure motivates closer field management.

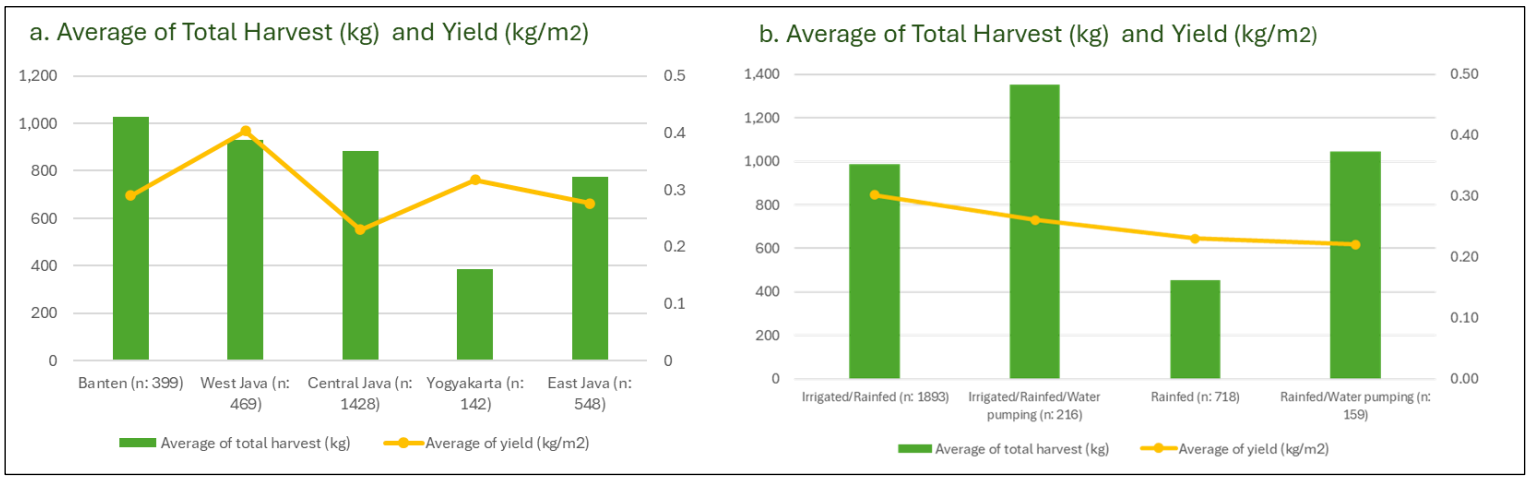
Figure 11. Total Harvest and Yield, by Farm Size



n = 2,986

Building on the farming cost analysis from the last season, respondents in West Java reported the highest paddy farming costs but also achieved the highest average harvest (994 kg) and yield (0.64 kg/m²) per respondent, followed by farmers in Banten and Central Java (see Figure 12a). By contrast, Yogyakarta had the lowest farming costs and total harvest, yet its yield (0.31 kg/m²) was higher than in Banten, East Java, and Central Java.

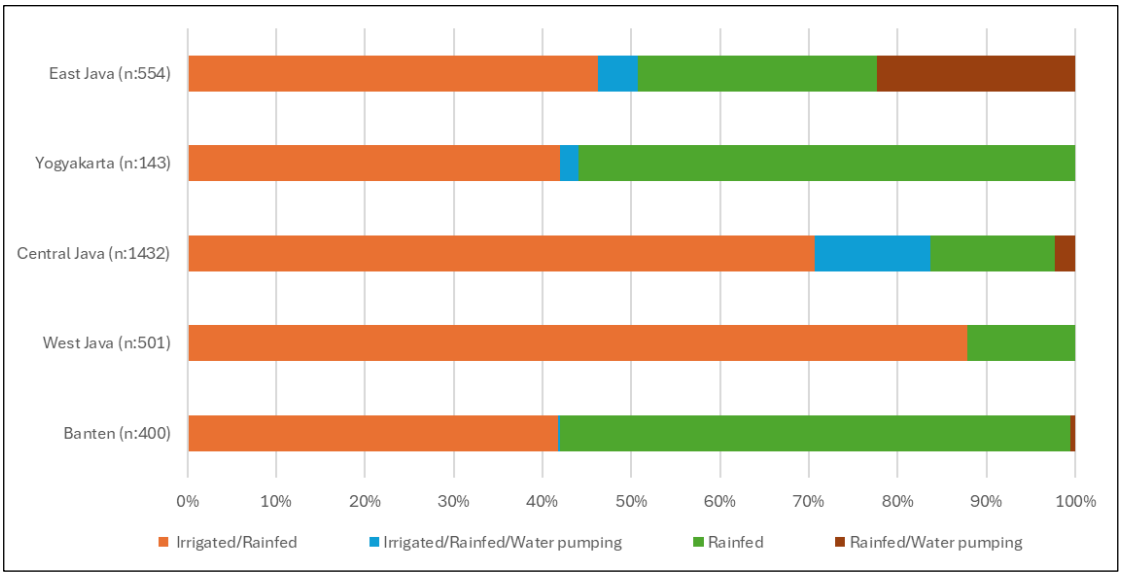
Figure 12. Average of Total Harvest and Yield by Location and by Practice



n = 2,986

Looking more closely at the factors influencing yield, Figure 12b shows that farmers using irrigated practices achieved higher yields than those relying primarily on rainfed systems or pumped water (from rivers, groundwater, or springs). While rainfed farmers recorded a relatively high yield (0.23 kg/m²), their total harvest per respondent was smaller (426 kg) due to limited farm sizes.

Figure 13. Distribution of Different Farming Practices by Province



n = 3,030

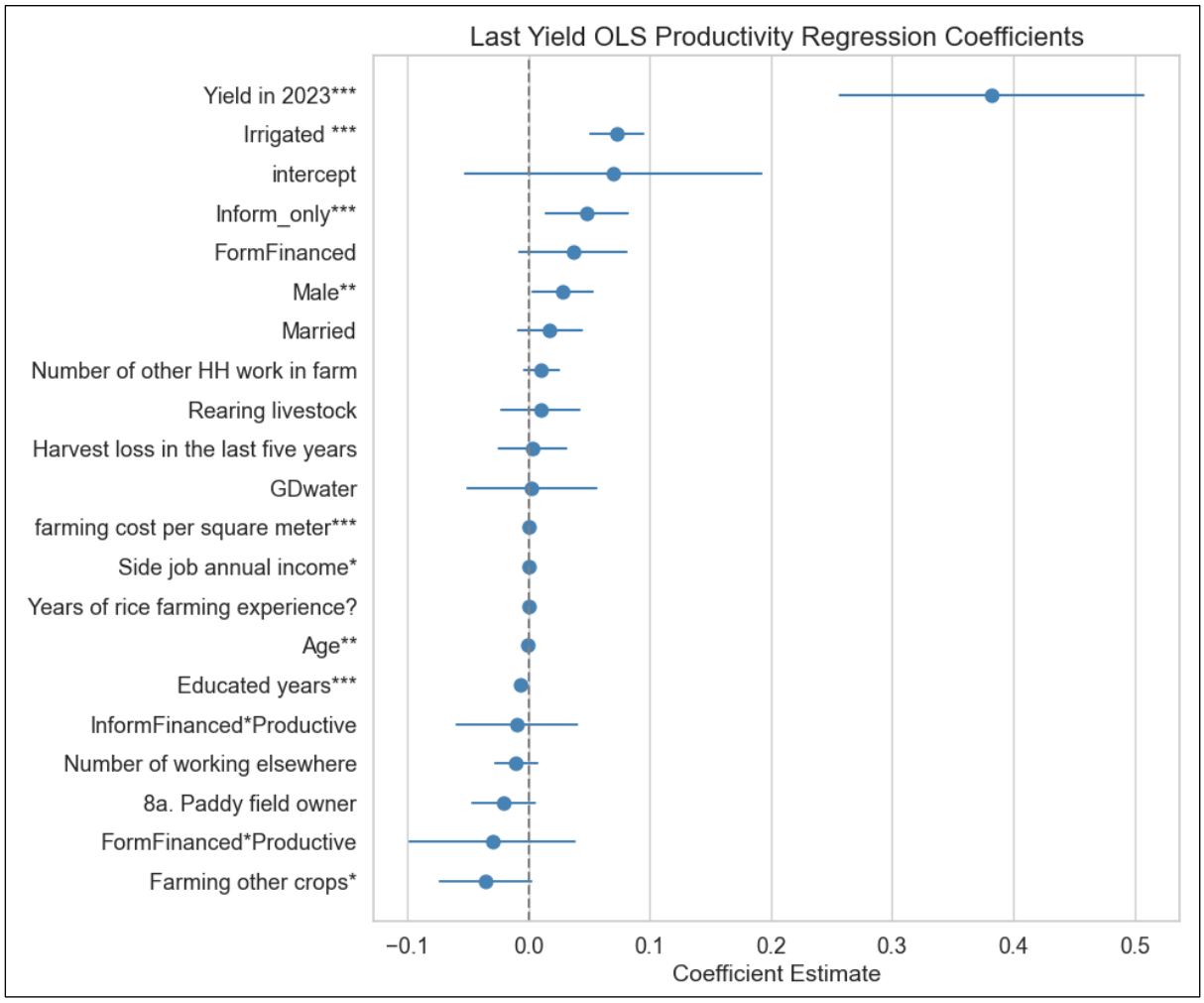
a. OLS Regression Analysis

Given the complexity of rural supply chains and smallholder farming systems, Ordinary Least Squares (OLS) regression was employed to examine linear relationships between the dependent variable, harvest yield (kg/m²) from the last growing season, and a set of independent variables. These included farming practices (e.g., irrigation and water pumping), operational costs, alternative income sources (side jobs, livestock, or other crops), financing access, and demographic attributes (e.g., gender, marital status, years of education, and farming experience).

The regression results (Figure 14) show a significant positive correlation between last season's yield and the 2023 yield (coefficient = 0.38), suggesting that farmers with higher yields in 2023 also tended to report higher yields in the most recent season. Several other variables displayed statistically significant but relatively weak correlations (coefficients < 0.1), likely due to high variability in the dataset.

Specifically, last season's yield was positively correlated with irrigated farming practices, access to informal and formal financing, farming costs, side jobs, and being male. Conversely, negative but weak correlations were observed with farmer age (indicating that younger farmers tend to achieve higher yields), years of formal education, and engagement in other crop farming.

Figure 14. Regression Analysis of Last Yield (kg/m²) by Key Independent Variables



n = 3,030

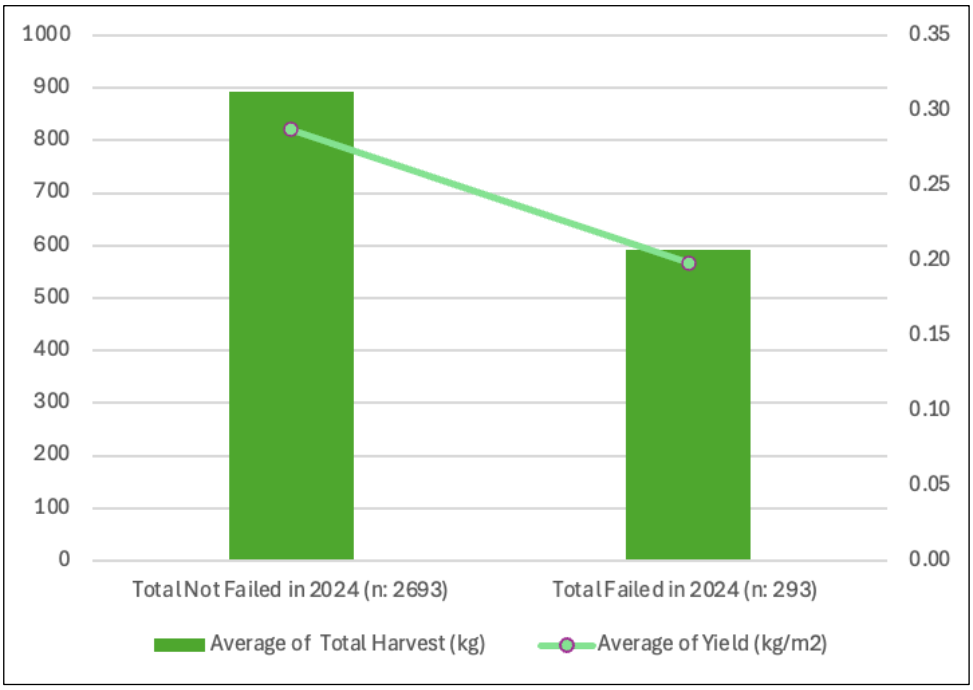
b. Harvest Failure

During the group discussions, respondents highlighted experiences of harvest failure that significantly reduced yields. The El Niño events of 2023 and early 2024 were particularly damaging, bringing prolonged dry conditions that affected paddy farming, which is highly water-dependent during the early growth stage.

When asked about harvest failures over the past five years, more than half of respondents (1,536) reported having such experiences, including 441 in 2023 and 293 in 2024. As shown in Figure 15, farmers who experienced failure in 2024 recorded about 30% lower total harvest (kg) and yield (kg/m²) compared to others.

To cope, many farmers resorted to pumping water from groundwater or nearby rivers and springs, but this strategy increased costs due to fuel or electricity needs and the frequent rental of pumping equipment.

Figure 15. Average Yield by Harvest Failure Experience and Farming Practices



The analysis excluded 44 outliers, respondents whose last harvest yield was greater than or equal to 2.1 kg/m^2

c. Last Harvest Profit

Following the predicted El Niño in late 2023 and early 2024, harvest failures led to reduced production (supply) and rising rice prices across the five provinces in Java. These failures affected both the total harvest and yield, which in turn had a significant impact on paddy farm profitability (see Table 4).

In addition to harvest failures, paddy farming profits were also influenced by production costs, though not always in a linear way. For instance, West Java achieved the highest yield (0.40 kg/m²) but also had the highest costs (IDR 2,089/m²), resulting in a gross profit of IDR 8.60 million, slightly lower than in East Java. In contrast, East Java, with lower costs (IDR 1,175/m²) and a medium yield (0.28 kg/m²), recorded the highest gross profit (IDR 9.47 million). Meanwhile, Yogyakarta, despite its lowest costs (IDR 733/m²) and relatively higher yield (0.32 kg/m²), generated the lowest profit (around IDR 4 million). This outcome reflects smaller farm sizes in Yogyakarta (average 1,501 m², see Figure 2), compared to larger plots exceeding 3,000 m² in other provinces.

When comparing practices, irrigated paddy fields generally achieved higher yields, as they could be harvested two to three times per year, whereas rainfed fields recorded lower yields, even when supplemented with water pumping. While more frequent harvests increase yields, they also depend on costs and total farm size. Farmers also raised concerns that intensive harvesting exhausts soil fertility, leaving insufficient time for natural recovery between cycles. Typically, fields are left fallow for a few weeks to a month to replenish nutrients before the next planting season.

Table 4. Yield, Farm Costs, and Revenue from the Last Harvest

Factor	Number of Respondents	Yield (kg/m²)	Farm Cost (IDR/m²)	Gross Profit (IDR/m²)*	Total Gross Profit (IDR)**
by Province					
West Java	469	0.4	2,089	3,279	8,596,173
Yogyakarta	142	0.32	733	3,262	3,973,837
Banten	399	0.29	1,153	2,603	9,468,730
East Java	548	0.28	1,175	1,701	5,675,536
Central Java	1,428	0.23	1,133	1,660	6,968,011
by Harvest Failure Experience in 2024					
Not Failed	2,693	0.29	1,284	2,280	7,714,567
Failed in 2024	293	0.2	1,186	687	2,249,482
by Farming Practices					
Irrigated/Rainfed	1,893	0.3	1,344	2,522	8,786,640
Irrigated/Rainfed/Water pumping	216	0.26	1,334	1,158	8,539,987
Rainfed	718	0.23	1,052	1,946	3,760,111
Rainfed/Water pumping	159	0.22	1,369	- 505	1,615,850
by Annual Times of Harvest					
Once	444	0.19	1,032	2,698	7,946,079
Twice	1,746	0.28	1,281	3,834	12,753,992
Thrice	796	0.32	1,395	4,365	11,927,920

* Gross profit (IDR/m²) is measured by [(total harvest (kg) X average rice price of five provinces per kg (IDR 13.,840) in 2024 minus total last harvest cost (IDR)]/Total farm size (m²)]
**Gross Profit was measured by [(total last harvest (kg) X average rice price of five provinces per kg (IDR. 13,840/kg) minus total last harvest cost (IDR)]

3.2.3 Off-Takers

Key Findings:

- *The supply chain is dominated by middlemen who offer essential non-market services (e.g., loans and harvesting assistance), creating farmer dependency.*
- *Government policy prioritizing low-cost chemical inputs risks fostering reliance on state support over long-term, sustainable private investment.*

Rice supply chains in Java remain largely traditional and extended, with limited post-harvest practices such as simple sun-drying. As shown in Table 5, most respondent farmers sell their wet or dried paddy to middlemen or crop traders, rather than to cooperatives or retailers through organized channels. Middlemen and traders are more popular because they offer services beyond basic market exchange, including loan provision, harvesting assistance, and post-harvest handling to increase the value of paddy sold. For other off-takers, farmers often knew only the buyer's name, though the services provided were generally similar to those of middlemen.

Table 5. Rice Off-takers and Service Distribution

Off-Taker	Trading Various Crops	Collecting/ Sorting/ Buying	Informal Loan Service	Supplying Agri-Input	Assist Harvesting	Drying/ Milling	Warehouse Service	Facilitate Training/ Extension	Marketing Support (re.organic, etc)
a. Middleman	448	1,764	22	2	11	193	5	-	27
b. Agricultural crop trader	470	232	7	-	8	75	7	-	-
c. Kios/Warung sembako	38	10	1	-	1	-	2	-	-
d. Farmer Group	1	1	2	1	-	1	1	-	-
e. Cooperative/KUD	9	5	1	-	1	2	9	-	-
g. Paddy mills	12	8	-	-	-	16	2	-	-
h. Others	16	177	-	-	5	6	4	1	7

> 1,500
1,500 - 500
499 - 250
249 - 100
99 - 50
49 - 1

n = 3,030

The nine services identified reveal a greater focus on post-harvest services, such as harvesting, milling, and warehousing, compared to the relatively limited supply of agri-input services provided by off-takers. One explanation is the availability of subsidized agri-inputs (particularly inorganic fertilizers), which are distributed through farmer groups and registered cooperatives. However, these quotas are typically small, while non-subsidized fertilizers remain prohibitively expensive for smallholder farmers.

Current government strategies emphasize low-cost chemical inputs and capital-intensive mechanization to achieve short-term objectives, such as securing national rice production quotas and stabilizing market prices. This has fostered dependence on government support, rather than encouraging private or collective investment needed for the long-term sustainability of rice production and its supporting ecosystems.

3.3 Income and Asset

3.3.1 Household Income Structure

Key Findings: Income Diversification and Financial Resilience

- *The profitability of rice farming alone is highly vulnerable: crop failure led to a 76% loss in gross profit, forcing farmers to diversify. Consequently, only 13% of households rely solely on rice, as households with multiple income sources are demonstrably better off financially.*
- ***Non-Farming Income - The Primary Anchor:** More than half of all respondents (51%) rely on non-farming income (e.g., daily labor, services, remittances) to stabilize their finances. For most households, non-farming earnings, combined with other agricultural services, constitute the largest share of total annual income, enabling many to surpass the provincial minimum wage.*
- ***Households with four- or five-income sources** are the most financially secure overall. This diversification stabilizes total annual earnings, insulating households from climate change shocks like El Niño-driven harvest failures.*

Rice farmers' household incomes are generally diverse and complex, reflecting their awareness, shaped by lived experience, of the vulnerability inherent in agriculture-based livelihoods. As a result, they rarely depend on a single income source. By examining 2023 rice production alongside other farming and non-farming activities, we can identify both the variation in income sources and their distribution across households.

a. 2023 Rice Income

Because rice is a staple food in Indonesia, paddy cultivation often serves as a subsistence strategy for rural households, with fields typically inherited across generations. For most respondents, rice farming primarily supports daily household consumption, with any surplus sold in the market.

Gross profit from the 2023 harvest was estimated by multiplying the total harvest (kg) by the average rice price, then subtracting the annualised farming cost (calculated as the cost of the last growing season in 2024 multiplied by the number of annual harvests). To ensure accuracy, yield outliers, defined as annual yields exceeding 2.01 kg/m² (total farm production ÷ total farm size), were excluded. This adjustment removed 52 respondents from the analysis presented in the Table 6 below.

Table 6. Average Annual Yield, Farming Costs, and Gross Profit, 2023

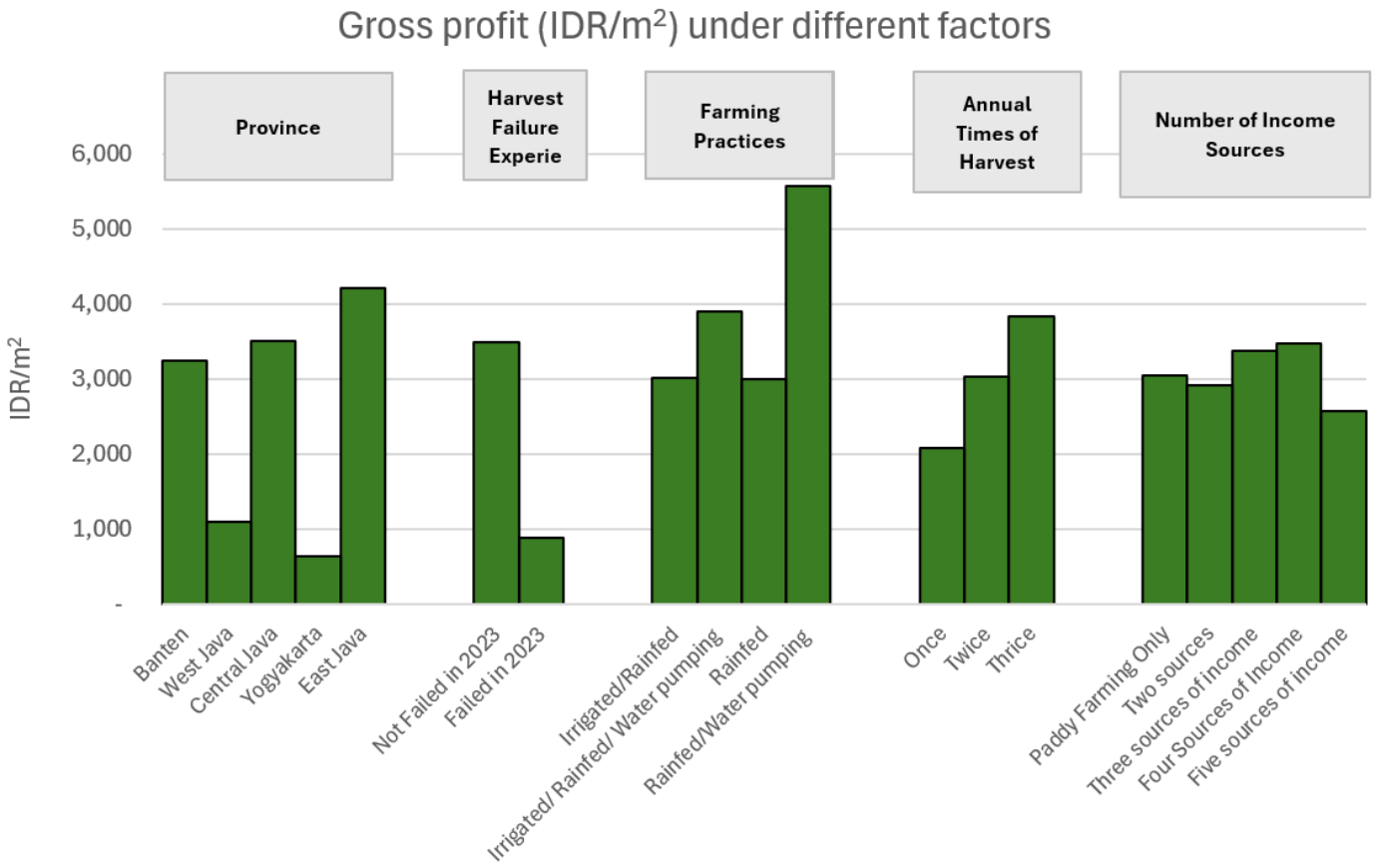
Factors	Number of Respondents	Farm Size (m^2)	Yield 2023 (kg/m^2)*	Harvest 2023 (kg)	Annual Cost (IDR/m^2)**	Gross Profit (IDR)***	Gross profit (IDR/m^2)
by Province							
Banten	399	4,932	0.57	1,871	2,307	16,043,502	3,253
West Java	473	3,147	0.41	991	5,057	3,486,636	1,108
Central Java	1,420	3,703	0.5	1,736	2,481	13,018,424	3,516
Yogyakarta	142	1,443	0.19	229	1,600	926,048	642
East Java	544	3,373	0.63	1,609	2,261	14,238,177	4,221
by Harvest Failure Experience in 2023							
Not Failed in 2023	2,540	3,652	0.52	1,639	2,685	12,754,933	3,493
Failed in 2023	438	3,373	0.34	891	3,363	3,022,095	896
by Farming Practices							
Irrigated/Rainfed	1,888	4,010	0.53	1,684	3,216	12,129,509	3,025
Irrigated/ Rainfed/ Water pumping	215	4,097	0.36	2,107	2,208	15,977,918	3,900
Rainfed	716	2,742	0.46	994	2,076	8,237,115	3,004
Rainfed/Water pumping	159	2,137	0.33	1,567	1,633	11,905,534	5,571
by Annual Times of Harvest							
Once	442	3,298	0.26	728	1,002	6,893,744	2,090
Twice	1,743	3,795	0.47	1,523	2,583	11,488,012	3,027
Thrice	793	3,382	0.66	1,880	4,223	12,971,082	3,835
by Number of Income Source							
Paddy Farming Only	387	5,374	0.54	2,253	3,302	16,374,886	3,047
Two sources of Income	985	4,112	0.49	1,676	3,225	11,988,704	2,916
Three sources of Income	901	2,863	0.54	1,299	2,841	9,662,168	3,375
Four Sources of Income	558	3,019	0.45	1,275	1,964	10,475,144	3,470
Five sources of income	147	2,457	0.25	754	1,250	6,327,251	2,575

* Yield is measured by 2023 total production (kg)/total farm size (m^2).
** Estimated Annual cost refers to the (last cost growing season in 2024 X times of harvested)/total farm size (m^2).
*** Gross Profit was measured by the 2023 total harvest X average price of medium quality rice/kg (IDR 12,541) - estimated annual paddy production cost (IDR).

Respondents from Yogyakarta recorded the lowest annual yield among provinces, resulting in the lowest annual income (IDR 926,048) and lowest yield (0.19 kg/m^2). Farmers in West Java followed, with relatively modest profits (IDR 3,486,636), partly due to the highest farming costs (IDR 5,057/m^2). By contrast, respondents in Banten, who

managed the largest average farm size (4,932 m²), achieved the highest profits (IDR 16,043,502) with a relatively high yield (0.57 kg/m²). Farmers in Central Java and East Java earned significantly less, around 18% and 10% lower, respectively, than their counterparts in Banten.

Figure 16: Gross Profit under Different Factors



Harvest failure in 2023 had a severe impact: affected respondents lost 76% of gross profit and 46% of yield compared to those who avoided crop failure.

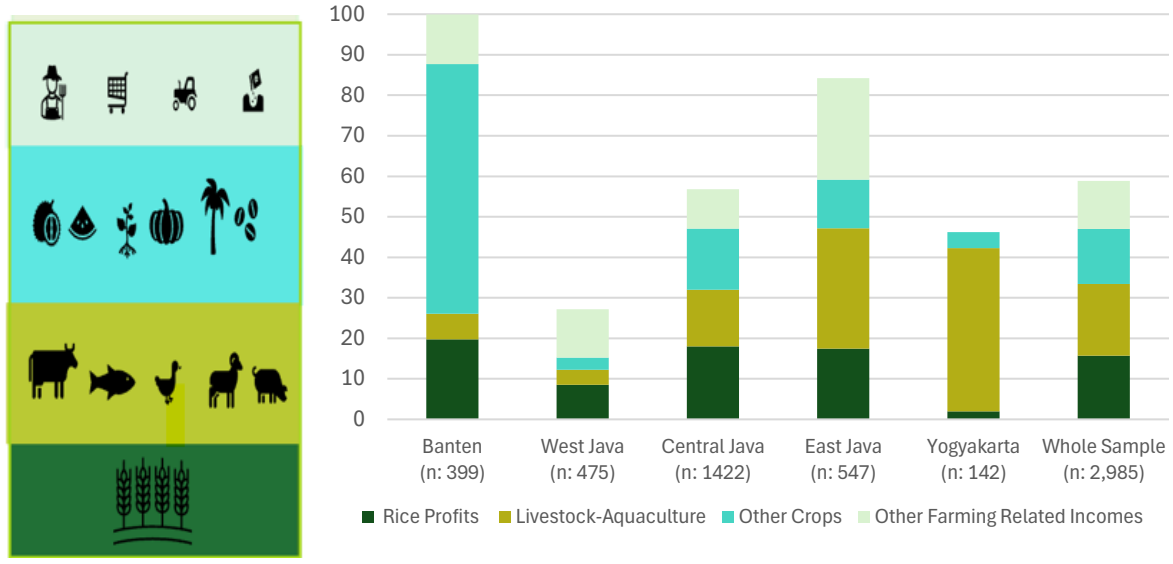
Examining farming practices, irrigated paddy fields generated higher annual net revenues than non-irrigated fields. This aligns with harvest frequency, as farmers harvesting more than twice per year tended to earn higher revenues. Income patterns also varied by livelihood strategies: farmers who relied exclusively on paddy farming managed the largest plots and generated the highest rice revenues, while those with two income sources showed similar tendencies. By contrast, farmers with as many as five income sources often reported lower rice revenues, reflecting a need to diversify in order to compensate for smaller farm-based earnings.

b. 2023 Household Income

Building on these results, as shown in Table 7, only 409 out of 3030 (13%) of respondents depended solely on paddy field profits. The majority (87%) diversified into multiple income streams, spanning both farming and non-farming activities. Farming-related income could be grouped into three main categories:

- income from raising animals (livestock, poultry, fishing and aquaculture)
- growing other crops (grains, horticulture, fruits, and cash crops)
- other farming services (farming labour, trading, and renting tools/machines).

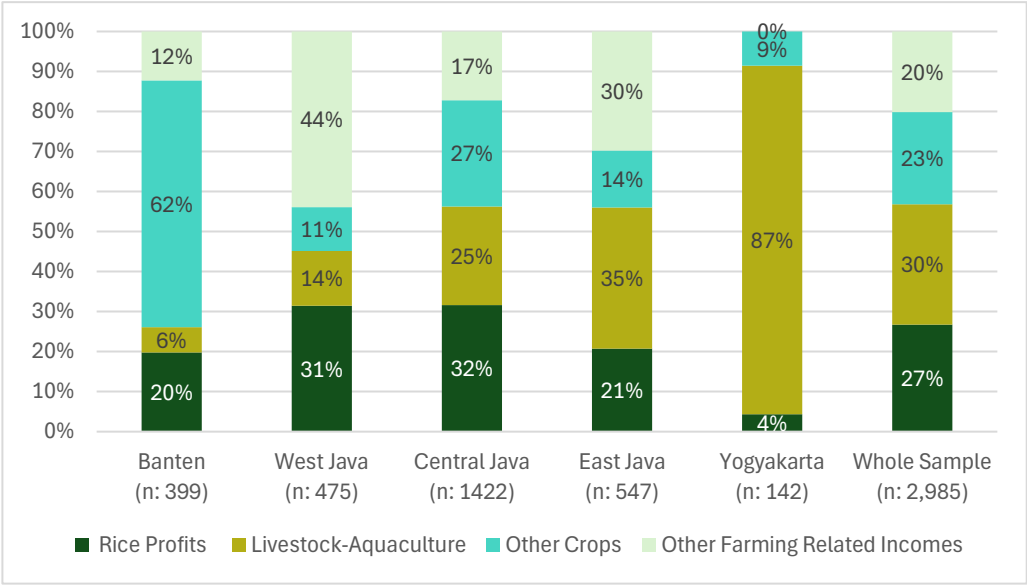
Figure 17. Average Farming-Related Household Income by Source (IDR million)



n = 2,985[5]

As illustrated in Figure 17, respondents from Banten reported the highest average household income (around IDR 100 million), driven largely by income from other crops. This is followed by East Java, with an average income of IDR 84 million. Figure 18 presents the distribution of household income across the five provinces. Across the full sample, rice contributed 27 percent of household income, slightly below livestock, which accounted for 30 percent. Rice formed a relatively large share of income in Central Java and West Java (32 percent and 31 percent, respectively), whereas in Yogyakarta it represented only 4 percent, with the majority of income (87 percent) coming from livestock such as cattle and poultry. Respondents in Central Java reported a more balanced distribution of income across rice, livestock, other crops, and other farming-related sources. In Banten, income from other crops constituted the largest share, although this was concentrated among only five respondents.

Figure 18. Household Income Distribution (%)

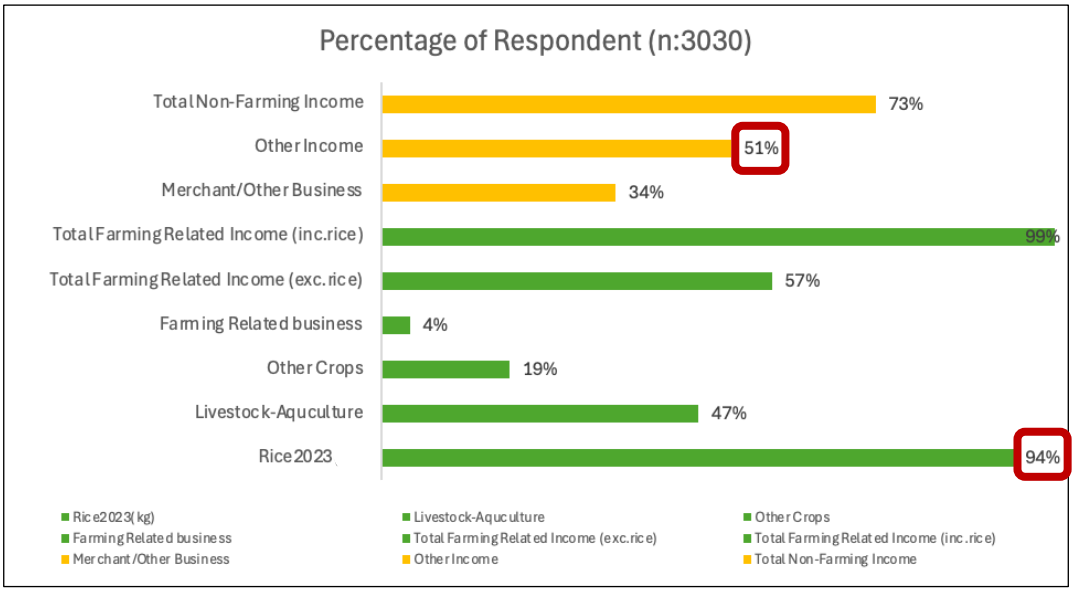


[5] 45 outlier respondents with more than 2.1 yield (kg/m^2) were excluding from the total 3030 datasets.

Figure 19 presents the share of respondents generating income from different sources. Based on the amount of income earned, 94% of farmers derived income from rice, while the remaining 6% either did not harvest in 2023 or could not recall their harvest volume. Nearly half of respondents earned additional income from livestock and aquaculture, followed by other crops and farming-related businesses (e.g., renting land or tractors, trading rice or other crops). Moreover, 51% of respondents reported earnings from non-farming activities, including daily labour (e.g., construction and other manual work), remittances, pensions, online driving, and other services.

This composition underscores that rice income alone is insufficient to sustain household livelihoods, pushing many rice farmers to diversify into multiple income streams.

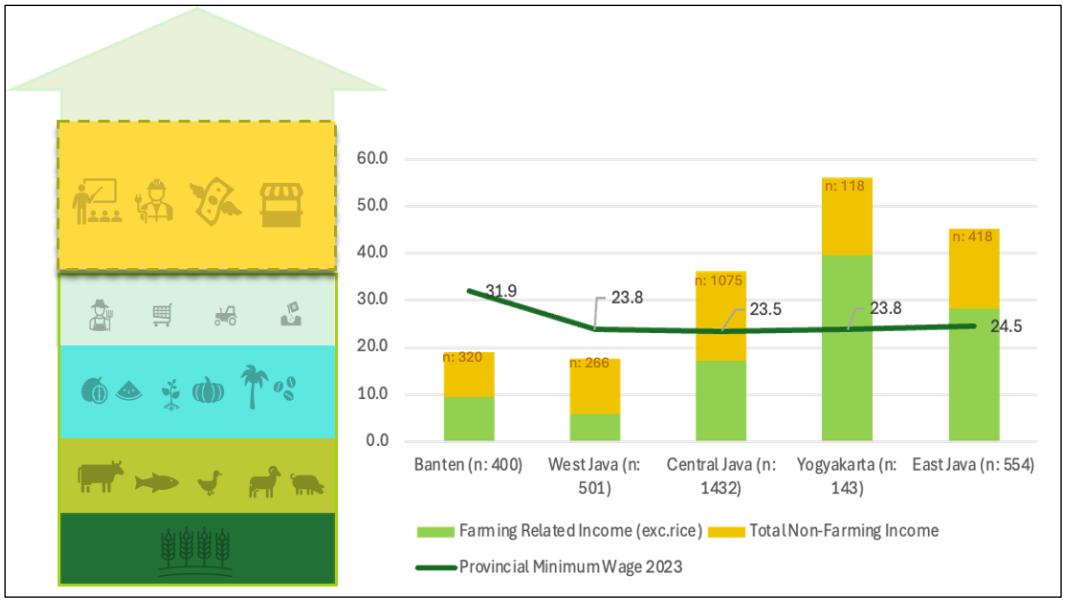
Figure 19. Respondents by Alternative Income Sources (%)



Including non-farming income in household annual earnings (see Figure 20) shows that most respondents relied more heavily on non-farming activities than on farming. The exception was in West Java, where households earned a slightly larger share from farming-related work; however, their total annual income still fell slightly below the provincial minimum wage.

By contrast, respondents in East Java, Central Java, and Yogyakarta earned above the provincial minimum wage, largely due to non-farming contributions. Non-farming income was reported by more than 75% of respondents in Banten, Central Java, East Java, and Yogyakarta, while only 53% of respondents in West Java reported such earnings.

Figure 20. Average Household Income vs. Provincial Minimum Wage (IDR Million)[6]



n = 3,030

Linking rice income with other income sources by farming practice (Table 7) shows that farmers using combined irrigated systems earned higher annual rice incomes (IDR 21.4 million and IDR 17.5 million) compared to those relying solely on rainfed systems. Respondents who combined irrigation with water pumping also reported higher rice incomes, supplemented by earnings from other farming activities and non-farming sources.

Looking at the number of income sources, respondents who relied on a single source earned the highest paddy income, largely due to their relatively larger farm sizes. They were followed by respondents with two income sources, while those with more than five sources earned the smallest paddy income. This suggests that once rice farming is no longer profitable, farmers diversify into alternative livelihoods to secure household income. Overall, when combining farm and non-farm earnings, households with multiple income streams, particularly those with four or five sources, were financially better off than single-income households.

[6] Reference of minimum wages by province in 2023, Ministry of Labor https://satudata.kemnaker.go.id/infografik/52

Table 7. Average Household Income by Farming Practices & Sources (IDR million)

Factor	Number of Respondents	Farm Size (m^2)	Rice	Livestock	Other Crops	Agri Service	Other Income	Total Farming (exc.rice)	Total Non-Farming
by Farming Practices									
Irrigated/ Rainfed	1,935	3,926	17.5	14.8	8.9	14.2	13.9	15.2	16.6
Irrigated/Rainfed/ Water pumping	216	4,078	21.4	19.0	24.0	15.6	19.7	28.7	28.8
Rainfed	720	2,734	10.5	21.8	14.5	6.4	9.0	25.6	10.5
Rainfed/ Water pumping	159	2,137	15.0	26.6	4.0	18.7	11.5	18.0	22.2
by number of Income Source									
Paddy Farming Only	409	5,108	22.8						
Two sources of income	1,001	4,059	17.3	16.4	15.8	13.5	11.0	16.0	10.4
Three sources of income	910	2,842	13.7	12.6	19.8	10.1	13.5	14.9	16.0
Four Sources of Income	563	2,997	13.4	23.3	13.9	7.5	14.5	24.7	21.8
Five sources of income	147	2,457	7.5	23.4	6.6	22.1	13.7	31.6	23.9

3.3.2 Household Asset Structure

Key Findings:

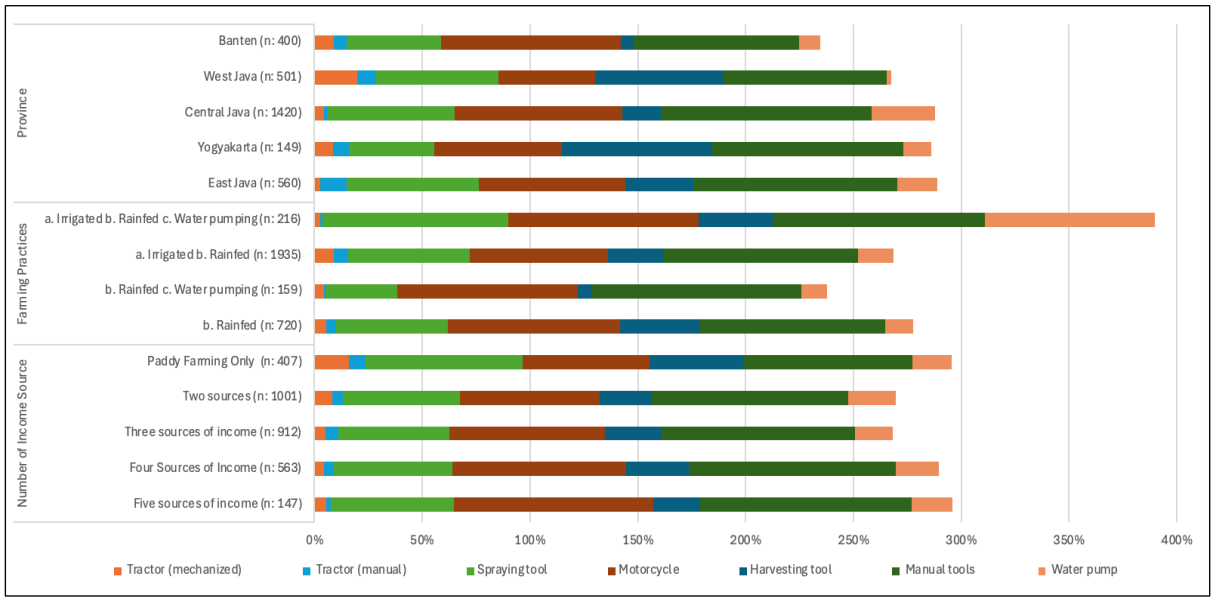
- *Farmers build financial resilience and wealth primarily through non-farming income streams, as demonstrated by the significantly higher total assets held by households that diversify.*
- *Investment in productive farm assets remains low and manual-tool focused; liquid savings are only mobilized for critical security investments, such as water pumping systems.*

Assets in agricultural households are typically divided into farming and non-farming categories. Farming assets are critical for production, while non-farming assets help sustain resilience against external shocks through supplementary investment or income. Farming assets include paddy fields, crops, livestock, farming tools, and access to water (often free for paddy farmers). Non-farming assets include cash, savings, vehicles, and housing.

a. Productive Farm Assets

As shown in Figure 21, a large share of respondents invested in manual tools for cultivation, followed by motorcycles, commonly used to transport harvests, and spraying equipment for applying pesticides or liquid fertilizers. These assets play an important role in sustaining farming productivity.

Figure 21. Ownership of Productive Farm Assets (%)



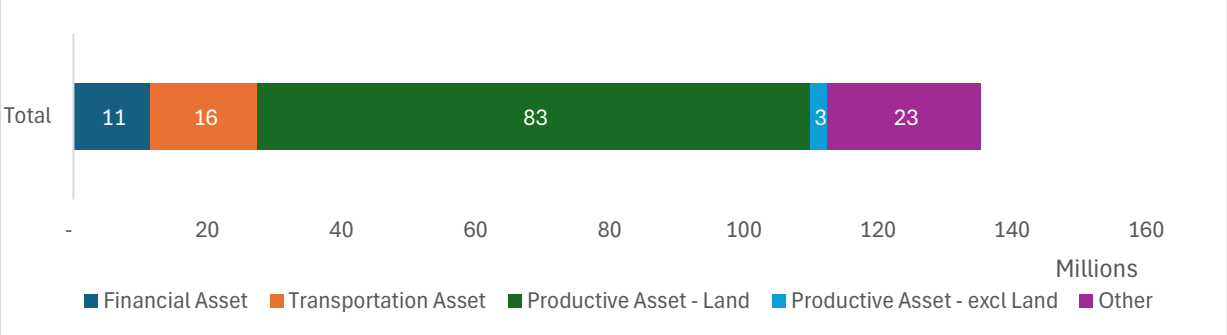
n = 3,030

A smaller proportion of respondents reported investing in tractors, harvesting tools, and water pumps. Notably, 29% of farmers in West Java owned both machine and manual tractors, compared with only 6% in Central Java. Among households reliant solely on paddy farming, 24% invested in tractors, followed by 13% of two-income households. For those practicing a combination of irrigated and water-pumping systems, 79% invested in pumps, while only 4% invested in tractors.

b. Household Assets

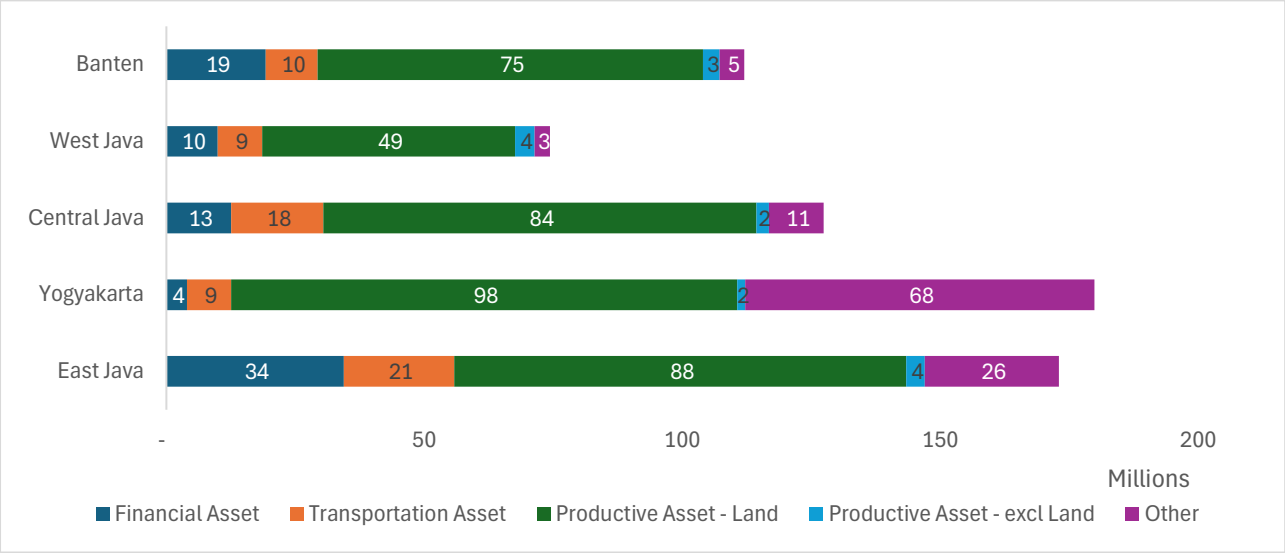
In terms of household asset value, as shown in Figure 22, lands and transportation (motorcycles and wagon) represented the largest shares, followed by financial assets (saving) and other assets from non-farm businesses such as kiosks, pushcarts, barber shops, and construction tools.

Figure 22: Total Estimated Asset Value



As shown in Figure 23, respondents in Yogyakarta reported the highest average asset value, followed by those in East Java and Central Java. Farmers in West Java, however, reported asset values below IDR 100 million. Yogyakarta leads in average land value and non-farm assets, while East Java has the highest ownership of financial assets (savings) and transportation assets (motorcycles and cars/wagons).

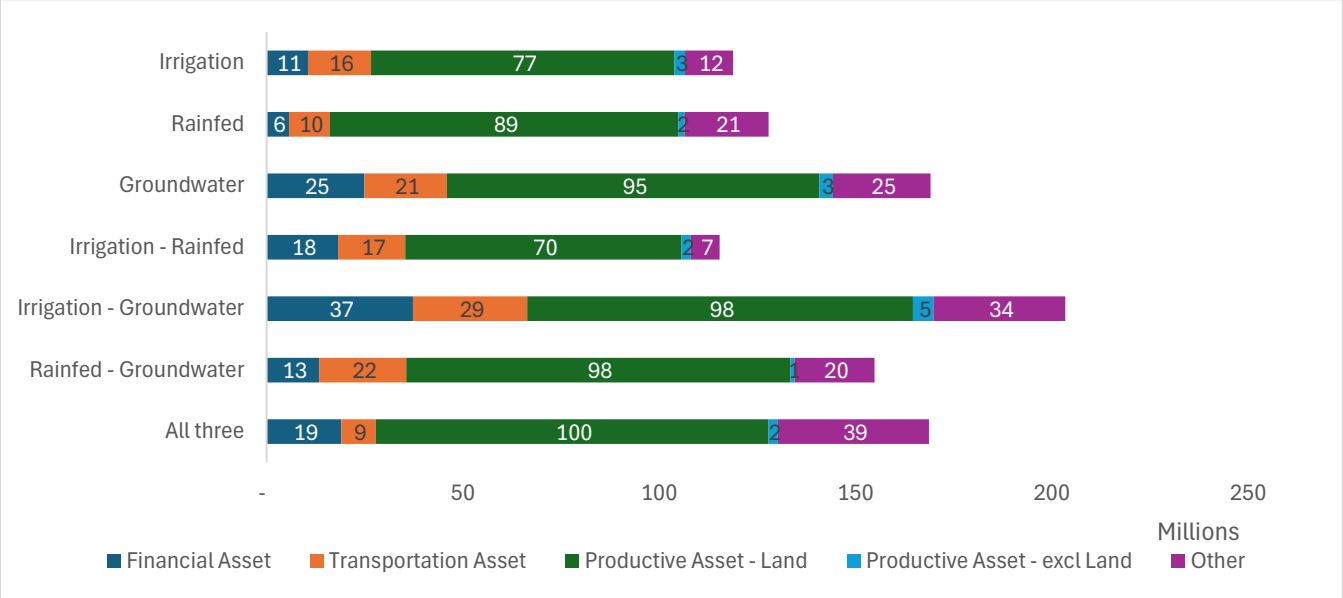
Figure 23. Estimated Asset Value by Province (IDR million)



n = 3,030

In Figure 24, farmers with higher land values (above IDR 95 million) are more likely to utilize groundwater, either as their sole water source or in combination with irrigation and rainwater. Those with the highest levels of financial and transportation assets typically access water through a mix of irrigation and groundwater, which provides more stable and reliable supply throughout the growing season. In contrast, farmers who rely solely on irrigation and rainwater tend to have the lowest asset values, reflecting more limited capacity to invest in secure water-access infrastructure.

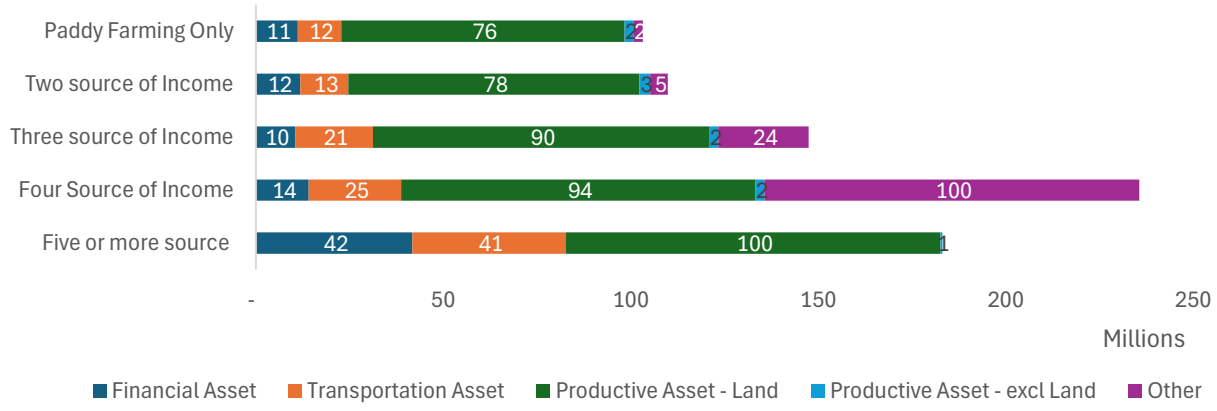
Figure 24. Estimated Asset Value by Farming Practices (IDR million)



n = 3,030

Figure 25 show a positive relationship between the number of income streams and total accumulated assets, particularly for financial assets, transportation assets, and land. This suggests that income diversification plays an important role in strengthening household asset positions. However, no clear pattern is observed for productive non-land assets or other non-farm assets.

Figure 25. Estimated Asset Value by Number of Income Source (IDR million)



n = 3,030

3.4 Access to Financial Services

Key Findings: Gaps in Financial Access, Debt, and Insurance

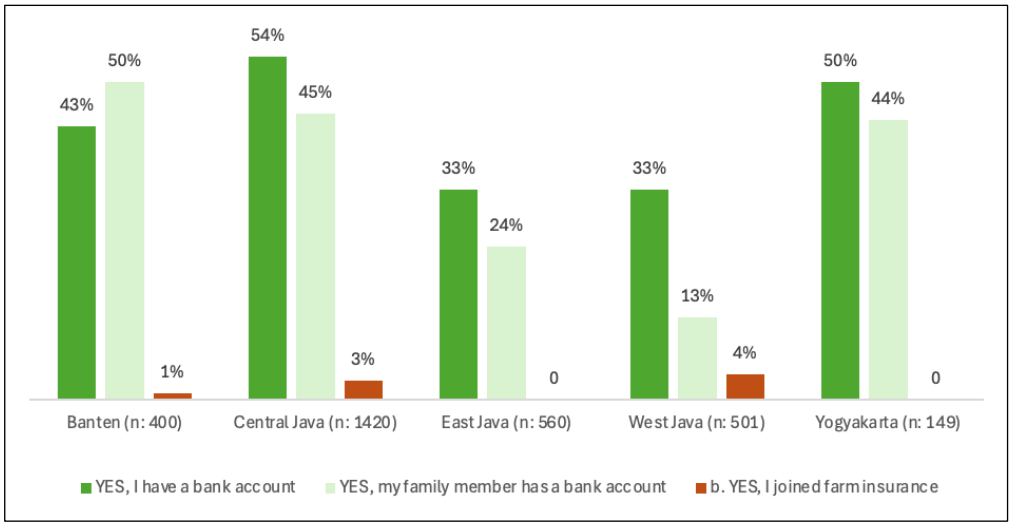
- ***Low Formal Financial Inclusion:*** *Less than half of all farmers (around 50%) own a bank account, with rates dipping as low as 33% in East and West Java. Despite government programs aimed at increasing inclusion, the overall rate remains critically low.*
- ***Informal Debt Dominates:*** *Among farmers with loans, the overwhelming majority (80%) rely on informal financial sources (family, neighbours, relatives, local cooperatives). These sources are favoured over banks due to trust-based social relationships and flexible, interest-free or negotiable repayment terms.*
- ***Loan Access Driven by Necessity, Not Investment****: Farmers are often compelled to borrow due to poor performance. Loans are primarily used to cover daily expenses (41%) and finance the next growing season, rather than for large-scale productive investments.*
- ***Insurance schemes have a slow adoption rate:*** *Government-subsidized paddy insurance (AUTP) has limited uptake due to restrictive compensation rules (payouts only for >75% crop damage) and a significant mismatch between the payout amount (IDR 6 million/ha) and the actual cost needed to finance the next season (averaging IDR 8 million for a smaller 4,000 m² farm).*
- *Farmers who **use loans** (both formal and informal) tend to **have lower asset values** and **lower rice profits** than non-borrowers. Those relying on climate-vulnerable practices (rainfed or pumping systems) and those with the lowest number of income sources showed high borrowing rates, reinforcing that borrowing is often a response to financial distress and instability.*
- ***Risk Aversion to Formal Credit:*** *Many farmers actively avoid formal loans and digital financing, citing fear of the risk and uncertainty of farming incomes, which makes difficult to guarantee repayment, and concerns over the high interest and aggressive debt collection associated with digital platforms.*

3.4.1 Access to Financing

Consistent with earlier findings from the World Bank's Indonesia Agro-Value Chain Assessment (2020), only about half of Indonesian farmers own a bank account, with even lower rates among rice farmers in East and West Java (33%) (see Figure 26). While financial inclusion has improved over the past decade, partly due to government transfer programs requiring vulnerable farmers to open bank accounts, the overall rate of formal inclusion remains low.

Similarly, despite government efforts to promote subsidized paddy farming insurance (AUTP, Asuransi Usaha Tani Padi) each growing season, uptake remains limited, particularly in East Java and Yogyakarta. Under the scheme, the government covers 80% of the premium (IDR 144,000), leaving farmers to pay only 20% (IDR 36,000) of the total IDR 180,000. Low participation is partly due to restrictive compensation rules: payouts of up to IDR 6,000,000 per hectare are only triggered when more than 75% of crops are damaged by natural disasters or pest infestations. Yet, as respondents noted, even 50% crop loss from pests and diseases is already devastating. Farmers also cited bureaucratic paperwork requirements as another barrier to making claims.

Figure 26. State of Formal Financial Services

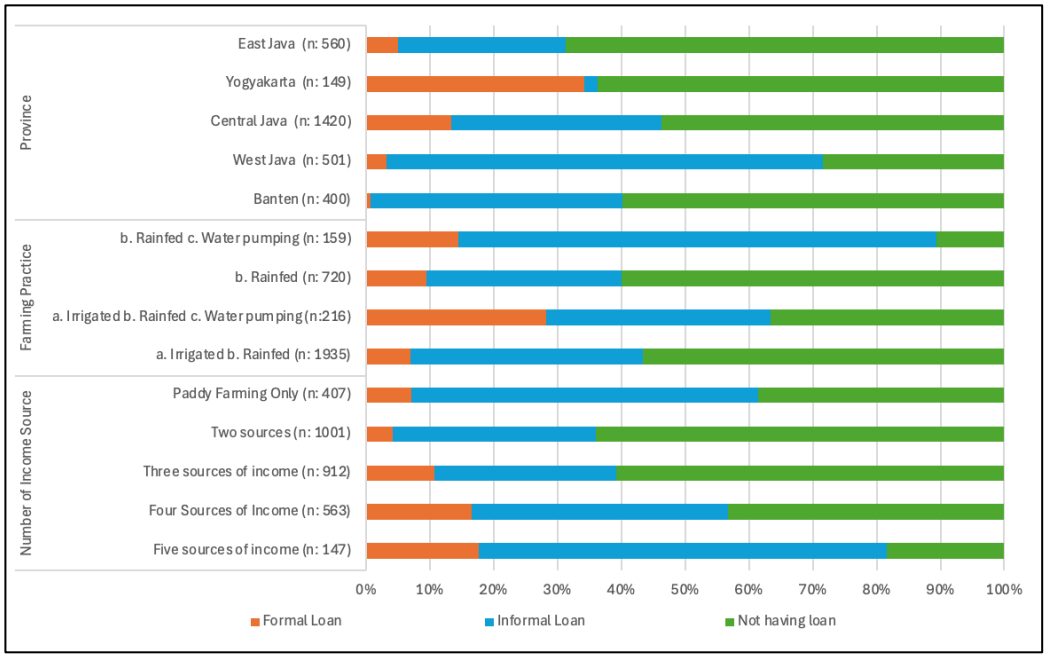


a. Existing Financial Services

Fifty-four percent of respondents reported they were not having any loans. Among those who did, the majority (34%) relied on informal financial sources such as family, relatives, neighbours, or local cooperatives, while only 9.5% accessed formal loans from banks, cooperatives, or digital financing platforms (see Figure 27).

When asked why they did not borrow, many respondents explained that they were uninterested in loans or fearful of formal credit, citing the risks and uncertainties of farming incomes, which make repayment difficult to guarantee.

Figure 27. Respondents with Financial Access (%)



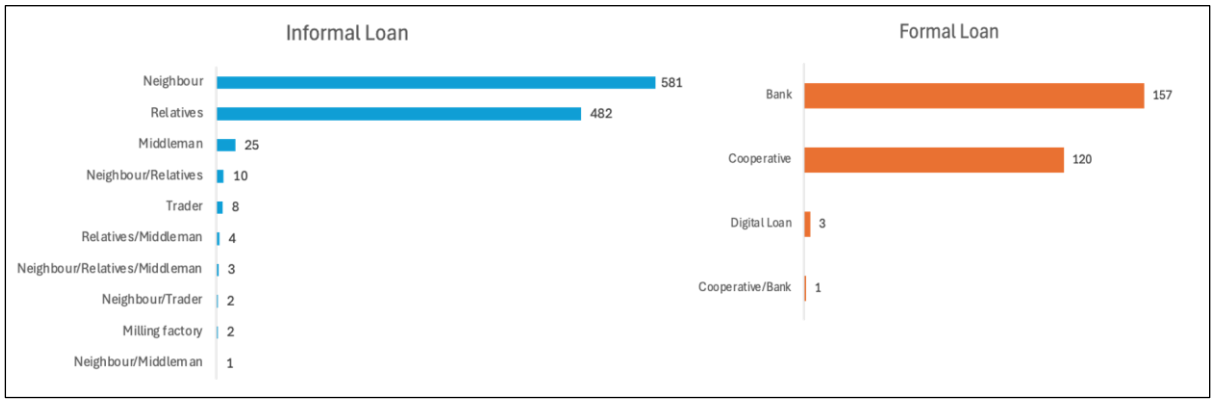
n = 3,030

Following Figure 28, which shows the low asset values of respondents in West Java, their situation aligns with 72% holding loans, of which 68% were sourced informally. High borrowing rates were also observed among farmers practicing rainfed or water-pumping systems and among those with five income sources (over 80% had loans, see Figure 26). Loans were used primarily to cover daily needs and finance the next growing season (Figure 31), followed by investment in other businesses and family-related expenses such as weddings, funerals, and celebrations. By contrast, lower loan incidence (fewer than 64% with loans) was found among respondents from East Java and Yogyakarta, as well as among farmers with two income sources. The largest groups accessing formal loans were farmers in Yogyakarta (34%) and those practicing irrigation plus water-pumping methods (28%).

As shown in Figure 29, the majority of loans (80%) came from informal sources such as neighbours, relatives, middlemen, and traders. These channels were preferred because of trust-based social relationships and flexible terms, often with no interest and negotiable repayment schedules. Formal loans were primarily accessed through banks and cooperatives, with 20% of respondents borrowing from these institutions.

Only a small share of respondents (45 farmers, or 3%) borrowed from supply chain actors (middlemen, traders, or mill owners), who typically imposed high interest rates or discounted crop prices with less flexible terms. An even smaller number (3 farmers) used digital lending platforms, despite their ease of access via smartphones. Farmers cited concerns about high interest charges and the negative reputation of aggressive third-party debt collectors as reasons for avoiding digital loans.

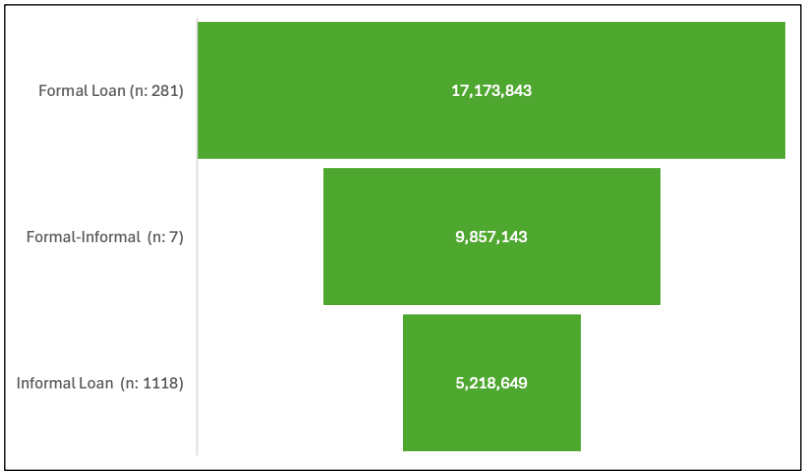
Figure 28. Respondents with Informal and Formal Loan



n = 1,406. *Note that only 7 respondents had combination of formal and informal loans.*

As shown in Figure 29, respondents who borrowed from formal providers obtained loans averaging nearly three times larger than those from informal sources (around IDR 5 million per respondent). Informal lenders, however, typically know the borrower personally and therefore base lending decisions on social relationships and trust rather than formal assessments. This unwritten understanding helps ensure repayment and reduces risk, since defaulting would not only damage the borrower's personal reputation but also risk losing community trust.

Figure 29. Average of Loan Amount by Loan Provider (in IDR)



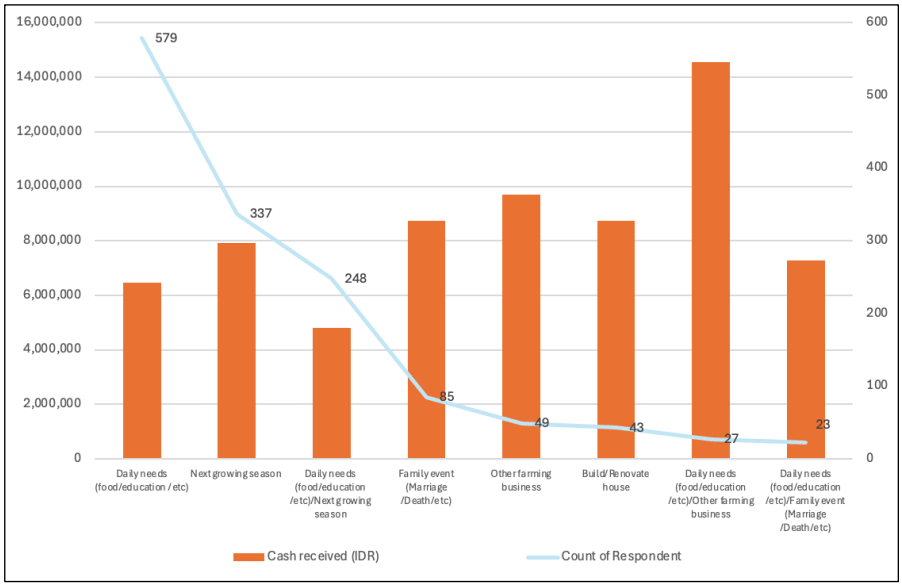
n = 1,406

The following figure presents the top eight uses of loan funds. While most respondents reported a single primary purpose, group discussions revealed that it was common to allocate loans to multiple needs. As found in Figure 30, the largest share of respondents (579 out of 1,406) used loans for daily expenses such as food and education (average IDR 6,464,249), followed by financing the next growing season (337 out of 1,406 with average IDR 7,928,042), and then a combination of both purposes.

When looking at the total loan amounts, larger sums were directed towards investing in other farming businesses, family events, and house construction. Linking these findings to farm insurance (see Section 2.11 on financial services), the average loan

needed to finance the next growing season was almost IDR 8 million for a 4,000 m² farm. By comparison, the farm insurance payout, IDR 6 million per hectare (10,000 m²), is relatively small. This mismatch between loan requirements and insurance compensation likely contributes to the respondents' limited interest in purchasing farm insurance, despite the 80% government premium subsidy.

Figure 30. Loan Allocation



n = 1,406

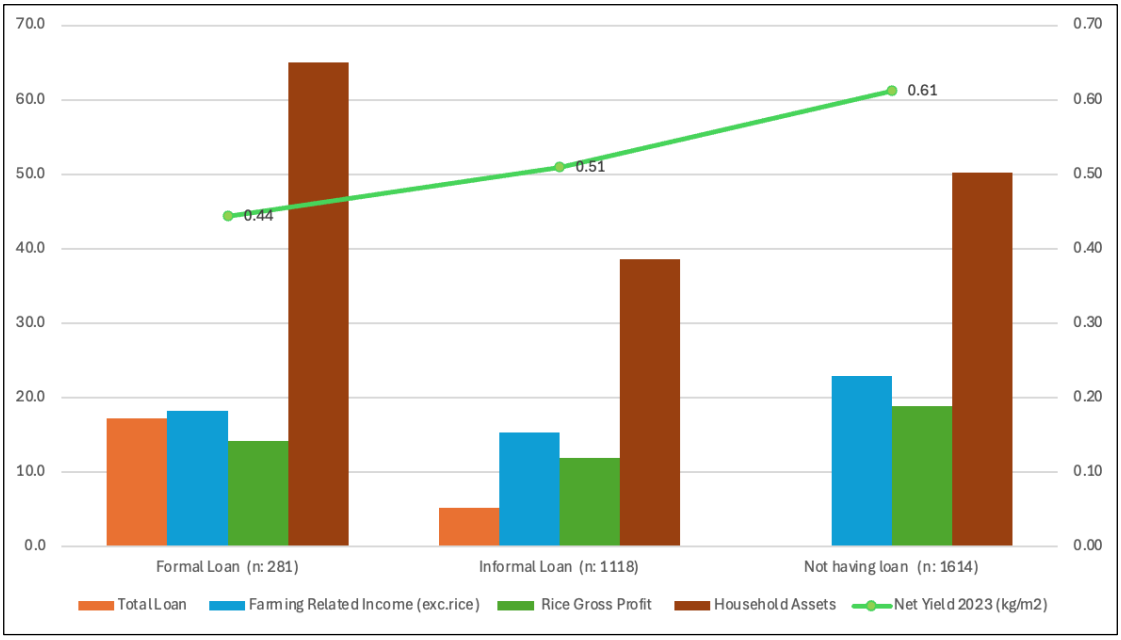
b. Financing and Farm Output

The following results present a descriptive analysis of financial access, household capacity (measured by assets and income sources), and paddy farming performance (yield). Figure 31 shows that respondents with formal loans held higher asset values and borrowed more than three times the amount accessed by those with informal loans. However, respondents with informal loans had asset values 40% lower than both formal borrowers and non-borrowers and also reported lower farming-related income and rice profits.

Respondents without loans had asset values about 20% lower than formal borrowers, yet they achieved higher farming-related income and rice profits. In terms of yield (kg/m²), farmers without loans performed best, followed by those with informal loans, and lastly those with formal loans.

These results suggest that farmers may seek loans out of necessity, as lower yields and reduced farming income push them to borrow. By contrast, farmers without loans appear to rely on sufficient income from harvests and other farming activities, reducing their need for credit.

Figure 31. Overview of Total Asset Value, Rice Profit, and Loan (IDR million)



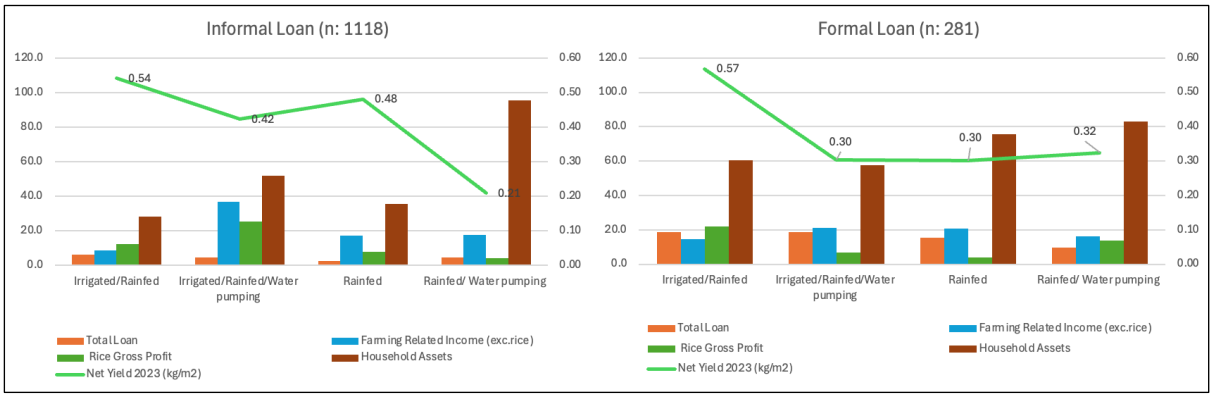
n = 3,013. *Note that we removed data of 7 respondents who had combination of formal-informal loans and 10 respondents who did not answer.*

c. Financing and Farm Output by Farming Practice

Figure 32 illustrates the relationship between farming practices, farmer performance, and total assets. Overall, respondents with formal loans reported higher accumulated assets across different practices. By contrast, those with informal loans generally held lower asset values, except among farmers using rainfed/water-pumping systems, where financial capacity to invest in pumping was positively correlated with total assets.

The yield results show that farmers practicing irrigated/rainfed systems achieved the highest yields, likely due to stable water availability from irrigation. Meanwhile, respondents who combined irrigation with water pumping recorded lower yields, possibly reflecting unreliable irrigation systems that forced additional investment in pumping to sustain production.

Figure 32. Type of Loan and Farm Output by Farming Practices



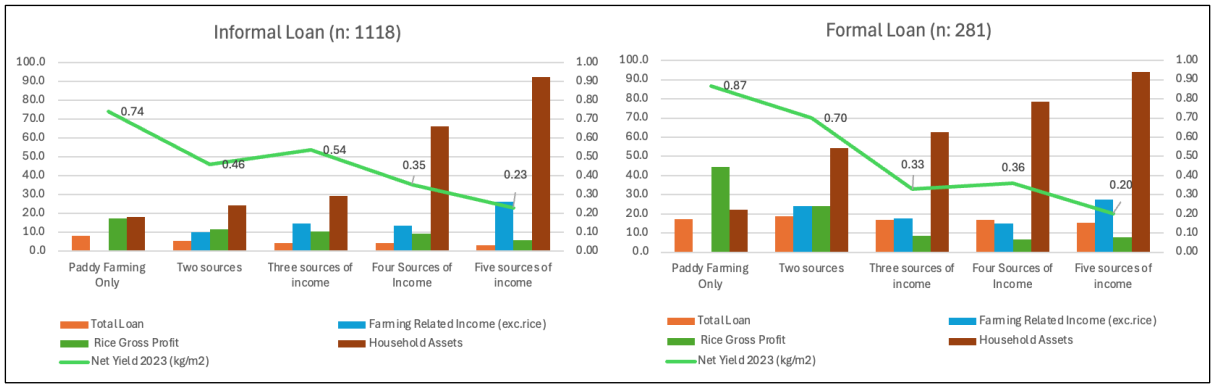
n = 1,399. *Note that we removed data of 7 respondents who had combination of formal-informal loans.*

d. Financing and Farm Output by Number of Income Source

Analysis of the link between income sources, borrowing status, performance, and total assets shows a clear trend: the greater the number of income sources, the higher the total asset value (Figure 33). Respondents with five income sources reported the highest asset accumulation, alongside relatively high farming-related income.

In terms of farm performance, however, respondents who relied solely on paddy farming achieved the highest yield and rice profits but also had the lowest overall asset accumulation. Taken together, the figures suggest that while income diversification improves household wealth and resilience, it does not necessarily translate into stronger rice yields or farm-level income.

Figure 33. Type of Loan and Farm Output by Number of Income Source



n = 1,399. *Note that we removed data of 7 respondents who had combination of formal-informal loans.*

3.4.2 Financing Preferences and Experience

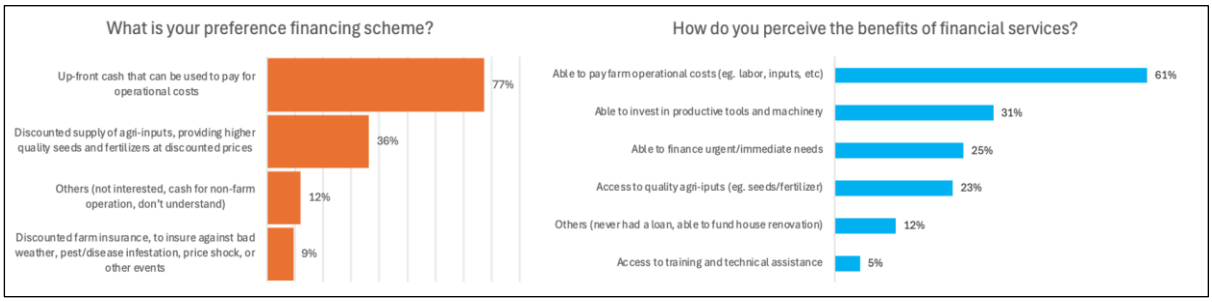
Key Findings: *Farmers overwhelmingly avoid formal financing because they recognize the unreliability of rice income and cite conventional barriers like complicated requirements and lack of collateral. Consequently, farmers prioritize loan flexibility (up-front cash) over subsidized products like insurance, highlighting the gap in suitable, risk-adjusted agricultural financial products.*

Since fewer than 10% of respondents had access to formal financial services and given the limited availability of products tailored to farmers, we asked about their preferred loan schemes (Figure 34) and perceptions of financial service benefits. Respondents showed the strongest preference for up-front cash payments, followed by discounted agricultural inputs, other forms of support, and discounted farm insurance.

When asked about the perceived benefits of financial services, respondents highlighted the ability to cover farming operation costs (61%), support investment (31%), meet urgent household needs (25%), and access quality agricultural inputs (23%).

Taken together, the findings suggest that farmers value flexibility in how loans are allocated, rather than restricting credit solely to farming operations. Notably, only 9% expressed preference for discounted farm insurance, despite their direct experiences with harvest losses and water scarcity.

Figure 34. Financing Preference and Benefits of Financial Services

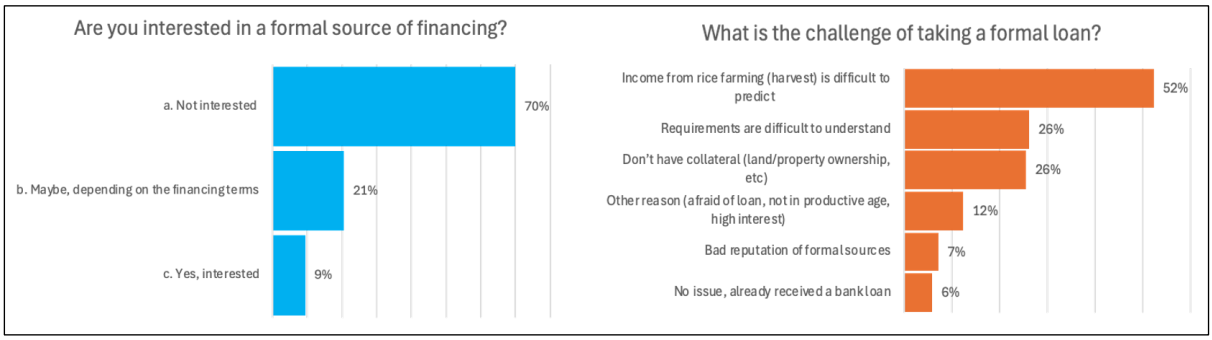


n = 3,030

As shown in Figure 35, 70% of respondents were not interested in formal financing. Their main reasons included: recognition of unreliable and irregular rice farming income (52%), complicated requirements (26%), and lack of collateral (26%). These responses highlight farmers' awareness of the volatility of agricultural income and the barriers posed by conventional lending conditions.

Existing microfinance products in Indonesia are typically designed with the assumption that rural households operate like small and medium enterprises (SMEs). However, farming is a distinct sector, ranging from subsistence-oriented production (to meet household needs) to commercial farming (for profit). As such, the financial service needs of farmers differ significantly from those of SMEs, underscoring the gap in suitable financial products for agricultural communities.

Figure 35. Formal Financing Interest and Challenge of Formal Loan

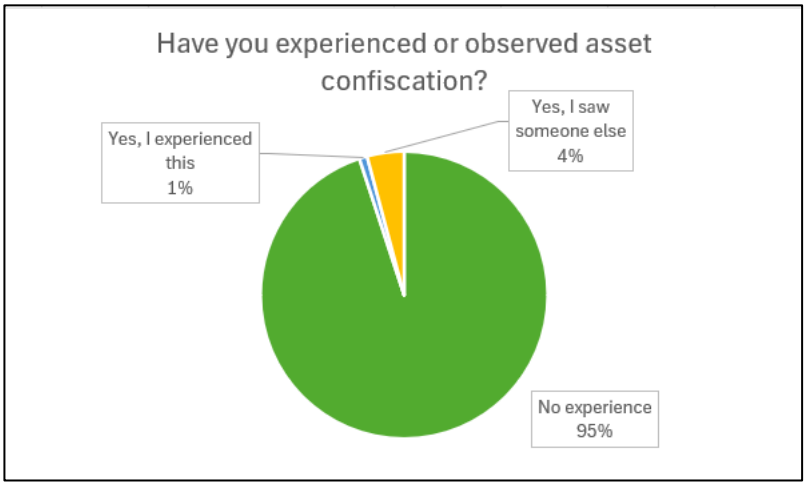


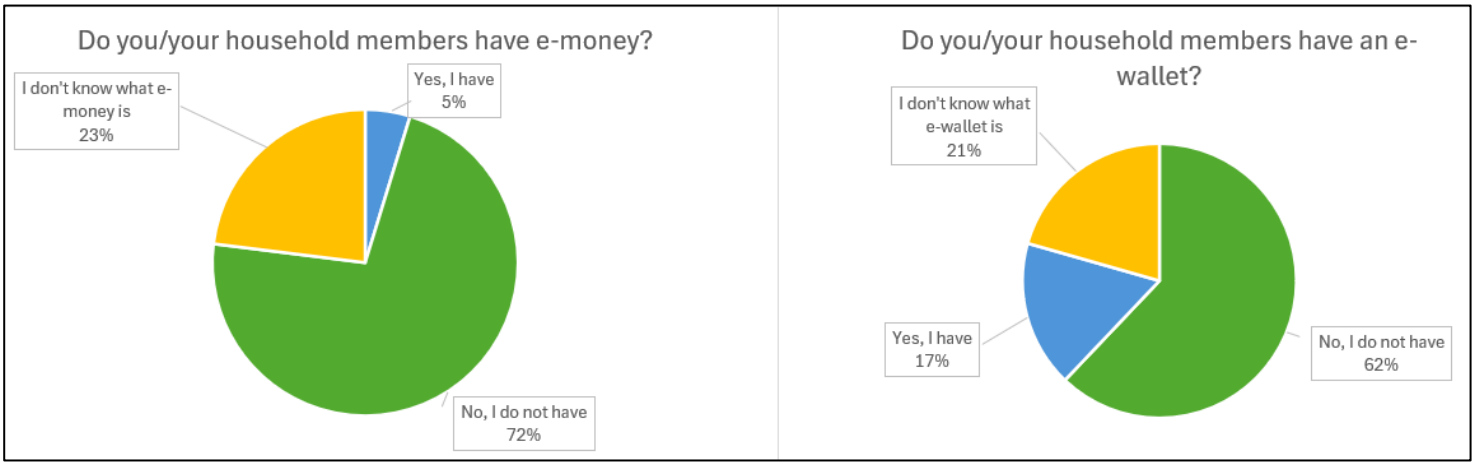
n = 3,030

The lack of interest in formal financial services was not primarily due to negative experiences such as asset confiscation, 5% of respondents reported either personal or second-hand experience of this (see Figure 36). Age was a more significant factor: with over 60% of respondents older than 50, adoption of digital finance tools was low. Only 5% used e-money and 17% used e-wallets.

Among e-wallet platforms, the most commonly used were ShopeePay (8.2%), Dana (8.0%), and GoPay (2.6%), while e-money usage was mostly linked to state-owned banks such as BRI, Bank Mandiri, and BNI.

Figure 36. Experience with Confiscation and Digital Financial Services





n = 3,030

3.5 Climate Change and Technology

Key Findings: Urgent Need for Climate-Smart Innovation

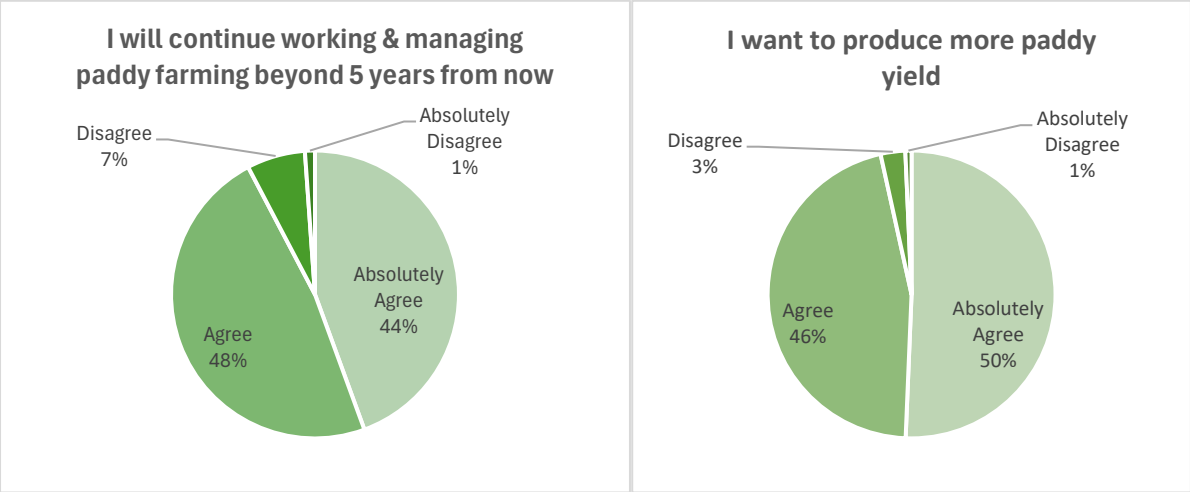
- ***Climate Impacts are Real:*** *A large majority of farmers report experiencing unpredictable rainfall patterns, prolonged dry seasons, and increasing pest infestations, highlighting an urgent need for adaptation.*
- ***High Learning Motivation:*** *Despite these challenges, farmers show a strong willingness to learn new technologies and reduce pesticide/water use, aligning with their core goal of maximizing yield.*
- ***The Digital Barrier:*** *The adoption of digital tools and access to timely market information is severely limited by the advanced age of the farmers, creating a major bottleneck for modernizing practices and accessing price updates.*

Climate change impacts are inevitable, particularly in the agricultural sector, where farmers depend heavily on climate, soil, and surrounding ecosystems. Using a Likert scale, we surveyed Indonesian rice farmers to understand their perceptions regarding the future of paddy farming, willingness to adopt new technologies, experiences with climate change, and use of smartphones.

a. Perception on Knowledge, Training and Digital Access

As shown in Figure 37, a large majority of respondents agreed or strongly agreed that they intend to continue cultivating paddy over the next five years and aspire to increase their yields. Only 8% indicated that they would stop managing paddy fields, citing old age as a limiting factor and expressing intentions to either rent out their land or hire labour instead. The remaining 92% demonstrated strong confidence and commitment to continue farming despite challenges such as climate change impacts, fluctuating farm-gate prices, and limited investment in machinery. On yield improvement, 96% of respondents agreed that achieving higher yields is both important and consistent with their interests.

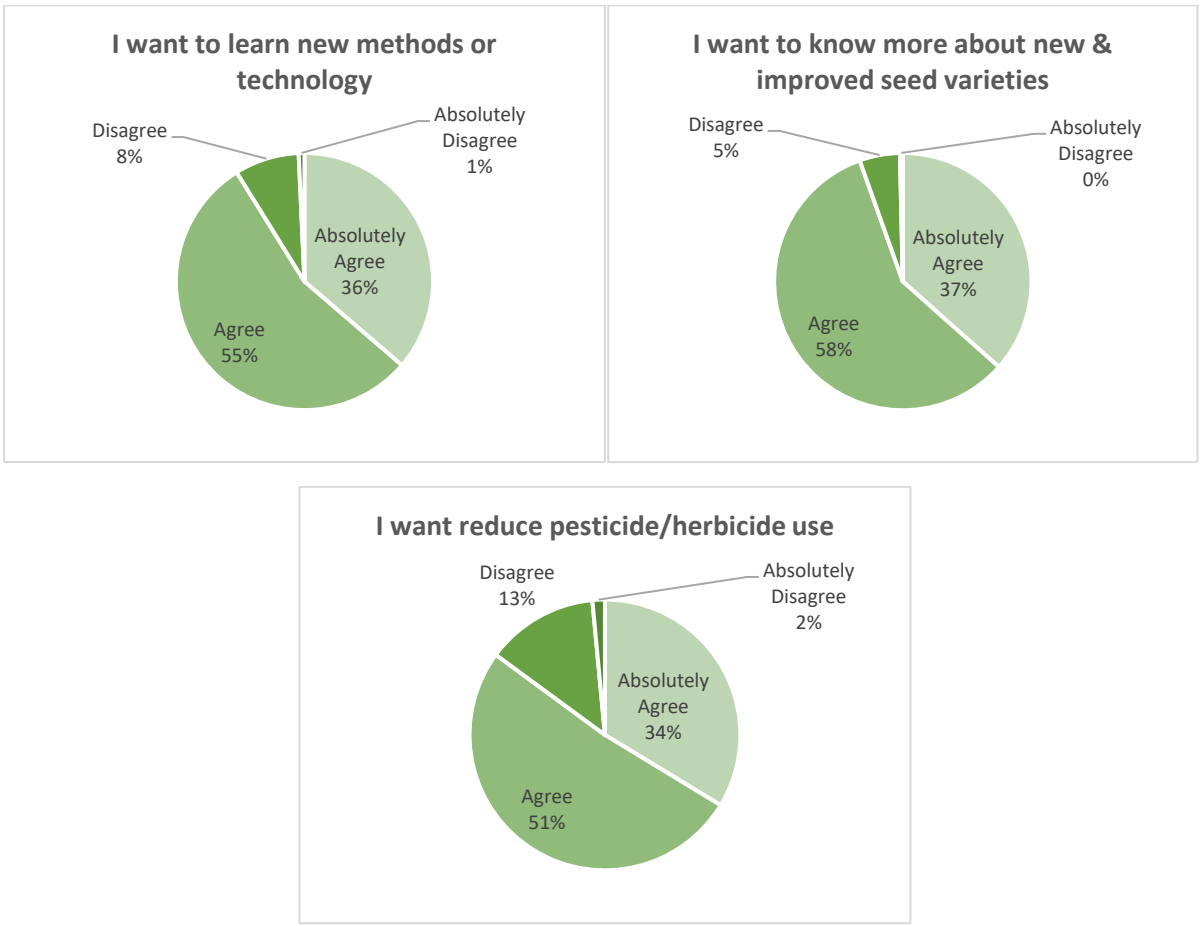
Figure 37. Perception on Future Paddy Farming and Yield Expectation



n = 3,030

Figure 38 shows that a large majority of respondents (91%) agreed or strongly agreed that they are willing to learn more about new technologies and improved seed varieties. This strong interest in capacity building aligns with their expectations of achieving better harvests and higher yields. In addition, 85% of respondents agreed or strongly agreed with reducing pesticide use, reflecting their awareness of the negative impacts of pesticides on ecosystems, such as increasing pest resistance and declining effectiveness of chemical applications. However, 15% of respondents disagreed or strongly disagreed with reducing pesticide use. This indicates that for some farmers, particularly those managing smaller plots, chemical pesticides remain more convenient compared to alternative approaches that require more labour, such as preparing natural or bio-pesticides at home, integrating animals (e.g., ducks or freshwater fish/crabs), or adopting other sustainable agroecological practices.

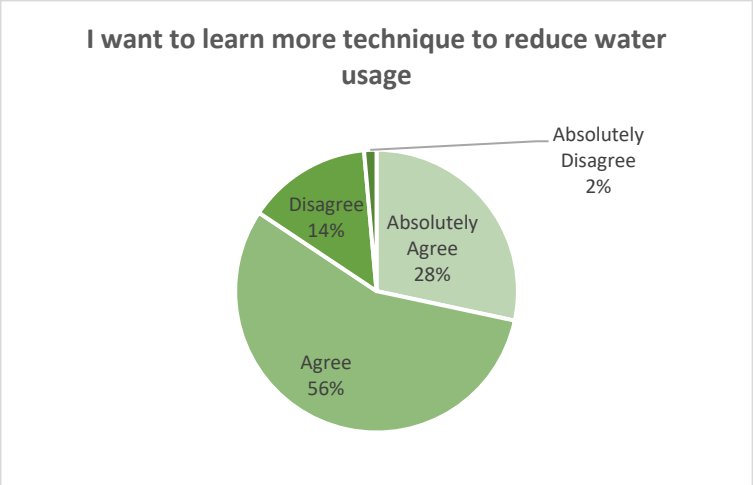
Figure 38. Willingness to Learn Farming Management Skills



n = 3,030

Figure 39 shows that a considerable proportion of respondents expressed strong interest in learning more about reducing water usage (84%) and exploring non-farming income opportunities (87%). As water is a critical resource for paddy cultivation, this high level of awareness reflects farmers' recognition of water shortages, particularly during the dry season. However, 16% of respondents were resistant to reducing water use due to concerns about potential yield declines. This underscores the need to promote suitable and context-relevant innovations. Over the past few decades, several approaches have emerged to address water scarcity in rice cultivation, including Alternate Wetting and Drying (AWD), drip and sprinkler irrigation, hydroponics, Direct Seeded Rice (DSR), the System of Rice Intensification (SRI), aerobic paddy culture on higher dry ground, as well as the development of drought-resistant seed varieties and genome editing for targeted challenges.

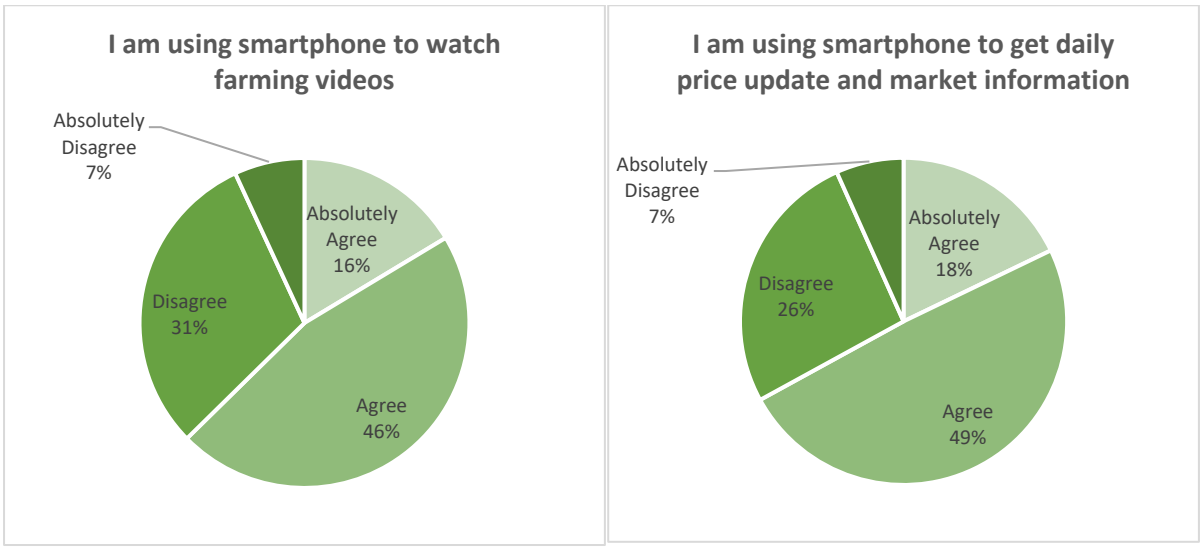
Figure 39. Perception on Water Usage and Scarcity



n = 3,030

Previous results indicate that farming and income diversification can strengthen household resilience and improve access to formal financial services. However, 13% of respondents disagreed or strongly disagreed with livelihood diversification. This stems from the fact that 13.5% of the total respondents rely solely on paddy cultivation for their livelihoods and are more resistant to adopting diversified approaches. In contrast, 87% expressed interest in pursuing alternative income sources and opening opportunities to foster rural entrepreneurship, particularly for the younger generation. Such opportunities include integrating digital solutions (e.g., Internet of Things applications) into agriculture and related sectors, covering areas such as farm monitoring, water management, organized supply chains, integration of sustainable energy in production, and other innovations.

Figure 40. Experience Using Smartphone



n = 3,030

The major challenge in transforming farming services and rural livelihoods lies in the ageing generation of paddy farmers, many of whom remain resistant to digital-based services, such as using smartphones beyond basic communication. As shown in Figure 40, thirty-eight percent of respondents who strongly disagreed with using smartphones to watch farming-related videos were those who had never used mobile phones,

smart or otherwise, in their daily lives. Although internet coverage in Java is widespread and supported by multiple providers, the regular use of mobile phones can still be costly by rural standards. Nevertheless, over the past decade, popular social media platforms have emerged as important vehicles for sharing new technologies and facilitating knowledge transfer.

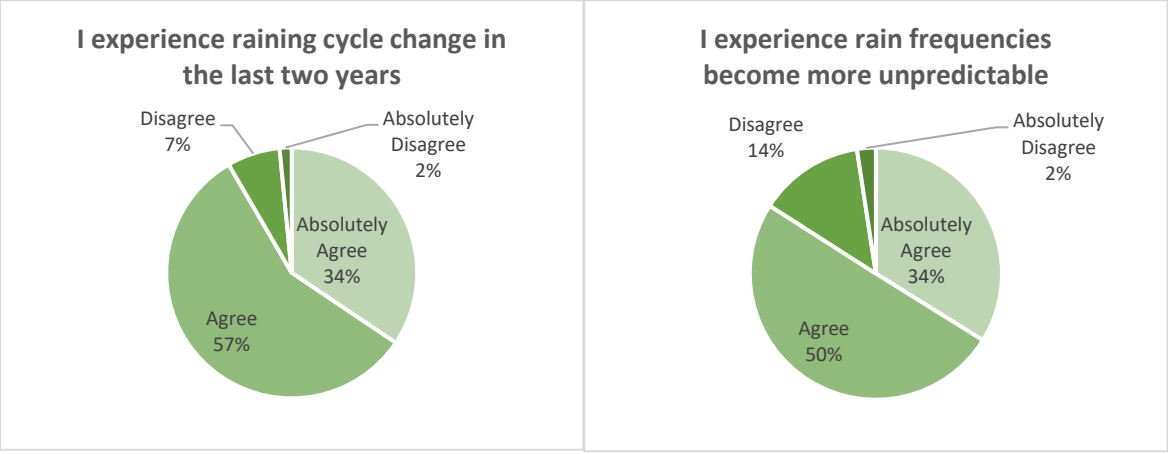
In addition, 33% of respondents strongly disagreed with receiving daily price updates and market information via mobile phones, likely reflecting the limited rate of smartphone ownership among farmers. Despite government initiatives to promote transparent pricing, such as the daily publication of the highest retail price (HET, Harga Eceran Tertinggi) for medium-quality rice as a benchmark at the farm-gate level, most respondents reported relying on middlemen and traders rather than accessing government online platforms for market price information[7].

b. Perception on Impact of Climate Change

Respondents from Central Java reported a decline in paddy harvests in 2023, attributing this to high pest infestations and reduced rainfall. Early last year, the Indonesian Meteorology Agency also reported that El Niño had caused a prolonged dry season and delayed rainfall, which negatively affected crop yields. Against this backdrop, we asked respondents about their experiences with different impacts of climate change.

As shown in Figure 41, 91% of respondents strongly agreed that rainfall patterns had changed over the past two years, while 84% also agreed that rainfall frequency had become increasingly unpredictable in their regions. Such variability makes it difficult for farmers to determine the optimal time to begin planting, increasing the risk that their investments may be lost if the dry season extends unexpectedly. Ultimately, these changes in rainfall patterns and frequency disrupt the steady water supply needed during the growing season, with significant consequences for both harvest success and farmers' livelihoods.

Figure 41. Experience on Change Raining Pattern



n = 3,030

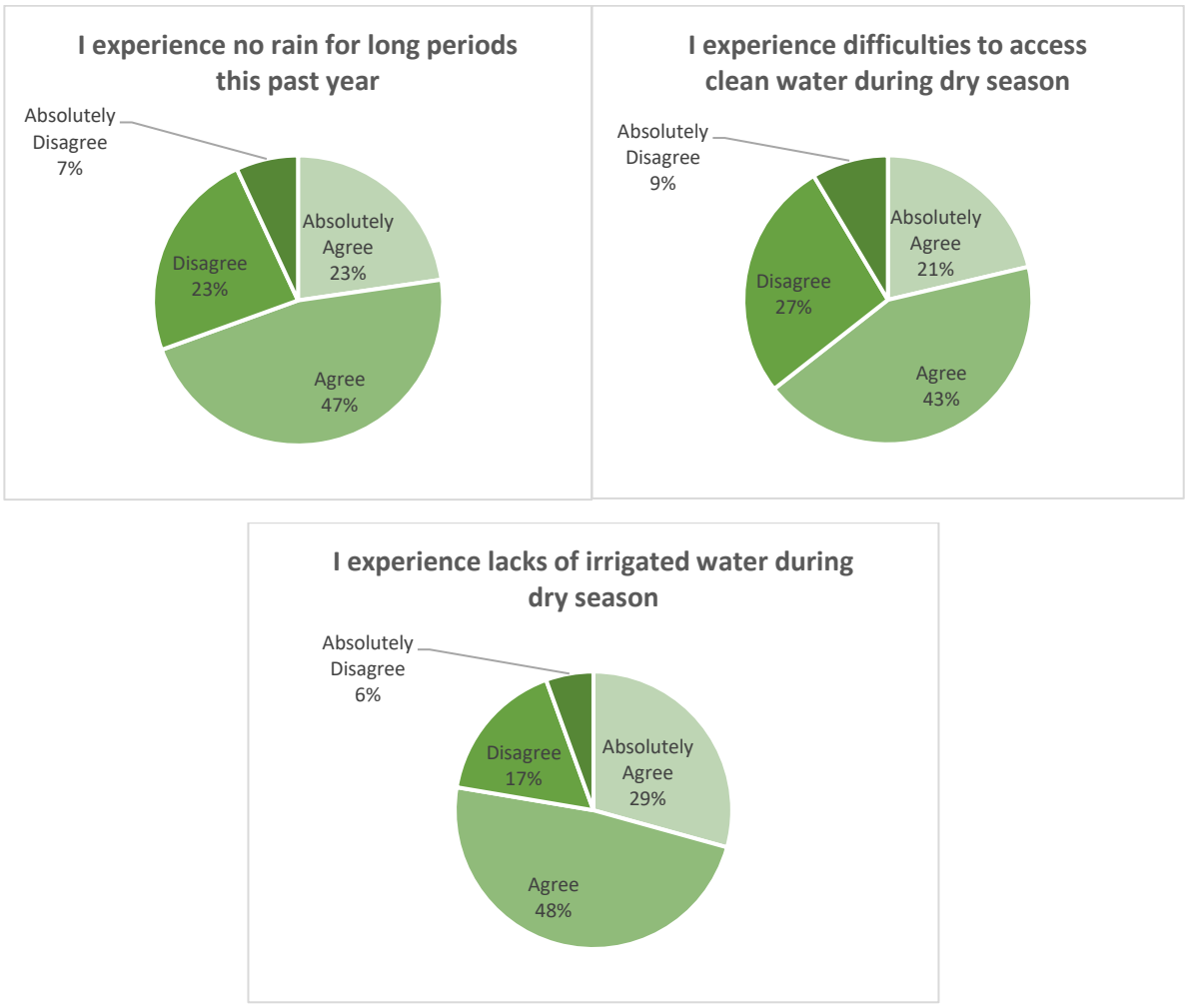
We also asked respondents about more severe effects of climate change, particularly prolonged dry seasons, defined as periods without rain lasting more than one growing cycle (3-4 months), and access to clean water for daily use. As indicated in Figure 42,

[7] Daily commodity price update by National Food Agency (BPN-Badan Pangan Nasional) https://panelharga.badanpangan.go.id/beranda

70 percent of respondents strongly agreed that experiencing no rain for over one growing season is a clear impact of climate change. Failure to anticipate such events could disrupt household food security and heighten vulnerability.

Closely related to prolonged drought is access to clean water, which is essential for human health and hygiene, including preventing dehydration and waterborne diseases, ensuring food safety, and sustaining ecosystems. Acknowledging the spatial inequality of water resources in Java and the challenges of water management, 64% of respondents strongly agreed that they have experienced difficulties in accessing clean water. Despite Indonesia's abundance of natural resources, the country faces a growing shortage of clean water, which is vital not only for households but also for the agricultural sector. Effective water management policies will therefore be critical to prevent an absolute water crisis in the near future.

Figure 42. Experience in Water Shortage

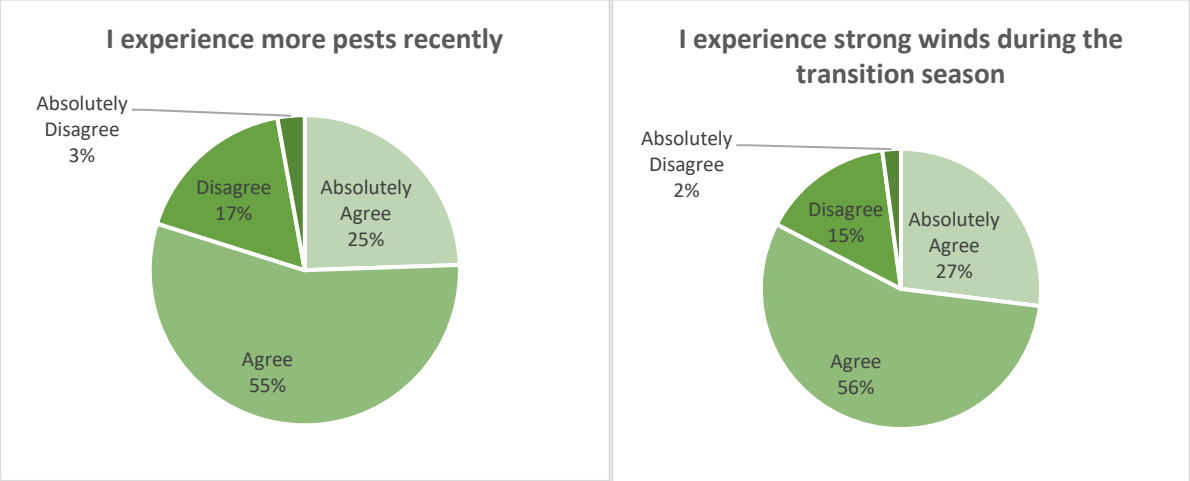


n = 3,030

Rising temperatures accelerate the life cycles of paddy pests by increasing reproductive rates, enhancing survival, and expanding their geographical distribution (Surmaini et al., 2024; Skendžić et al., 2021). These factors collectively lead to higher pest populations and pose significant threats to agricultural crops, including paddy. Consistent with these findings, 80% of respondents strongly agreed that they had experienced increasing pest infestations (Figure 43). In addition, 77% reported experiencing shortages of irrigated water, while 83% noted strong winds, both of

which contributed to physical damage and systemic harvest losses, particularly in the open-field environments typical of paddy farms.

Figure 43. Perception on Other Climate Related Impacts



n = 3,030

4. Discussion

Almost half of Indonesians live in rural areas, and 28% are engaged in the agricultural sector, which contributed nearly 14% to the national GDP in 2020. With a growing population, agriculture has become increasingly critical in meeting the rising demand for food and agro-industrial products, particularly rice, the country's main staple crop and a cornerstone of food security and resilience.

This study highlights the intricate role of paddy farming communities in sustaining livelihoods and shaping rural economies and development. By examining household farming practices and income structures, we document the complexity of paddy farming as a family-based enterprise that presents both opportunities and challenges. Transforming smallholder paddy farming into more sustainable practices is essential not only for strengthening rural economies but also for ensuring long-term food security and reducing poverty.

4.1 Improving Farming and Agri Supply Chain

a. Demography and Growing Season

Paddy farming has become a less attractive livelihood option, discouraging younger generations from inheriting the business from their parents. As a result, the farming population is ageing, with 61% of farmers above 50 years old. Education levels are also low: 61% of respondents had not completed more than six years of primary schooling. Small-scale farming, with its low returns, is particularly unattractive to educated youth, who prefer higher-paying jobs in urban areas, leaving farmland to be managed by older generations. Older farmers with limited education face challenges in adopting practices or strategies to improve farm profitability and productivity.

On average, respondents managed paddy fields of just 3,560 m², with nearly one-third cultivate less than 0.1 hectares (1,000 m²). In Yogyakarta, where the average farm size was only 1,434 m² per respondent, just 17% managed more than 0.5 hectares. Small, subsistence-oriented holdings make farmers especially vulnerable to external shocks such as prolonged dry seasons or pest infestations, which can lead to significant harvest losses.

Despite these challenges, three quarters of respondents owned and directly managed their farms. Furthermore, 21% diversified by cultivating other crops and rearing livestock such as cattle, sheep, poultry, and aquaculture. Beyond agriculture, 68% of respondents reported additional income sources, including remittances, running kiosks or small businesses, and renting out land or machinery. These alternative income streams helped buffer against harvest losses and external shocks.

Growing seasons also vary by regions across Java. For example, Serang (Banten), Bogor (West Java), and Gresik (East Java) typically have two growing seasons annually, while Klaten and Karanganyar (Central Java) can have three. The number of growing cycles depends heavily on water availability: irrigated paddy fields can sustain two to three regular harvests per year, while rainfed farms remain highly dependent on rainfall and supplementary sources such as springs or groundwater, resulting in less consistent harvest.

b. Farming Practices

Despite government efforts to expand rural infrastructure and provide large subsidies for paddy, 29% of respondents still relied on rainfed farming, particularly in Banten (59%) and Yogyakarta (56%). By contrast, 88% of respondents in West Java and 84% in Central Java benefited from extensive irrigation systems, owing partly to the steady water supply from natural resources such as large rivers and freshwater lakes in these regions.

In terms of farming practices, all respondents reported using chemical fertilizers, with a wide variety applied. Nitrogen-based fertilizers (urea) were most common (91%), followed by mixed nitrogen–phosphorus–potassium (NPK) fertilizers (64%). Both types were heavily subsidized, often at 70–80% below commercial prices. However, because urea is significantly cheaper, it tends to be overused, as reflected in the survey in which 2,757 out of 3,030 farmers reported using urea as their primary fertilizer. Such overuse can lead to soil acidification, nutrient imbalances, excessive algae growth, oxygen depletion, and the release of nitrous oxide (N_2O), a potent greenhouse gas.

Chemical pesticides were also widely applied, with 85% of respondents using insecticides and 54% using herbicides, compared to only 9% using organic pesticides. Continuous and frequent application of chemical pesticides raises concerns over pest resistance and harm to beneficial insects (e.g., natural predators and biological controls). Herbicide use further disrupts ecological balance by contaminating drinking water and causing runoff into streams.

Seed preferences leaned toward inbred varieties rather than hybrids, as inbred seeds generally require fewer fertilizers, are more pest-resistant, and can be reused for the next season. Nevertheless, only one-quarter of respondents recycled seeds from previous harvests; the majority had to purchase commercial seeds from kiosks, adding to production costs. Farmers largely relied on manual tools to manage paddy fields, supported by motorcycles for crop transport, and spraying pumps for fertilizers and pesticides. Harvesting was mostly done manually, though machine harvesters were occasionally rented. While electric waterjet pumps were affordable, they carried extra costs for generators and fuel or electricity.

Production costs varied significantly across provinces. Yogyakarta recorded the lowest expenditure (IDR 773/m²), while West Java recorded the highest (IDR 2,339/m²). Fertilizers accounted for the largest share of costs, followed by labor, tractor rental, seeds, and pesticides. Although all farmers invested in fertilizers, provincial differences appeared in other inputs: over half of respondents in Central and East Java incurred additional costs for pumping water, more than half in West Java paid for milling and transport, whereas only about 10% of Yogyakarta reported costs for water, milling, transport, and harvest.

Harvest outcomes scaled with farm size. Small plots (<1,000 m²) produced an average of 283 kg but had higher failure rates, while larger plots (>4,001 m²) yielded up to 1,812 kg with fewer failures. Interestingly, smaller farms achieved higher yields per area (0.42 kg/m²) compared to larger farms (0.20 kg/m²). This diseconomy of scale is potentially due to the difficulties in scaling up better soil replenishment and management practices. By province, West Java had the highest costs but also the largest harvests (994 kg) and highest yield efficiency (0.64 kg/m²), followed by Banten and Central Java. Yogyakarta had the lowest costs and harvests but displayed higher yield efficiency than several provinces.

Farming practices strongly influenced outcomes. Irrigated fields produced the highest yields, whereas rainfed plots achieved moderate yields but smaller harvests due to limited farm sizes. Irrigation practices varied widely: West Java (88%) and Central Java (71%) had the highest shares of irrigated fields; Yogyakarta (54%) relied heavily on rainfed farming; Banten (58%) combined irrigation with rainfed methods; and East Java (19%) depended primarily on pumped water.

Harvest failures, exacerbated by the 2023–2024 El Niño and reduced rainfall, had significant impacts. More than half of respondents reported failures in the past five years, including 441 cases in 2023 and 293 in 2024. Farmers who failed in 2024 saw harvests and yields drop by about 30%. Those dependent on pumping faced higher costs for fuel and equipment rental, while irrigated farms achieved more stable production, with 2–3 harvests per year compared to annual harvest on rainfed farms. The number of growing seasons proved critical for resilience: farmers with only one growing season lost 56% of their harvests in 2024, while those with two or more seasons limited losses to 20–28%. More frequent harvests did not always translate into greater total harvests, but they consistently improved yield stability.

c. Household Income and Asset Structure

For most farmers, rice is grown primarily for household consumption, with any surplus sold to supplement income. Profit estimates from the 2023 harvest reveal sharp provincial differences. Farmers in Yogyakarta earned the lowest income (IDR 926,048) due to low annual yields, while those in West Java reported small profits despite higher yields because of high production costs. Banten farmers, benefiting from the largest average farm sizes, achieved the highest profits (IDR 16 million). Farmers in Central and East Java earned 10-18% less than their counterparts in Banten. Harvest failures in 2023 led to severe losses; respondents who experienced crop failure saw gross profits fall by 76% and yields by 46%.

Multiple harvests per year associated with irrigated fields generated the highest revenues, whereas reliance on rainfed farming reduced returns. Irrigated rice farming provides the highest annual income (IDR 17.5-21.4 million), especially when combined with pumped water, and often supports additional earnings from other farm and non-farm activities. Farmers who depend primarily on rice managed larger fields and earned higher rice incomes, while those with multiple income streams typically had smaller farms and relied less on rice. Rice remains the most common source of income for rice farmers; it is insufficient on its own. Only 13% of respondents relied solely on rice profits, while 87% diversified into other farming activities (livestock, secondary crops, farm services) or non-farming sources. Rice contributes about one-third of household income in Central Java and Banten, but only 9% in Yogyakarta, where livestock dominates (87%). Across all provinces, most households combine rice with livestock, other crops, or farm services, and 51% also depend on non-farming incomes such as construction, remittances, pensions, or driving. Supplementary non-farm income enables households in most provinces to exceed provincial minimum wages, with the exception of West Java, where farming remains dominant but average income remains slightly below the minimum threshold.

Multiple income sources were associated with lower rice income but greater total wealth, particularly in East Java. Farmers investing in water pumps often held higher-value assets (savings, tractors, businesses), though overall investment in productive farm equipment, aside from wagons, remained limited, suggesting rice farming was

not the primary livelihood. Diversified income portfolios were strongly correlated with higher asset accumulation compared to rice-only farmers. Although paddy fields remain the largest single asset for farmers, rice contributes less than 20% of total household wealth, especially in Yogyakarta.

Farmers' assets are split between farming resources (land, crops, livestock, tools, water access) and non-farming resources (cash, savings, vehicles, housing), both critical for sustaining production and resilience. Most respondents invested in manual tools, motorcycles, and spraying equipment, while fewer owned tractors, harvesters, or pumps. Asset ownership varied significantly: 29% of West Java farmers owned tractors compared to just 6% in Central Java; 24% of rice-only farmers invested in tractors versus 13% of two-income farmers; and 79% of farmers using irrigation combined with pumping invested in pumps. In terms of asset value, paddy fields and wagons dominated, followed by bank savings and other business assets. Savings were highest among irrigated-plus-pumping farmers (IDR 62 million) and East Java farmers (IDR 56 million), but lowest among rainfed farmers and those with five income sources (around IDR 13–15 million).

Irrigated farmers earn more than their rainfed counterparts, and those with greater savings and assets can invest in pumping systems to boost returns. Single-income rice farmers achieve the highest yields and net incomes (IDR 13 million; 0.54 kg/m²), but their heavy reliance on rice makes them highly vulnerable to shocks such as El Niño. Farmers with multiple income sources accumulate more assets but earn less from rice, as attention shifts toward other livelihoods. Yogyakarta farmers and those with five income streams had the lowest rice income and yields, relying on non-rice activities to compensate. West Java farmers also remain vulnerable, with relatively small asset holdings and modest rice income (IDR 8.6 million), about half of which is derived from non-rice sources.

Respondents with formal loans generally held higher accumulated assets than those relying on informal loans. Exceptions were rainfed or water-pumping farmers, whose ability to invest in pumping systems correlated with higher asset values. Irrigated and rainfed farmers achieved the highest yields due to stable water access, while those combining irrigation and pumping faced less reliable systems and higher costs. Asset accumulation also rose with income diversification, farmers with five income sources reported the largest assets and substantial farm-related income.

d. Gap in Supply Chains

Rice supply chains in Indonesia remain long and conventional, despite minimal post-harvest processing, most commonly limited to sun-drying. The majority of farmers sell paddy to middlemen or crop traders, who are preferred over cooperatives and retailers because they also provide loans, harvesting assistance, and other post-harvest services. Off-takers typically offer services such as harvesting, milling, and storage rather than agricultural inputs. This is partly because subsidized fertilizers are distributed through farmer groups in limited quotas, while non-subsidized inputs remain unaffordable for most smallholders. Current government strategies prioritize short-term gains by providing subsidies and promoting intensive chemical and mechanical inputs, which fosters dependency on state support rather than incentivizing private or collective investment in sustainable rice production.

The existing supply chains also lack critical support functions. Training and extension services are limited, agri-input suppliers are few, financial providers remain scarce, and labour supply is often unorganized. With weak private sector participation, most of these services are provided by government agencies, creating potential inefficiencies due to resource misallocation and reduced incentives for farmers to improve productivity. Heavy reliance on government support can also distort farmers' decision-making, discouraging shifts towards sustainable practices. Moreover, uneven access to government programmes risks widening income disparities: better-resourced farmers have the capacity to participate and benefit, while marginal farmers are often excluded.

4.2 Financing Access for Rice Smallholder Farmers

Only about half of our respondents have bank accounts, consistent with World Bank findings (2020) with even lower ownership among respondents in East and West Java (33%). While formal financial inclusion has improved through government programmes that require vulnerable farmers to open accounts, overall participation remains low.

a. Loans and Insurance

More than half of respondents (54%) reported having no loans, largely due to risk aversion and unstable farm income. Among those who did borrow, the vast majority (80%) relied on informal sources such as relatives, neighbours, or cooperatives, while only less than 10% accessed formal credit from banks, cooperatives, or digital platforms. Formal loans tended to be significantly larger, averaging IDR 5 million, about three times the size of informal loans. Informal borrowing relied heavily on personal trust and social ties, with repayment failures risking both reputation and community relationships. Informal loans were preferred because of: 1) mutual trust between farmers and lenders; 2) payment flexibility; and 3) perceived low interest. Formal loans were somewhat more common in Yogyakarta and among farmers using irrigated-plus-pumping systems. West Java farmers showed the highest loan dependence (72%), mainly informal, reflecting their lower asset values.

Few farmers (3%) borrowed from supply chain actors, citing high interest rates and rigid terms. Digital lending also remained unpopular due to its negative reputation for.

Loans were primarily used for daily needs and farming inputs, with smaller shares allocated to business investments or family events. In terms of allocation, loans were used for daily expenses (41%, ~IDR 6.5 million) and farming inputs for the next growing season (~IDR 7.9 million), though many served multiple purposes. Larger loans supported business investment, family events, or house construction.

Uptake of subsidized rice farming insurance (AUTP) has been limited, despite the government covering 80% of premiums. Farmers cited low compensation (IDR 6 million/ha, only for >75% losses), exclusion of partial damage (e.g., 50% pest-related losses), and burdensome administrative processes as key barriers. A persistent mismatch exists between farmers' average loan needs (~IDR 8 million per 4,000 m²) and the limited farm insurance payout (IDR 6 million/ha), even with subsidies, helping explain weak demand for insurance. Despite frequent harvest losses, only 9% indicated a preference for farm insurance.

b. Financial Preferences

Fewer than 10% of farmers accessed formal financial services, with most preferring upfront cash loans or discounted agricultural inputs over insurance. Farmers valued financial services primarily for covering farming costs (61%), investment (31%), urgent household needs (25%), and accessing quality inputs (23%), with a strong preference for flexibility in how loans were used.

Around 70% of farmers avoided formal financing altogether, citing unreliable farm income (52%), complicated requirements (26%), and lack of collateral (26%). Existing microfinance products often treat farming as equivalent to small and medium-sized enterprises (SMEs), overlooking key differences between subsistence-oriented and commercial farming systems. Importantly, the low uptake was not driven by negative past experiences, as only 5% of respondents reported such cases. Age was another barrier: over 60% of respondents were older than 50, limiting adoption of digital financial tools. Only 5% used e-money and 17% used e-wallets, primarily ShopeePay, Dana, GoPay, and state-owned bank services.

Conclusion

Rice farming in Indonesia remains both an economic necessity and a critical household livelihood, yet it faces structural, financial, and environmental challenges that constrain its sustainability and growth. This study highlights several key findings:

1. **Demography and Farm Size:** Rice farming is dominated by older, less educated farmers, with limited youth participation due to small farm sizes, low returns, and few opportunities. Most rice farms are smaller than 0.5 hectares, leaving farmers highly vulnerable to climate shocks such as prolonged droughts and pest infestations.
2. **Farming Practices and Productivity:** Despite substantial government support through input subsidies and irrigation, practices remain heavily reliant on chemical fertilisers and pesticides. Irrigated farms achieve better yields, while rainfed farms are more exposed to climate risks. However, excessive input use (e.g., three harvests per year) could threaten soil health and long-term productivity.
3. **Income and Assets:** Rice harvests contribute significantly to rice farmers' household income, but they typically do not provide sufficient livelihood support. Only 13% of respondent farmers depend solely on rice farming; the majority diversify into livestock, other crops, or non-farm income sources such as kiosks, services, and remittances. Farmers with diversified household income accumulate more assets and are generally more resilient financially, though they often earn proportionally less from rice farming.
4. **Supply Chains:** Farmers rely on long, conventional supply chains dominated by middlemen, who also provide loans and post-harvest services. Limited post-harvest processing and weak agricultural extension services that deliver technical support to farmers, together with dependence on subsidies, restrict innovation and private-sector engagement. Unequal access to government programmes risks excluding marginal farmers and widening existing disparities.
5. **Financing and Risk Management**: Financial inclusion remains low: only half of farmers hold bank accounts, and fewer than one in ten access formal loans. Most farmers rely on informal credit, valued for its flexibility, trust-based relationships, and low cost. Borrowing proceeds are used mainly for daily needs and family events rather than agricultural inputs and additional investments. Uptake of subsidised farm insurance is very minimal due to limited coverage, complex claim process, and weak confidence that payouts will be made reliably. Indeed, farmers overwhelmingly prefer upfront cash loans or discounted inputs to insurance schemes.

Overall, smallholder rice farming sustains rural households but is neither highly profitable nor resilient in its current form. Rice farming remains central to food security and livelihoods, yet household resilience relies more on income diversification, robust social networks, and informal financial systems than on formal services or government-subsidized insurance.

Future works and Research Directions

This study provides a foundational assessment of the socio-economic and structural challenges facing Indonesian rice smallholders, underscoring the urgent need for more targeted interventions in financial inclusion, farming practice improvement, and technological adoption. Our findings also identify several critical priority areas for future research and pilot programmes that deserve immediate attention from academics, development partners, and private-sector stakeholders.

Given the increasing volatility in agricultural productivity, future work should prioritize the integration of climate risk into both contract design and financial risk modelling. Research is needed to develop and test contracts that explicitly incorporate climate adaptation strategies, such as insurance payouts tied to specific weather indices or mechanisms that adjust input provisioning based on seasonal forecasts. This focus would shift the agenda from general market risk mitigation to directly confronting the severe, systemic risks that inhibit lenders from treating contract farming as a credible basis for credit provision.

In parallel, future research should investigate innovative approaches to achieving full financial inclusion for contracted farmers. This includes assessing the efficacy of bundled services (e.g., credit and crop insurance offered jointly), analysing the success factors of digital financial services that leverage contract data for credit scoring, and designing policy experiments to test the impact of mandated "financial linkage" requirements for off-takers in high-value contract farming schemes. The ultimate goal of this line of inquiry is to identify scalable, technology-driven solutions that enable farmers to transition from mere contract participation to full, resilient integration into the formal financial system.

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