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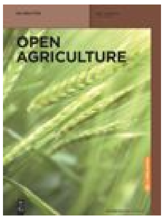

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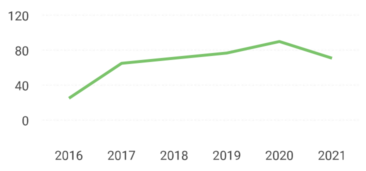

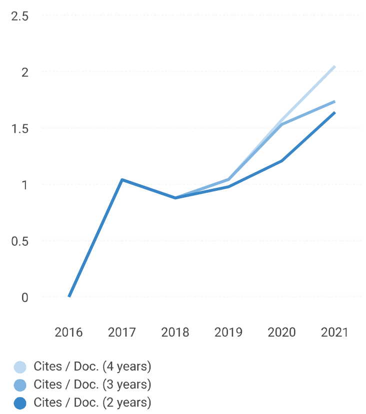

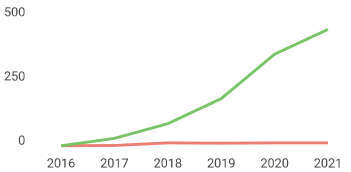

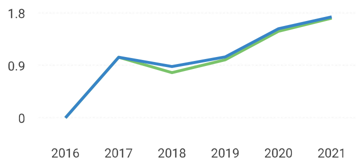

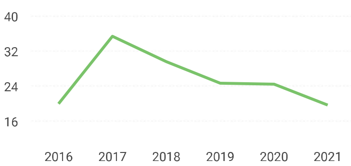

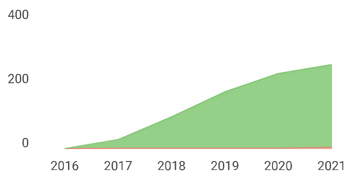

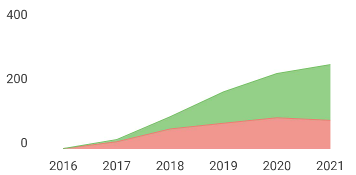

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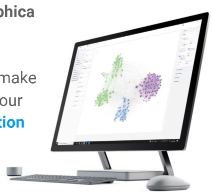

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Research Article

Poppy Arsil*, Yeong Sheng Tey, Mark Brindal, Ardiansyah, Eni Sumarni, Masrukhi

Perceived attributes driving the adoption of system of rice intensification: The Indonesian farmers' view

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Abstract: This article argues that the System of Rice Intensification (SRI) future promotion should be based on the potential users' good understanding of sustainable agriculture. A qualitative approach was used to examine the perceptions of SRI attributes among Indonesian rice farmers, which is built upon the developing theory of diffusion of innovation. Through focus group discussions in three Indonesian provinces, compatibility, complexity, and relative advantage were identified as essential factors for SRI adoption. SRI was seen as incompatible with current farming practices, labour capacity, budget, and time available for additional labour inputs. SRI was seen as relatively complicated in terms of compost processing and application as well as mechanised agricultural technologies. As a result of the economic surplus provided by SRI rice, organised farmers may be able to obtain a higher price for SRI rice than non-organised farmers. Environmental and agronomic benefits were thought to have a long-term payoff. Such results demonstrate the subjective evaluation of SRI by farmers, which is important to its implementation.

Keywords: compatibility, complexity, diffusion of innovation, Rogers' theory, relative advantage

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1 Introduction

One innovation aimed at increasing rice productivity is the System of Rice Intensification (SRI). This innovation emphasises sustainability principles in managing local plants, soil, water, and nutrients and their incorporation into farmers' current practices (where they deem compatible). SRI, as promoted to rice farmers in our study areas, is a set of principles [1]. Core principles of the SRI are (1) younger seedling, (2) one seedling planted at one clump, (3) wide square planting (more than 20 cm × 20 cm), and (4) intermittent irrigation [2]. SRI is a fluid technological package [1]. It needs to be adjusted according to local nuances. Even though the sudden conversion from standard practice to fully organic is not recommended [3], organic fertilisers are still advised to reduce synthetic fertilisers and improve the soil structure and quality [4]. Different kinds of biological control further differentiate SRI from conventional weed and pest management [1,4]. Through the SRI principles, rice plants are reported more resistant to pests and pathogens as their leaves are bolder, larger, and stronger than those planted using conventional systems [5]. When properly followed and implemented, chemical inputs, water, and seed are used efficiently [2]. Because the system diminishes external inputs, SRI principles have positive impacts on resource and environmental conservation [1]. As such, SRI offers a means to realise the goals of sustainable agriculture. Importantly, too, given its flexibility and robustness, SRI principles are applicable to small-scale farmers.

Despite offering great potential, the adoption rate of the SRI generally remains low, especially among Indonesian rice farmers [6–9]. However, little research effort has been made to understand why adoption rates remain low. This issue has, to the best of our knowledge, only been investigated by Takahashi [8]. Like many farmers' adoption studies (i.e. [10]), their investigation focused on relating the heterogeneity of producer, farm, institutional, and intervention variables to adoptive decisions.

Others investigate the effect of intermittent irrigation on rice yield [11]. Such approaches are criticised for providing a few practical insights, which might help extension agents understand how to encourage greater adoption [12,13]. Farmers' opinion and ideas are based on their experience over the years when practising farming. Therefore, their knowledge can be used as an explanation of the variation of input and output quantities in rice production that existed and sometimes cannot be explained statistically. The objective of SRI adoption set by policymakers is to increase farmer incomes and food security as well as improved environmental quality. Policymakers and change agents should understand SRI from the subjective view of farmers as potential users. Thus, policymakers can achieve the goal of adoption of the SRI method. Focus group discussion (FGD) is one way to obtain farmers' insight from different SRI exposure in a natural discussion guided by a moderator.

SRI was introduced in Indonesia during 1997. Local farmers were introduced to the SRI methods through self-help training in plant ecology lessons in 2002 in Tasikmalaya. As the pioneer, this area serves as a key learning resource to farmers or group of farmers, extension agents, and researchers. In contrast to the history of SRI in the Tasikmalaya regency, Purbalingga and Tabanan regencies followed the SRI program initiated by the Indonesian Government. The program was introduced to local farmers in the mid of 2000s. However, the adoption rate, for example in Purbalingga, was considered low, which was less than half of the local rice farmers who participated in the SRI programme initiated by the local Government.

In Rogers' seminal synthesis on the adoption of innovations, innovation attributes are identified as having a profound impact on farmers' adaptive decisions [14]. Agricultural studies have also demonstrated the importance of the perceived attributes of innovation in relation to its adoption (i.e. [15]). However, as posited in ref. [12], the current explanatory power of past empirical studies is less than adequate. Their work suggests that a lot of important information on perceived innovation attributes is likely to remain unaccounted when using restrictive empirical methods. To address this research gap that we have identified, this study examines the perceptions of SRI attributes held by current and potential Indonesian users. We propose to do this using the exploratory framework as prepositioned by Rogers [14]. In this framework, innovation attributes are theorised to influence farm decision-making in relation to its adoption. This study utilises a qualitative approach to understand adoption, focusing on the role of SRI attributes. The study aims to investigate farmers' views of perceived attributes driving the adoption of SRI through the use of a focus group in a frame of Rogers' theory of the adoption of innovation. A key benefit of this approach is that it does not involve judgement from the researchers. It values what individual farmers believe the attributes are and evaluates which attributes are acceptable from their point of view [16].

In Rogers' theory of diffusion of innovation [14], there are five common attributes of innovations: relative advantage, complexity, compatibility, observability, and trialability. Individuals are likely to vary in their perceptions according to a matrix based on their congruence stretching across attributes. The term "relative advantage" refers to the extent to which new ideas, behaviours, and objects are viewed as more innovative and superior to the innovations they are replacing [14]. It is commonly evidenced through financial costs and/or gains. Sustainable innovations that generate a net financial advantage, both perceived and actual, are more likely to be adopted [17]. Additional relative advantages include timesaving, reduction of discomfort, social prestige, and immediacy of the benefits from the innovation.

Compatibility is defined as the degree to which potential adopters perceived the innovation consistent with their existing values and past experiences [14]. This is traditionally interpreted in terms of the compatibility with an existing system, with little modification [18]. Sustainable innovations that are believed to be necessary and applicable are more likely to be adopted [19]. Similar inclination is also likely to crystallise when a sustainable innovation is aligned with the value of a social system [20]. Complexity is described as the degree to which potential users perceived the innovation as relatively difficult to comprehend and use ([14], p. 15). Complex innovations typically involve a new learning curve before initiating them into practice. They are less likely to be adopted [21]. Trialability is characterised by "the degree to which an innovation may be experimented with on a limited basis" ([14], p. 16). Trial on a small scale allows users to experiment with the integration of innovations within an existing system and to learn relative advantages and handle the complexity of innovations prior to their full implementation. Trialability thereby reduces the risk associated with and increases the likelihood of adoption [22]. Observability is the degree to which others can see the results of an innovation [14]. Visibility is split into practice observability and benefit observability. Being able to see the actual implementation and the associated benefits strengthen the inclination towards adoption [23]. According to Rogers [14], the perception of innovation attributes affects an individual's action. Favourable ones are more likely to induce farmers to adopt and continue using the innovation.

2 Methods

Guided by Rogers' conceptual framework [14], FGDs were conducted in the Tasikmalaya, Purbalingga, and Tabanan regencies. Tasikmalaya regency is known as the pioneer of SRI implementation and becomes the central learning of SRI farming practices. Purbalingga and Tabanan regencies followed through a government assistance program. Tasikmalaya and Purbalingga are regencies on the island of Java, the most populated island in Indonesia, whereas the Tabanan regency is located on the Bali island. Our target participants were rice farmers who have heard of the SRI. A total of 40 key informants participated in the FGD held. They were selected according to the recommendations made by local extension agents and the leader of farmer organisations. The participants were selected based on their knowledge and experience and their roles in the community. Two subgroup FGDs consisted of five to nine participants for each regency to give all participants enough time to share. The first subgroup consisted of farmers who received the SRI program's government assistance, whereas the other did not receive the assistance program for data cross-checking. Each subgroup involved SRI adopters and dis-adopters. Careful consideration was given to the definition of "SRI adopters." Figure 1 shows how the research was conducted to cross-check the data.

Some researchers have argued that farmers who applied at least one core practice of SRI can be classified as adopters [6,24]. That same definition is applied in local standards and, in turn, is used in this study. Dis-adopters are rice farmers who are aware of, have applied, but then have discontinued using SRI principles. A skilled moderator led the FGDs using a semi-structured interview. The moderator would stop the FGDs if no more comprehensive new information is identified.

As the FGDs were conducted in Indonesia, the collected information was transcribed and translated into English to achieve a standard understanding across the individual researchers involved in this study. Two researchers identified the common keywords, the subsequent themes (attributes), and patterns, which the FGD participants valued following Rogers' theory of the adoption of innovation.

3 Results and discussion

The characteristics of the participants of the FGDs are presented in Table 1. On average, the participants are approximately 50 years old, and most of them completed senior high school education. Two-thirds of the participants

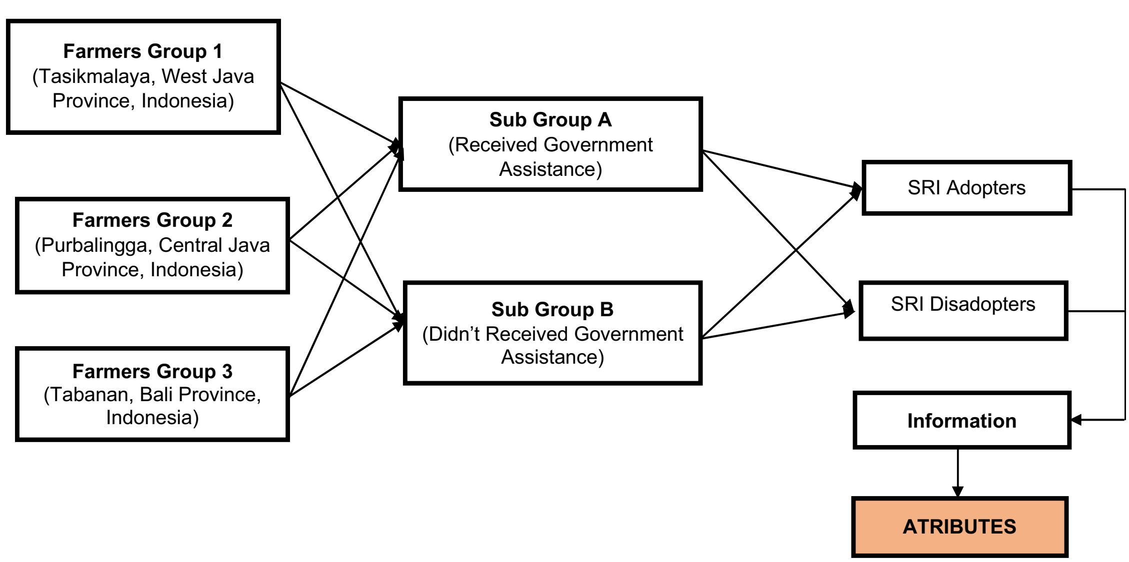

Figure 1: Research model.

Table 1: Respondents' characteristics of FGDs

Characteristics	Tasikmalaya (*n* = 12) Mean	Purbalingga (*n* = 18) Mean	Tabanan (*n* = 10) Mean	Overall (*n* = 40) Mean
Age (years old)	48.4	49.1	54.1	50.33
Male (%)	83	78	100	87
Education level				
Primary school (%)	16	—	10	8.7
Junior high school (%)	—	17	20	12.3
Senior high school (%)	42	50	60	50.7
University (%)	42	33	10	27.7
SRI adopters (%)	58.3	55.6	60	58
SRI dis-adopters (%)	41.7	44.4	40	42
Duration applying the SRI (year)	10	2.8	3.8	5.53
Land area planted using the SRI (ha)	6.146	3.740	3.681	4.52
Fertiliser and pest control methods				
Fully organic inputs (%)	16.7	—	20	12,3
Mixed organic and chemical inputs (%)	83.3	100	80	87.7

were adopters of the SRI. The pioneers in Tasikmalaya regency started using the SRI 10 years ago on 6.15 hectares of rice farm. Their counterparts in Purbalingga and Tabanan have had less than 5 years' experience with the innovation and applied it on smaller scales. It was observed that only a fraction of the adopters had entirely used organic inputs. The majority employed a mix of organic and chemical inputs.

FGD participants frequently mentioned common keywords such as rice yields, production costs, price of the SRI rice, the use of organic fertiliser, labour capacity, land preparation, and water irrigation control. The keywords were categorised into three significant attributes of SRI, according to Rogers' theory of the adoption of innovation. They are compatibility, complexity, and relative advantages. These findings are substantially congruent with Rogers' general framework [14]. Each of these significant attributes is interrelated with the others. Little mention was made of perceived trialability by implementing a trial on a small scale of paddy field to experiment with the innovation. The FGD participants did not mention perceived observability such as success story. These two less significant attributes are similarly identified by Tornatzky and Klein [25] and Rogers [14]. Table 2 shows the dimensions driving the adoption and dis-adoption of SRI.

3.1 Compatibility

Despite several years of experience, previous rice farming experience and local culture still constrained their SRI practises. This remains, therefore, a major concern. Application of the SRI principles requires the modification of existing farming practices. Adopters from the Purbalingga regency remained uncomfortable with planting seeds in a tray, shallow planting, and the land preparation methods, all of which are promoted under SRI. Similar concerns were also expressed by adopters from the Tabanan regency, specifically concerning the discipline required to grow seed for less than 10 days before transplanting and then transplant the seed at a rate of one seed per hole.

> "Although SRI techniques are well-intended to boost seedling survival rate and vegetation, it is difficult to change the mindset of farmworkers who are used to conventional methods."
> Dis-adopter from Tabanan, two years of SRI experience.

Resistance to change in technical aspect was commonly mentioned as partial reasoning contributing to dis-adoption. Those who chose to observe from the sidelines remained sceptical, preferring to wait to see how SRI techniques would affect farm productivity. The same observation is shared by Sato et al. [9] and Handono [26]. Other researchers also reported that some farmers are lazy to learn and adopt new technology [27].

The implementation of sustainable weed and pest management is labour intensive [28]. Participants typically observed rapid growth of weeds and snails as a result of the SRI because it involves cultivating rice with wide spacing between plants, the use of organic fertilisers, and less water. Snail invasion was said to be particularly prevalent soon after the transplanting cycle.

Table 2: Determinant attributes driving the adoption and dis-adoption of SRI following Rogers' theory of the adoption of innovation

Dimensions of innovation	Benefits	Obstacles
Compatibility	—	1. Need a modification of existing farming practices involving planting seeds technique, land preparation, and water control 2. Persistent to change in the technical view of rice agriculture
Complexity	—	1. Difficult to adjust the appropriate organic fertiliser according to spatial farming requirement 2. Farmers face a shortage of raw material for making organic fertiliser.
Relative advantages	1. Farmers believe that the SRI method yields higher productivity than conventional practices if farmers follow the SRI principles	1. Extra labour is needed for planting, weeding, applying fertiliser, and water control
	2. The production cost of seed might be reduced due to less seed used	2. Scarce farm labour against high industrial demand
	3. Price is higher than traditional farming of rice if the farmer cooperatives have bargaining power at the markets	3. Price seems the same as conventional rice farming if the farmers or farmer cooperatives have no bargaining power at the markets
	4. SRI increases natural pest and disease control in the paddy field	
	5. Soil condition improved	
	6. Water usage decreased	
Immediacy of results	—	A significant time gap between the time of adoption and returns of the application of SRI methods

3.2 Complexity

As SRI principles encourage organic fertiliser use, adopters have to grapple with a degree of complexity in judging the farm's nutrient needs and applying the appropriate organic fertiliser according to their farm's spatial requirements. The knowledge of integrated nutrient management is crucial for sustaining high yield of SRI [29]. In our study areas, composts are promoted as suitable organic fertilisers that restore organic matter and enhance soil properties. Subsidised by local Government, such organic fertiliser is sold at affordable prices. Given its affordability, high local demand is often unsatisfied because of supply shortages. Consequently, participants in the SRI program are often forced to do the extra task of making their own compost. Although most of them received training in both composting and application techniques, production and application processes in respect to composts are not always straightforward. Therefore, it is recommended that there is an unmet need to educate participants to become competent to troubleshoot composting problems (e.g. anaerobic fermentation or incorrect N:P:K balance) and determine the resultant quality of compost. This is in line with ref. 27 that increasing training access is useful to prepare farmers to practise SRI.

3.3 Relative advantages

Yield: Nearly all participants of the FGDs agreed that the SRI promises high productivity. Notwithstanding this, it must be noted that, in fact, productivity levels varied between enterprises.

However, the participants believed that the productivity of the SRI depends mainly on the adherence to its principles: use 5 tons/ha of compost, plant a single seedling in each hole with wide spacing between clumps, apply local microorganisms and at least four times, and conduct four periods of weeding each season. Liquid fermentation contains local microorganism derived from base material such as cow rumen or rabbit urine provided a useful decomposition tool for making nutrient available to plant. Then, the organism will reproduce with natural ingredients containing carbohydrates, proteins, vitamins, and minerals. Indeed, following these practices, adopters from Purbalingga and Tasikmalaya regencies produced approximately 7–8 ton/ha of milled rice in comparison to the yield of conventional methods. Similar findings are also recorded by [30], who reported that Bangladesh farmers who implement water-saving technology (WST) of rice agriculture recorded higher productivity than farmers who were practising the conventional irrigation method. The farmers' income also increased by 24.6% when using the WST method.

SRI's superior yield was said to be a key factor contributing to the inclination to adopt and continue using the SRI principles.

> "Most SRI farmers in my area do not strictly follow the recommendations. We applied 3 ton/ha of compost, sole cropping systems, one time of local microorganisms, and 2–3 times of weeding in a season. We only produced about 7–8 ton/ha of milled rice on average. Nevertheless, the yield is still considered high compared to the 5 ton/ha of milled rice produced through conventional farming in the local area. Although we do not entirely follow the SRI, we are more directed to organic farming. Collectively, nearly 70% of land in Manonjaya sub-district is planted using organic methods, and the certified organic farmland is about 37 hectares."
> Adopter from Tasikmalaya, 10 years of SRI experience.

Production costs: Among participants of the FGDs, who have had experience with SRI techniques, there were mixed opinions with regard to production costs of SRI. Such findings were related to variations in the cost of seed, labour input, and organic fertilisers. Rice cultivated under the SRI generally uses less seed than conventional systems. Adopters from the Tabanan regency indicated that the cost of seeds was reduced as much as 65% and this had led them to save more money.

As previously mentioned, extra labour hours were necessarily allocated for planting, weeding, fertilisation, and irrigation activities. The greater demand for human input further squeezed the already scarce farm labour, which has increasingly shifted to other industries. The availability of farm labour thus becomes a critical issue in some local contexts. For example, access to labour has been identified as a key factor determining the continuity of SRI in the Jeneponto district of the South Sulawesi province [8] and Madagascar [27]. Farmers who have an opportunity to more labour resources have increased their capability to adopt SRI [27].

As demonstrated above, any calculation of production costs is not straightforward. The application of SRI techniques could save nearly 20% production cost [31] and decrease production cost with the benefit–cost ratio of 1.49 [30]. However, FGD participants relied on their subjective evaluation rather than an objective one when weighing the cost and benefit for their decision-making.

> "We support the government program aiming at achieving 10 ton/ha of milled rice. Through SRI techniques, I used to produce around 8 ton/ha of milled rice, but its production cost was high. In opposite, the *Jajar Legowo* technique, a planting rice method with the pattern of multiple rows of rice plant interspersed with an empty row, is simpler in terms of planting and crop maintenance. Although I achieved slightly lower yield (7–7.7 ton/ha) using the traditional method, the associated cost was significantly lower."
> Dis-adopter from the Tabanan regency, 6 years of SRI experience.

Price of SRI rice: The price of SRI rice was suggested to be the most important factor driving farmer decisions in relation to adoption and dis-adoption. Rice produced using the SRI principles, especially organic rice, is considered to be of higher quality and to have health benefits. Consequently, it should follow that SRI farmers should reap higher prices. However, two divisions were noted among our focus group participants. Organic SRI rice in the Purbalingga regency typically commands a price premium of about 50% above the standard market price. At the time of study, the SRI rice was sold for around 12,000–13,000 IDR/kg, and undifferentiated rice was priced at approximately 8,000 IDR/kg. This pricing outcome was due to the collective bargaining power of group action. Local organic farmers were engaged and organised through the Pamorbangga Farmer Association. The farmer association worked as a marketing agent, distributing local organic rice to Jakarta – the capital city of Indonesia – and selling directly to consumers. Without going through any middlemen, the farmer association recorded a higher profit margin and returned greater profits to its members.

> "Price of the organic rice that sold through the Pamorbangga Farmer Association is lucrative. However, this farmer association only covers a sub-district, and there are many organic farmers out there. We hope the local Government will help and support us to extend the outreach of the farmer association."
> Adopter from Purbalingga, 5 years of SRI experience.

In contrast, participants from the Tasikmalaya and Tabanan regencies had significantly less bargaining power on an individual basis. The price achieved for rice grown using SRI principles was only marginally higher than the price of conventional rice. Such pricing was already generally lower (8,000–9,000 IDR/kg) than the returns in the Purbalingga regency. This occurred because SRI rice was sold directly to a farmers' group (*gapoktan*) in the Tasikmalaya regency. With little premium gained for the extra effort involved, participants were demotivated and expressed an intention to quit the SRI.

> "Healthy rice is what we called for rice produced using SRI methods. However, its demand is still low. That leads to the low prices of SRI rice."
> Dis-adopter from Tabanan, 1 year of SRI experience.

Agronomic benefits: Through the integrated pest management that is promoted under the SRI, participants of our FGDs believed that they are likely to strike a natural balance in which pests and diseases are well controlled. Anecdotal evidence was provided by an adopter from Purbalingga that his rice plants cultivated using SRI techniques were more pest and disease resistant. The use of SRI is also believed to improve environmental quality such as improved soil aeration. Plants were also more resistant to diseases and pests [30]. Adopters of SRI observed that their soil conditions differed from non-users of SRI techniques.

Water-saving derived from the irrigation management that is promoted under the SRI was another significant impact that is valued by participants of the FGDs. Under controlled environment, water usage of SRI can be reduced up to 86% [4,30]. This translates into a significant improvement in water productivity [30]. Such benefit was said to be particularly critical during dry seasons.

Immediacy of results: Participants in our FGDs emphasised that they cannot afford to wait for long periods before they benefit from adopting SRI. Adopters have invested significant effort to learn and master SRI techniques to produce more satisfactory yields. In other words, there is a significant time gap between learning SRI methods and optimising returns from its use. Such lead times have led dis-adopters to believe that the SRI does not promise lucrative benefits in the short-term. This concern was particularly highlighted by participants who worked on leased lands under time-limited tenancies across all three study areas. As a result, such farmers had the minimal motivation to invest in the SRI.

Arsil et al. [32] who conducted a study regarding perceived importance and performance of SRI attributes between adopters and dis-adopters reported that "profit," "risk," and "effort" are three critical attributes for rice farmers. The performance of those attributes was reported below the average. In this study, profit is related to rice yield, production cost, and price. As other business-like attributes, the benefit is an important attribute by farmers. Therefore, the promotion of SRI should involve any effort related to increasing the SRI price. The risk was identified as a second essential attribute for both adopters and dis-adopters. Crop failure due to the complexity of mastering the SRI technique such as organic fertiliser application, farm nutrient needs according to their spatial requirement, land preparation, and planting the seed in trays are identified as barriers to adopt SRI for farmers. Applying the SRI technique is sometimes thought to be a waste of time and effort for farmers.

This study highlights that it is a subjective evaluation of SRI attributes that drives its adoption. While learning through experience, adopters remain objective. For example, SRI users expect their organic rice to command higher prices both in view of higher production costs and to achieve acceptable profit levels. Failure to meet their objectives is likely to result in discontinuation of SRI. The adoption process varied slightly between farmers and regions during the application of fertiliser and pest control method. Bali and Tasikmalaya farmers seem to use more organic fertiliser and pest control during the adoption of SRI. The heterogeneity of adoption might be affected by psychological, behavioural, economic, and technological factors [33].

4 Conclusions and policy implications

Through FGDs, a number of perceived attributes have been identified. Compatibility, complexity, and relative advantage appeared to be the key attributes driving the adoption of SRI. As their motivation for the adoption of SRI is centred on the relative advantages of economic returns, future promotions of SRI should highlight and inform potential users of the degree to which SRI is more profitable than competing rice farming systems in both the short- and long-run. Having convinced them to use and stay in the program seems likely to overcome farmer difficulty in the perception of SRI's non-economic relative advantages in the long-term.

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Perceived attributes driving the adoption of system of rice intensification: The Indonesian farmers' view

by Ardiansyah Ardiansyah

Research Article

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Perceived attributes driving the adoption of system of rice intensification: The Indonesian farmers' view

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Abstract: This article argues that the System of Rice Intensification (SRI) future promotion should be based on the potential users' good understanding of sustainable agriculture. A qualitative approach was used to examine the perceptions of SRI attributes among Indonesian rice farmers, which is built upon the developing theory of diffusion of innovation. Through focus group discussions in three Indonesian provinces, compatibility, complexity, and relative advantage were identified as essential factors for SRI adoption. SRI was seen as incompatible with current farming practices, labour capacity, budget, and time available for additional labour inputs. SRI was seen as relatively complicated in terms of compost processing and application as well as mechanised agricultural technologies. As a result of the economic surplus provided by SRI rice, organised farmers may be able to obtain a higher price for SRI rice than non-organised farmers. Environmental and agronomic benefits were thought to have a long-term payoff. Such results demonstrate the subjective evaluation of SRI by farmers, which is important to its implementation.

Keywords: compatibility, complexity, diffusion of innovation, Rogers' theory, relative advantage

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1 Introduction

One innovation aimed at increasing rice productivity is the System of Rice Intensification (SRI). This innovation emphasises sustainability principles in managing local plants, soil, water, and nutrients and their incorporation into farmers' current practices (where they deem compatible). SRI, as promoted to rice farmers in our study areas, is a set of principles [1]. Core principles of the SRI are (1) younger seedling, (2) one seedling planted at one clump, (3) wide square planting (more than 20 cm × 20 cm), and (4) intermittent irrigation [2]. SRI is a fluid technological package [1]. It needs to be adjusted according to local nuances. Even though the sudden conversion from standard practice to fully organic is not recommended [3], organic fertilisers are still advised to reduce synthetic fertilisers and improve the soil structure and quality [4]. Different kinds of biological control further differentiate SRI from conventional weed and pest management [1,4]. Through the SRI principles, rice plants are reported more resistant to pests and pathogens as their leaves are bolder, larger, and stronger than those planted using conventional systems [5]. When properly followed and implemented, chemical inputs, water, and seed are used efficiently [2]. Because the system diminishes external inputs, SRI principles have positive impacts on resource and environmental conservation [1]. As such, SRI offers a means to realise the goals of sustainable agriculture. Importantly, too, given its flexibility and robustness, SRI principles are applicable to small-scale farmers.

Despite offering great potential, the adoption rate of the SRI generally remains low, especially among Indonesian rice farmers [6–9]. However, little research effort has been made to understand why adoption rates remain low. This issue has, to the best of our knowledge, only been investigated by Takahashi [8]. Like many farmers' adoption studies (i.e. [10]), their investigation focused on relating the heterogeneity of producer, farm, institutional, and intervention variables to adoptive decisions.

Others investigate the effect of intermittent irrigation on rice yield [11]. Such approaches are criticised for providing a few practical insights, which might help extension agents understand how to encourage greater adoption [12,13]. Farmers' opinion and ideas are based on their experience over the years when practising farming. Therefore, their knowledge can be used as an explanation of the variation of input and output quantities in rice production that existed and sometimes cannot be explained statistically. The objective of SRI adoption set by policymakers is to increase farmer incomes and food security as well as improved environmental quality. Policymakers and change agents should understand SRI from the subjective view of farmers as potential users. Thus, policymakers can achieve the goal of adoption of the SRI method. Focus group discussion (FGD) is one way to obtain farmers' insight from different SRI exposure in a natural discussion guided by a moderator.

SRI was introduced in Indonesia during 1997. Local farmers were introduced to the SRI methods through self-help training in plant ecology lessons in 2002 in Tasikmalaya. As the pioneer, this area serves as a key learning resource to farmers or group of farmers, extension agents, and researchers. In contrast to the history of SRI in the Tasikmalaya regency, Purbalingga and Tabanan regencies followed the SRI program initiated by the Indonesian Government. The program was introduced to local farmers in the mid of 2000s. However, the adoption rate, for example in Purbalingga, was considered low, which was less than half of the local rice farmers who participated in the SRI programme initiated by the local Government.

In Rogers' seminal synthesis on the adoption of innovations, innovation attributes are identified as having a profound impact on farmers' adaptive decisions [14]. Agricultural studies have also demonstrated the importance of the perceived attributes of innovation in relation to its adoption (i.e. [15]). However, as posited in ref. [12], the current explanatory power of past empirical studies is less than adequate. Their work suggests that a lot of important information on perceived innovation attributes is likely to remain unaccounted when using restrictive empirical methods. To address this research gap that we have identified, this study examines the perceptions of SRI attributes held by current and potential Indonesian users. We propose to do this using the exploratory framework as prepositioned by Rogers [14]. In this framework, innovation attributes are theorised to influence farm decision-making in relation to its adoption. This study utilises a qualitative approach to understand adoption, focusing on the role of SRI attributes. The study aims to investigate farmers' views of perceived attributes driving the adoption of SRI through the use of a focus group in a frame of Rogers' theory of the adoption of innovation. A key benefit of this approach is that it does not involve judgement from the researchers. It values what individual farmers believe the attributes are and evaluates which attributes are acceptable from their point of view [16].

In Rogers' theory of diffusion of innovation [14], there are five common attributes of innovations: relative advantage, complexity, compatibility, observability, and trialability. Individuals are likely to vary in their perceptions according to a matrix based on their congruence stretching across attributes. The term "relative advantage" refers to the extent to which new ideas, behaviours, and objects are viewed as more innovative and superior to the innovations they are replacing [14]. It is commonly evidenced through financial costs and/or gains. Sustainable innovations that generate a net financial advantage, both perceived and actual, are more likely to be adopted [17]. Additional relative advantages include timesaving, reduction of discomfort, social prestige, and immediacy of the benefits from the innovation.

Compatibility is defined as the degree to which potential adopters perceived the innovation consistent with their existing values and past experiences [14]. This is traditionally interpreted in terms of the compatibility with an existing system, with little modification [18]. Sustainable innovations that are believed to be necessary and applicable are more likely to be adopted [19]. Similar inclination is also likely to crystallise when a sustainable innovation is aligned with the value of a social system [20]. Complexity is described as the degree to which potential users perceived the innovation as relatively difficult to comprehend and use ([14], p. 15). Complex innovations typically involve a new learning curve before initiating them into practice. They are less likely to be adopted [21]. Trialability is characterised by "the degree to which an innovation may be experimented with on a limited basis" ([14], p. 16). Trial on a small scale allows users to experiment with the integration of innovations within an existing system and to learn relative advantages and handle the complexity of innovations prior to their full implementation. Trialability thereby reduces the risk associated with and increases the likelihood of adoption [22]. Observability is the degree to which others can see the results of an innovation [14]. Visibility is split into practice observability and benefit observability. Being able to see the actual implementation and the associated benefits strengthen the inclination towards adoption [23]. According to Rogers [14], the perception of innovation attributes affects an individual's action. Favourable ones are more likely to induce farmers to adopt and continue using the innovation.

2 Methods

Guided by Rogers' conceptual framework [14], FGDs were conducted in the Tasikmalaya, Purbalingga, and Tabanan regencies. Tasikmalaya regency is known as the pioneer of SRI implementation and becomes the central learning of SRI farming practices. Purbalingga and Tabanan regencies followed through a government assistance program. Tasikmalaya and Purbalingga are regencies on the island of Java, the most populated island in Indonesia, whereas the Tabanan regency is located on the Bali island. Our target participants were rice farmers who have heard of the SRI. A total of 40 key informants participated in the FGD held. They were selected according to the recommendations made by local extension agents and the leader of farmer organisations. The participants were selected based on their knowledge and experience and their roles in the community. Two subgroup FGDs consisted of five to nine participants for each regency to give all participants enough time to share. The first subgroup consisted of farmers who received the SRI program's government assistance, whereas the other did not receive the assistance program for data cross-checking. Each subgroup involved SRI adopters and dis-adopters. Careful consideration was given to the definition of "SRI adopters." Figure 1 shows how the research was conducted to cross-check the data.

Some researchers have argued that farmers who applied at least one core practice of SRI can be classified as adopters [6,24]. That same definition is applied in local standards and, in turn, is used in this study. Dis-adopters are rice farmers who are aware of, have applied, but then have discontinued using SRI principles. A skilled moderator led the FGDs using a semi-structured interview. The moderator would stop the FGDs if no more comprehensive new information is identified.

As the FGDs were conducted in Indonesia, the collected information was transcribed and translated into English to achieve a standard understanding across the individual researchers involved in this study. Two researchers identified the common keywords, the subsequent themes (attributes), and patterns, which the FGD participants valued following Rogers' theory of the adoption of innovation.

3 Results and discussion

The characteristics of the participants of the FGDs are presented in Table 1. On average, the participants are approximately 50 years old, and most of them completed senior high school education. Two-thirds of the participants

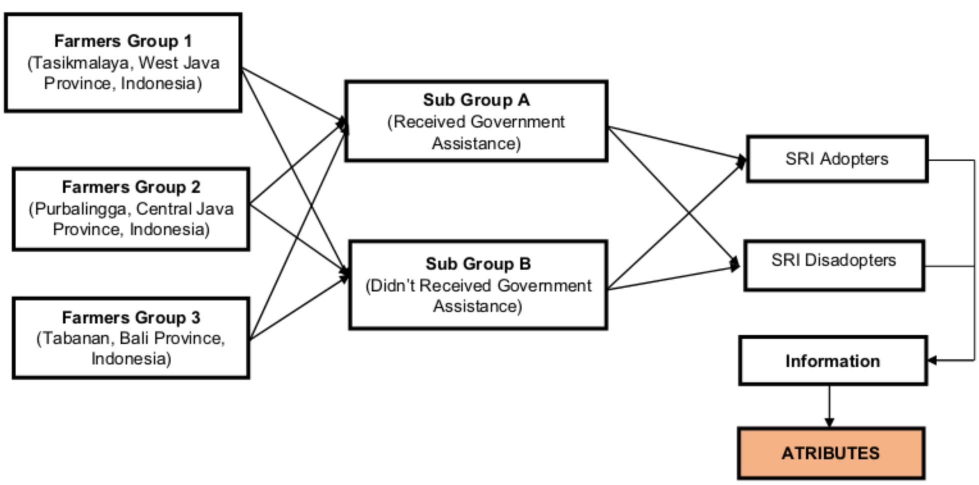

Figure 1: Research model.

Table 1: Respondents' characteristics of FGDs

Characteristics	Tasikmalaya (*n* = 12) Mean	Purbalingga (*n* = 18) Mean	Tabanan (*n* = 10) Mean	Overall (*n* = 40) Mean
Age (years old)	48.4	49.1	54.1	50.33
Male (%)	83	78	100	87
Education level				
Primary school (%)	16	—	10	8.7
Junior high school (%)	—	17	20	12.3
Senior high school (%)	42	50	60	50.7
University (%)	42	33	10	27.7
SRI adopters (%)	58.3	55.6	60	58
SRI dis-adopters (%)	41.7	44.4	40	42
Duration applying the SRI (year)	10	2.8	3.8	5.53
Land area planted using the SRI (ha)	6.146	3.740	3.681	4.52
Fertiliser and pest control methods				
Fully organic inputs (%)	16.7	—	20	12,3
Mixed organic and chemical inputs (%)	83.3	100	80	87.7

were adopters of the SRI. The pioneers in Tasikmalaya regency started using the SRI 10 years ago on 6.15 hectares of rice farm. Their counterparts in Purbalingga and Tabanan have had less than 5 years' experience with the innovation and applied it on smaller scales. It was observed that only a fraction of the adopters had entirely used organic inputs. The majority employed a mix of organic and chemical inputs.

FGD participants frequently mentioned common keywords such as rice yields, production costs, price of the SRI rice, the use of organic fertiliser, labour capacity, land preparation, and water irrigation control. The keywords were categorised into three significant attributes of SRI, according to Rogers' theory of the adoption of innovation. They are compatibility, complexity, and relative advantages. These findings are substantially congruent with Rogers' general framework [14]. Each of these significant attributes is interrelated with the others. Little mention was made of perceived trialability by implementing a trial on a small scale of paddy field to experiment with the innovation. The FGD participants did not mention perceived observability such as success story. These two less significant attributes are similarly identified by Tornatzky and Klein [25] and Rogers [14]. Table 2 shows the dimensions driving the adoption and dis-adoption of SRI.

3.1 Compatibility

Despite several years of experience, previous rice farming experience and local culture still constrained their SRI practises. This remains, therefore, a major concern. Application of the SRI principles requires the modification of existing farming practices. Adopters from the Purbalingga regency remained uncomfortable with planting seeds in a tray, shallow planting, and the land preparation methods, all of which are promoted under SRI. Similar concerns were also expressed by adopters from the Tabanan regency, specifically concerning the discipline required to grow seed for less than 10 days before transplanting and then transplant the seed at a rate of one seed per hole.

> "Although SRI techniques are well-intended to boost seedling survival rate and vegetation, it is difficult to change the mindset of farmworkers who are used to conventional methods."
> Dis-adopter from Tabanan, two years of SRI experience.

Resistance to change in technical aspect was commonly mentioned as partial reasoning contributing to dis-adoption. Those who chose to observe from the sidelines remained sceptical, preferring to wait to see how SRI techniques would affect farm productivity. The same observation is shared by Sato et al. [9] and Handono [26]. Other researchers also reported that some farmers are lazy to learn and adopt new technology [27].

The implementation of sustainable weed and pest management is labour intensive [28]. Participants typically observed rapid growth of weeds and snails as a result of the SRI because it involves cultivating rice with wide spacing between plants, the use of organic fertilisers, and less water. Snail invasion was said to be particularly prevalent soon after the transplanting cycle.

Table 2: Determinant attributes driving the adoption and dis-adoption of SRI following Rogers' theory of the adoption of innovation

Dimensions of innovation	Benefits	Obstacles
Compatibility	–	1. Need a modification of existing farming practices involving planting seeds technique, land preparation, and water control 2. Persistent to change in the technical view of rice agriculture
Complexity	–	1. Difficult to adjust the appropriate organic fertiliser according to spatial farming requirement 2. Farmers face a shortage of raw material for making organic fertiliser.
Relative advantages	1. Farmers believe that the SRI method yields higher productivity than conventional practices if farmers follow the SRI principles 2. The production cost of seed might be reduced due to less seed used 3. Price is higher than traditional farming of rice if the farmer cooperatives have bargaining power at the markets 4. SRI increases natural pest and disease control in the paddy field 5. Soil condition improved 6. Water usage decreased	1. Extra labour is needed for planting, weeding, applying fertiliser, and water control 2. Scarce farm labour against high industrial demand 3. Price seems the same as conventional rice farming if the farmers or farmer cooperatives have no bargaining power at the markets
Immediacy of results	–	A significant time gap between the time of adoption and returns of the application of SRI methods

3.2 Complexity

As SRI principles encourage organic fertiliser use, adopters have to grapple with a degree of complexity in judging the farm's nutrient needs and applying the appropriate organic fertiliser according to their farm's spatial requirements. The knowledge of integrated nutrient management is crucial for sustaining high yield of SRI [29]. In our study areas, composts are promoted as suitable organic fertilisers that restore organic matter and enhance soil properties. Subsidised by local Government, such organic fertiliser is sold at affordable prices. Given its affordability, high local demand is often unsatisfied because of supply shortages. Consequently, participants in the SRI program are often forced to do the extra task of making their own compost. Although most of them received training in both composting and application techniques, production and application processes in respect to composts are not always straightforward. Therefore, it is recommended that there is an unmet need to educate participants to become competent to troubleshoot composting problems (e.g. anaerobic fermentation or incorrect N:P:K balance) and determine the resultant quality of compost. This is in line with ref. 27 that increasing training access is useful to prepare farmers to practise SRI.

3.3 Relative advantages

Yield: Nearly all participants of the FGDs agreed that the SRI promises high productivity. Notwithstanding this, it must be noted that, in fact, productivity levels varied between enterprises.

However, the participants believed that the productivity of the SRI depends mainly on the adherence to its principles: use 5 tons/ha of compost, plant a single seedling in each hole with wide spacing between clumps, apply local microorganisms and at least four times, and conduct four periods of weeding each season. Liquid fermentation contains local microorganism derived from base material such as cow rumen or rabbit urine provided a useful decomposition tool for making nutrient available to plant. Then, the organism will reproduce with natural ingredients containing carbohydrates, proteins, vitamins, and minerals. Indeed, following these practices, adopters from Purbalingga and Tasikmalaya regencies produced approximately 7–8 ton/ha of milled rice in comparison to the yield of conventional methods. Similar findings are also recorded by [30], who reported that Bangladesh farmers who implement water-saving technology (WST) of rice agriculture recorded higher productivity than farmers who were practising the conventional irrigation method. The farmers' income also increased by 24.6% when using the WST method.

SRI's superior yield was said to be a key factor contributing to the inclination to adopt and continue using the SRI principles.

> "Most SRI farmers in my area do not strictly follow the recommendations. We applied 3 ton/ha of compost, sole cropping systems, one time of local microorganisms, and 2–3 times of weeding in a season. We only produced about 7–8 ton/ha of milled rice on average. Nevertheless, the yield is still considered high compared to the 5 ton/ha of milled rice produced through conventional farming in the local area. Although we do not entirely follow the SRI, we are more directed to organic farming. Collectively, nearly 70% of land in Manonjaya sub-district is planted using organic methods, and the certified organic farmland is about 37 hectares."
> Adopter from Tasikmalaya, 10 years of SRI experience.

Production costs: Among participants of the FGDs, who have had experience with SRI techniques, there were mixed opinions with regard to production costs of SRI. Such findings were related to variations in the cost of seed, labour input, and organic fertilisers. Rice cultivated under the SRI generally uses less seed than conventional systems. Adopters from the Tabanan regency indicated that the cost of seeds was reduced as much as 65% and this had led them to save more money.

As previously mentioned, extra labour hours were necessarily allocated for planting, weeding, fertilisation, and irrigation activities. The greater demand for human input further squeezed the already scarce farm labour, which has increasingly shifted to other industries. The availability of farm labour thus becomes a critical issue in some local contexts. For example, access to labour has been identified as a key factor determining the continuity of SRI in the Jeneponto district of the South Sulawesi province [8] and Madagascar [27]. Farmers who have an opportunity to more labour resources have increased their capability to adopt SRI [27].

As demonstrated above, any calculation of production costs is not straightforward. The application of SRI techniques could save nearly 20% production cost [31] and decrease production cost with the benefit–cost ratio of 1.49 [30]. However, FGD participants relied on their subjective evaluation rather than an objective one when weighing the cost and benefit for their decision-making.

> "We support the government program aiming at achieving 10 ton/ha of milled rice. Through SRI techniques, I used to produce around 8 ton/ha of milled rice, but its production cost was high. In opposite, the *Jajar Legowo* technique, a planting rice method with the pattern of multiple rows of rice plant interspersed with an empty row, is simpler in terms of planting and crop maintenance. Although I achieved slightly lower yield (7–7.7 ton/ha) using the traditional method, the associated cost was significantly lower."
> Dis-adopter from the Tabanan regency, 6 years of SRI experience.

Price of SRI rice: The price of SRI rice was suggested to be the most important factor driving farmer decisions in relation to adoption and dis-adoption. Rice produced using the SRI principles, especially organic rice, is considered to be of higher quality and to have health benefits. Consequently, it should follow that SRI farmers should reap higher prices. However, two divisions were noted among our focus group participants. Organic SRI rice in the Purbalingga regency typically commands a price premium of about 50% above the standard market price. At the time of study, the SRI rice was sold for around 12,000–13,000 IDR/kg, and undifferentiated rice was priced at approximately 8,000 IDR/kg. This pricing outcome was due to the collective bargaining power of group action. Local organic farmers were engaged and organised through the Pamorbangga Farmer Association. The farmer association worked as a marketing agent, distributing local organic rice to Jakarta – the capital city of Indonesia – and selling directly to consumers. Without going through any middlemen, the farmer association recorded a higher profit margin and returned greater profits to its members.

> "Price of the organic rice that sold through the Pamorbangga Farmer Association is lucrative. However, this farmer association only covers a sub-district, and there are many organic farmers out there. We hope the local Government will help and support us to extend the outreach of the farmer association."
> Adopter from Purbalingga, 5 years of SRI experience.

In contrast, participants from the Tasikmalaya and Tabanan regencies had significantly less bargaining power on an individual basis. The price achieved for rice grown using SRI principles was only marginally higher than the price of conventional rice. Such pricing was already generally lower (8,000–9,000 IDR/kg) than the returns in the Purbalingga regency. This occurred because SRI rice was sold directly to a farmers' group (*gapoktan*) in the Tasikmalaya regency. With little premium gained for the extra effort involved, participants were demotivated and expressed an intention to quit the SRI.

> "Healthy rice is what we called for rice produced using SRI methods. However, its demand is still low. That leads to the low prices of SRI rice."
> Dis-adopter from Tabanan, 1 year of SRI experience.

Agronomic benefits: Through the integrated pest management that is promoted under the SRI, participants of our FGDs believed that they are likely to strike a natural balance in which pests and diseases are well controlled. Anecdotal evidence was provided by an adopter from Purbalingga that his rice plants cultivated using SRI techniques were more pest and disease resistant. The use of SRI is also believed to improve environmental quality such as improved soil aeration. Plants were also more resistant to diseases and pests [30]. Adopters of SRI observed that their soil conditions differed from non-users of SRI techniques.

Water-saving derived from the irrigation management that is promoted under the SRI was another significant impact that is valued by participants of the FGDs. Under controlled environment, water usage of SRI can be reduced up to 86% [4,30]. This translates into a significant improvement in water productivity [30]. Such benefit was said to be particularly critical during dry seasons.

Immediacy of results: Participants in our FGDs emphasised that they cannot afford to wait for long periods before they benefit from adopting SRI. Adopters have invested significant effort to learn and master SRI techniques to produce more satisfactory yields. In other words, there is a significant time gap between learning SRI methods and optimising returns from its use. Such lead times have led dis-adopters to believe that the SRI does not promise lucrative benefits in the short-term. This concern was particularly highlighted by participants who worked on leased lands under time-limited tenancies across all three study areas. As a result, such farmers had the minimal motivation to invest in the SRI.

Arsil et al. [32] who conducted a study regarding perceived importance and performance of SRI attributes between adopters and dis-adopters reported that "profit," "risk," and "effort" are three critical attributes for rice farmers. The performance of those attributes was reported below the average. In this study, profit is related to rice yield, production cost, and price. As other business-like attributes, the benefit is an important attribute by farmers. Therefore, the promotion of SRI should involve any effort related to increasing the SRI price. The risk was identified as a second essential attribute for both adopters and dis-adopters. Crop failure due to the complexity of mastering the SRI technique such as organic fertiliser application, farm nutrient needs according to their spatial requirement, land preparation, and planting the seed in trays are identified as barriers to adopt SRI for farmers. Applying the SRI technique is sometimes thought to be a waste of time and effort for farmers.

This study highlights that it is a subjective evaluation of SRI attributes that drives its adoption. While learning through experience, adopters remain objective. For example, SRI users expect their organic rice to command higher prices both in view of higher production costs and to achieve acceptable profit levels. Failure to meet their objectives is likely to result in discontinuation of SRI. The adoption process varied slightly between farmers and regions during the application of fertiliser and pest control method. Bali and Tasikmalaya farmers seem to use more organic fertiliser and pest control during the adoption of SRI. The heterogeneity of adoption might be affected by psychological, behavioural, economic, and technological factors [33].

4 Conclusions and policy implications

Through FGDs, a number of perceived attributes have been identified. Compatibility, complexity, and relative advantage appeared to be the key attributes driving the adoption of SRI. As their motivation for the adoption of SRI is centred on the relative advantages of economic returns, future promotions of SRI should highlight and inform potential users of the degree to which SRI is more profitable than competing rice farming systems in both the short- and long-run. Having convinced them to use and stay in the program seems likely to overcome farmer difficulty in the perception of SRI's non-economic relative advantages in the long-term.

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