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Why Do Farmers Disadopt Successful Innovations? Socio-Ecological Niches and Rice Intensification

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Abstract: The adoption of innovations in rice cultivation is presumed to operate in a rational manner, wherein new technologies or practices that successfully increase productivity or resource efficiency are adopted by target farmers based on cost-benefit calculations. In contrast, this paper examines a case of a public initiative to promote the system of rice intensification (SRI), wherein farmers widely disadopted the technique despite reporting increasing yields and reduced water consumption. To explain this paradox, we use the concept of the socio-ecological niche to examine a range of social and institutional factors that shape farmers' decision-making. These included (1) access to land and labour; (2) water management capacity; (3) the quality of networks for knowledge sharing. The research suggests that small variations in these categories among otherwise similar smallholder households can markedly shape farmers' risk perceptions and tangible outcomes with SRI. The implication is that agricultural innovations should be judged within their wider social context rather than on narrow evaluations of agronomic efficiency. Importantly, this must involve greater feedback mechanisms from smallholders with a variety of socio-economic profiles to help shape the character of agricultural innovations and extension strategies.

Keywords: system of rice intensification; socio-ecological niche; agricultural innovations; technology transfer; rural India; Telangana; agronomy for development



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1. Introduction

How do we explain cases where successful agricultural innovations in rice cultivation—i.e., those in which farmers report successes in key goals such as increased productivity and resource efficiency—are widely disadopted by smallholders shortly after their introduction? This paper addresses such a case with a focus on the system of rice intensification (SRI), which was introduced through a widescale government program to smallholders in the semi-arid region of Mahabubnagar, South India. In this study, a clear majority of interviewed smallholder farmers spanning a cluster of six villages agreed that the system of rice intensification delivered two core agronomic benefits promised by implementing agencies: (1) improved yields and (2) reduced water usage. Paradoxically, however, our research showed that few, if any, of the smallholders interviewed continued with the method after the initial period of supervised and subsidised promotion. This leads to a key research question: why would smallholders abandon a seemingly rational cultivation method that they acknowledge contributes to enhanced productivity and water efficiencies?

To answer this question, our research conducted open-ended interviews with farmers aimed at highlighting the relative fit between the agronomic practices of SRI and their social and environmental contexts. To do so, we draw upon recent contributions to the analysis of agricultural technology adaption that emphasise the importance of smallholder diversity. As this literature highlights, even relatively small differentials in social and ecological contexts can have wide implications for technology adoption [1–3]. Using this framework, we analyse how different smallholders rejected SRI owing to diverse social, institutional

and environmental factors. Specifically, we establish how the unique demands of SRI created an awkward fit with smallholders' access to key productive inputs, including land, water, knowledge and labour. This mismatch ultimately led to the widespread disadoption of an agronomically 'successful' management practice.

The implications of this research are to foreground a different order of questions for effective agronomic interventions. The issue is not whether a given agricultural technology 'works' as judged by externally generated agronomic criteria determined through trials in controlled agroecological settings. Rather, the meaning of success must be placed in its local context: who can make a given technology or management practice work, and under what conditions, both social and agroecological? In short, innovations will struggle to take hold if there is not a strong fit with the socio-ecological niches that smallholders occupy. Posing the question in these terms requires methods of engagement that privilege smallholder input into agricultural development strategies. These, we argue, are essential for ensuring the effective design and uptake of agricultural innovations.

1.1. Background Context

As is well established, the system of rice intensification involves a series of management changes within paddy cultivation that—when used collectively in sequence—are argued to increase yields while reducing aggregate water usage. By transplanting relatively younger seedlings at a wide yet closely regimented spacing and deploying alternate wetting and drying (AWD) alongside a mechanical weeder, advocates argue that SRI improves root development and soil health, leading to a virtuous cycle of vigorous plant growth and increased yields [4]. At the same time, the use of AWD is argued to reduce overall water usage, which—in semi-arid regions in particular—provides a welcome boost to resource use efficiency and water conservation [5].

Notably, most of the debates over the relative virtues of the system of rice intensification are conducted around its underlying principles and whether it creates superior in-field results predicated upon standard variables like yield and resource efficiency. Here, we do not engage in these more general questions about whether and how SRI 'works' in agronomic terms [6]. Instead, we insist it is a more important question to ask what categories of smallholders can work effectively with SRI under their diverse social and agroecological conditions across distinct locations. This, we contend, is a far more useful question for advancing both effective and equitable innovations across a highly differentiated rural space.

Two analytical orientations are important for conducting the following analysis. First, as the farming systems literature has long established, smallholder farmers often do not make planning decisions based on projected yield or efficiency gains in a single crop. Rather, decision-making occurs in consideration of complex synergies and trade-offs between varied on-farm activities and off-farm livelihood components [7]. As a result, when considering different agricultural technologies and management techniques, smallholders may not set a target to maximize grain yield for a particular crop but rather to ensure the interacting suite of livelihood components facilitates the reproduction of the household with a close eye on risk mitigation [8]. This provides the wider context in which farmers make cultivation decisions, yet it can often be underplayed within agronomic research, which tends to overly focus on maximising outcomes for a single crop that happens to be the focus of an agronomic intervention.

Second, even among smallholders with relatively similar profiles, small differences in capabilities, assets and resources—including the character of land and water availability—can have a significant impact on the outcomes of planned technological changes and shifts in management practices. As Sinclair and Coe note, technology options vary enormously in performance according to variations in the social, economic and ecological contexts into which they are necessarily embedded [9]. This accords with the notion of a 'socio-ecological niche', in which a convergence of agroecological, social, cultural and economic factors collectively shapes the performance and suitability of technologies or management

practices that can be predicted [1]. For example, a socio-ecological niche in semi-arid Telangana would not only include agronomic factors such as soil type, quality, rainfall patterns and groundwater availability but also the farmer's social ability to access labour, credit, technology and knowledge networks including gendered divisions of labour and resource management. From household to household, village to village, small changes in the socio-ecological niches that specific farmers occupy can radically shape their capacity to engage in innovations and minimise ensuing risks. On this basis, this concept of socio-ecological niches helps us understand how even well-designed and otherwise successful technologies or cultivation techniques can have differentiated impacts according to minor differentials between farmers in terms of access to land, water, labour and knowledge.

The implication here, as Coe et al. [10] emphasise, is that social and economic factors must be considered as assiduously as biophysical factors when determining the performance of agronomic innovations. This is not currently the case in much of the research on the system of rice intensification, wherein the bulk of discussion focuses on either the validity of its underlying agronomic principles or whether it 'works' in controlled trials based on aggregate outcomes [5,11]. Such studies are, of course, extremely useful in generating generalized assessments of the potential virtues of SRI, yet they rarely consider the variations among farmers that can create differentiated experiences and pose significant barriers for some farmers that limit their ability to achieve these potential benefits. A smaller number of papers have looked at contexts where SRI has had mixed impacts and have noted how social and institutional factors are key determinants of who can make SRI work and why [12,13]. This important consideration, however, is still missing from much of the SRI literature despite its importance in designing appropriate extension strategies.

1.2. Research Purpose

To help address this gap, our research asked under what social and agroecological contexts could smallholders in semi-arid regions make SRI work, given their diverse farming systems and asset portfolios. To engage this question, we used semi-structured interviews with forty-three farmers across a cluster of six villages in northern Mahabubnagar district, Telangana, India. What made these farmers an ideal study group was their enrolment in a state-sponsored program to promote SRI, operationalised by local rural development NGOs and supported by university agronomists. For the implementing authorities, the purported benefits of SRI had been demonstrated through field trials at the Indian Institute of Rice Research in Hyderabad, about 100 kms east of the study villages, yet operating within a similar climatic zone and broadly comparable soil types. In such settings, university researchers were keen to emphasise that SRI had been demonstrated to 'work', with notable yield gains and water savings compared to standard cultivation practices. Now, the remaining task appeared to be the diffusion of SRI across rural settings, where it was anticipated to help a smallholder farmer population facing considerable climatic and economic strains.

Real-world applications of agricultural innovations, however, are infinitely more complex than this linear notion of transferring a 'good' technology to a target population [3]. In its implementation plan, the program considered smallholders as a blanket category and presumed that the benefits of SRI would be attainable across all social categories. This was a convenient assumption, yet one that would prove problematic. In practice, the smallholders across the villages demonstrated wide heterogeneity in socio-economic characteristics, which is typical of the region. The farmers in our study had landholdings that ranged from two to thirty acres. While, in theory, all had some access to groundwater irrigation through private borewells, the number and reliability of such wells varied greatly both within and across the region [14]. Alongside differences in access to land and water, these farmers also demonstrated strongly differing abilities to recruit labourers (hired, household or through in-kind arrangements) and were variably integrated into formal extension networks. Some had strong links to extension services, whereas others felt cut off, either socially or through relative geographical isolation. In short, unlike at the agronomic

testing farm of the Institute of Rice Research, smallholder farmers implementing SRI did not enjoy a socio-ecological niche composed of stable access to labour, water for irrigation, electricity to run pumps and expert problem solving through on-site agronomic advice. On the contrary, such conditions were extremely uneven across the village sites. This variation makes this study a useful entry point into how socio-ecological niches impact the adoption, utilisation and potential disadoption of agricultural innovations.

2. Materials and Methods

Public agencies in charge of implementing the SRI promotion program in this area had an available list of around 100 farmers who had received training and trialled SRI during the initial two years of the program. Of these 100 farmers, we were able to approach 48 who had participated, and semi-structured interviews were then undertaken with 43 of those farmers, representing a cross-section of landholding sizes, ranging from marginal (less than 2.5 acres) to large (over 25 acres), with the majority being small to medium farmers holding 5 to 10 acres (see Table 1). These categories of landholding are the standard ones applied within Indian government statistics on rural development. Without a doubt, access to irrigation is more significant than total landholding size, which is almost exclusively through private borewells in this semi-arid region. All the farmers interviewed had at least one borewell—with the costs of drilling typically afforded through credit—although the reliability of borewells was notoriously unpredictable, as discussed below.

Table 1. Composition of interviews according to land holdings.

Category	Landholding (Acres)	# Farmers Interviewed
Marginal	0 to 2.5	5
Small	2.5 to 5	11
Semi-medium	5 to 10	18
Medium	10 to 25	7
Large	Over 25	2

The majority of the interviewed farmers (38) were male, although a focus group with female farmers (5) was also conducted. Additionally, four female agricultural labour group leaders were interviewed to better understand labour and gender dynamics. All the interviewed farmers had been part of the Jai-SRI program, which promoted SRI through focused training programs and provided some—albeit uneven—subsidisation of inputs.

Farmers were interviewed individually or in small focus groups about their experiences using SRI, with a focus on their relative ability to undertake each component of SRI practice, their relative outcomes from using SRI, and their overall reasons for continuing or abandoning the practice. Interviews generally took 30 min and, while semi-structured around core questions, were wide-ranging in scope, allowing farmers to go into detail about particular concerns, challenges and successes. Primary items discussed across all interviews included the following:

- Socio-economic characteristics of the farmer and their household, including education, caste, gender, land owned, access to irrigation, labour and extension support.
- The level of training received, including subsidies for first practicing SRI. The specific practices employed in using SRI, including the varieties chosen, age of seedlings used for transplanting, seedlings planted per hill, watering regime, weeding practices and fertiliser use.
- The use of labour at each stage of cultivation, including the balance between hired and family labour, rates paid and the ease of finding labourers.
- Outcomes in terms of bags of rice produced, fertiliser used and income estimates.
- Farmer perceptions of the biggest opportunities, risks or concerns faced using SRI.

The semi-structured interviews were transcribed and then grouped and analysed according to the stated reasons for the adoption/disadoption of SRI. This approach allowed us to investigate common themes while also respecting the diversity of farmer responses. Indeed, even within the ostensibly similar profile of villages and farmers, there was a range of highlighted reasons for disadopting SRI, which underline the diversity of experiences at hand. Additional supplemental interviews were conducted with those involved in project implementation, including university researchers, NGO managers and field-level extension officers. Collectively, these research methods provided a strong qualitative understanding of farmer decision-making and their experience with the SRI program in this region. Lastly, our study was conducted two years after the Jai-SRI program had fully concluded to ensure that farmers felt free to answer questions without compromising relationships with project staff that might otherwise inhibit their willingness to speak openly about their experiences.

3. Results

All respondents had been enrolled in the government-funded Jai-SRI program, which promoted SRI adoption through extension services and partial input subsidisation over the previous years (see [15] for a fuller discussion). Across our fieldwork villages, farmers almost universally (>95%) reported higher yields using SRI methods during the duration of the Jai-SRI program. Although variable, most reported yield gains are between 10 and 25 percent compared with standard production methods. Given that we relied on self-reporting, it was not possible to independently verify such yields. However, increases of this magnitude tally with field trials and other studies in the wider region [16–19]. There is little reason to doubt, therefore, that a strong majority of farmers achieved a small but significant yield benefit. Similarly, all farmers noted how the implementation of AWD resulted in less water use in terms of the number of pumpings over the course of a season. Understandably, farmers struggled to quantify this saving, given that they could not easily measure the overall amount of water used nor measure its impacts on aggregate groundwater levels. That said, there was widespread agreement that AWD offered a discernible decrease in overall irrigation water requirements.

Paradoxically, despite reporting these benefits, which were key goals of the Jai-SRI program, initial discussions with farmers showed that the disadoption of SRI was pronounced following the culmination of the formal project. Our interviews occurred two years after the end of the program to promote SRI in this cluster. Despite most farmers (66%) attempting to cultivate rice using borewell water during the winter (rabi) season when our fieldwork took place, not a single farmer in our sample continued to implement SRI. Moreover, only a small proportion (~20%) suggested that they would consider using SRI in future seasons, whether kharif or rabi. As we illustrate below, those farmers who intended to resume SRI cultivation were those whose resource base and capacities fit a specific socio-ecological niche, and they felt confident that they could make the innovation work while minimising risks. The other farmers felt that the risks and constraints outweighed the accepted gains of the method. For them, tensions between the method and their socio-ecological niche meant that disadoption was a rational course of action.

This reality on the ground was in sharp contrast with the vision of effective outcomes emphasised by one of the main implementing NGOs based in the city of Hyderabad, 100 kms away. While project leadership insisted that the program had been successful and that farmers were still widely using the method, this claim found no substantiation in our interviews with farmers or our first-hand observations of rice cultivation in the field. Scientists affiliated with the local agricultural university, who had also been involved in the program, were more optimistic about the possibilities of SRI in the region. They acknowledged constraints to adoption, particularly in terms of labour requirements. Nonetheless, based on our interviews and observation, there appeared to be a strong disjuncture between the claims of success made by implementing partners and the decisions taken by farmers in the target villages.

Importantly, our research showed that farmers provided a diverse range of reasons for not continuing with SRI, closely aligned with distinct socio-ecological niches that impacted their field-level experiences. As such, while disadoption was prevalent across the sample, the motivations for returning to standard cultivation methods were not. Instead, farmers gave reasons that were highly differentiated according to social and agroecological contexts and emphasised how different social conditions interacted with agroecological risks. From these discussions, three key elements were identified that shaped smallholder experiences using the SRI method and ultimately impacted their decision to either disadopt and/or modify the practice. These elements are (1) access to labour; (2) access to water; and (3) access to knowledge networks. Additionally, the size of land holdings was a fourth factor at play, with larger landholdings going hand-in-hand with greater access to labour, water and networks. As we set out below, how these factors were combined in practice varied heavily across the smallholder population, creating different tensions between the socio-ecological niche and the ability to maintain SRI cultivation methods. This emphasises that there are a diversity of socio-ecological niches even within a geographically bounded population operating under broadly similar agronomic conditions, such as soil quality and climate. We will address each in turn to highlight both the general constraints they placed on smallholders alongside some specific illustrative examples.

4. Discussion

4.1. *The Labour Niche*

There were three aspects of the changing labour dynamics implied by the transition to SRI that farmers reported as hindrances to their continued usage of the technique. First, it was recognised by farmers that SRI involves a more intense management function. The farmer must more closely monitor the cultivation process, given the precise timing and performance of key tasks. For some farmers, this added attentiveness to cultivation processes was unwelcome. Balancing different tasks across both their farming systems as a whole and other off-farm livelihoods, some farmers perceived SRI as overly complicated and demanding for their needs. This was particularly the case for farmers with smaller land holdings, who spent less overall time on agriculture and sought relative simplicity in farm management.

Second, SRI alters the labour dynamics of transplanting seedlings owing to its reliance on a more labour-intensive, time-sensitive and relatively more diligent form of work. This diligence is related to the delicate nature of the young seedlings used, the required accuracy of plant spacing, and the specific way seedlings must be planted to ensure proper root development. In the study area, the usage of hired labour in the form of female agricultural labour groups for intensive tasks such as transplanting was commonplace. For smallholders, a significant constraint was whether these labour groups could be conscripted at the relatively precise time needed for transplanting young seedlings.

Notably, farmers of all sizes of landholdings noted increasing wage rates and a tendency towards competitive bidding to secure female labour groups—particularly ones with greater experience of SRI—at the specific times required for transplanting. Smallholders with less land, who could provide less consistent work and had less social capital to leverage priority within the schedules of labour groups, typically had to wait extended periods for these labour groups. As a result, delayed transplanting was preponderant among farmers owning three or fewer acres of irrigated land. Among this group, seventy percent of farmers planted seedlings older than 15 days. The precise impacts of these transplanting delays on yields were unclear from our study, but it is worth highlighting that early transplanting is regarded as a pivotal feature behind the potential success of the SRI method owing to the way that young seedlings form vigorous root systems compared to older plants. Conversely, only a quarter of surveyed farmers with four or more acres of irrigated land—i.e., a relatively more resource-affluent section—reported transplanting seedlings older than 15 days. This suggests that such farmers had less trouble accessing timely labour and were therein better placed to maximise the returns from SRI adoption.

Third, rather than using hired female labour groups to manually undertake weeding as in conventional cultivation practices, weeding within SRI is transformed owing to the required usage of a specialised conoweeder according to an established post-transplanting schedule. Importantly, the use of these weeders created a further inclination towards disadoption because it transferred labour duties from women, who typically undertake the drudgery task of hand weeding, to men, who are typically charged with agricultural tasks that require the use of any machinery or technology. A strong proportion of male respondents in specific villages suggested that this realignment of the gendered division of labour was a key factor in disadoption. Simply put, men did not consider increased yields and water savings to be sufficient gains to warrant the transfer of drudgery onto their shoulders (see also [20]).

4.2. The Water Niche

Through the implementation of alternate wetting and drying (AWD), the aggregate water used for crops is reduced within SRI compared to the constant flooding of standard cultivation practices. These water savings were confirmed in our interviews in which respondents universally noted that SRI required less water use overall, a point that has been well documented in the agronomic literature on SRI [21,22]. However, many smallholders reported significant concerns regarding AWD based on the perception of accentuated risks. In the semi-arid environment of Mahabubnagar, borewells are notoriously unreliable and prone to sudden failure. From the smallholder perspective, groundwater levels and well efficiency depend on a host of overlapping social and environmental factors beyond their control. At the same time, frequent electricity blackouts render pumps unworkable for prolonged periods with no certainty of when power might return.

Given that groundwater supply is uneven and inherently risky, many farmers documented that they feared letting the field dry to the prescribed point where cracks appear in the soil. Should their pumps be unworkable at that specific point in time, they could face a prolonged delay before being able to replenish the field, during which time their crop could perish. Put simply, they argued that AWD was too risky, notwithstanding its lower overall water requirement. For some, this led to immediate disadoption of the technique. Others, during the initial project-driven implementation period, insisted that they needed to modify SRI to account for this socio-ecological context. They did so by abandoning a pure form of AWD and consistently retaining one inch of water in the field as a buffer to manage the risk of pump failure owing to blackouts. The prevalence of this risk-aversion strategy became widespread among all but the largest farmers, some of whom tended to have multiple borewells tapping distinct aquifers. Indeed, local implementation NGOs began teaching this altered practice as a standard by the end of the project period.

While rational in terms of risk management in a semi-arid environment with frequent power blackouts, this modification contradicts one of the fundamental principles of SRI practice [23]. Allowing water levels to fall until only puddles remain and cracks form is intended to aerate the soil and promote soil and root health. It was not feasible within our survey to accurately measure the impact of this variation in practice on yields or water efficiencies. While small and marginal farmers who practiced the altered method still reported yield gains during their initial period of using the technique, these grains were smaller compared to those reported by larger farmers. However, the precise impact of differing water management strategies could not be separated from the other factors we have discussed, and ultimately, most smallholders disadopted the practice once the formal project had ended.

4.3. The Knowledge-Network Niche

The third area that farmers highlighted as a determinant of SRI outcomes was the uneven levels of access to extension networks that provided both knowledge transfer, troubleshooting and the provision of tools and—on occasion—subsidised inputs. While SRI was intended to be implemented uniformly across the region, there was high variation

within a program beset by problems, including disruptions in the timing of funds disbursed by the Department of Agriculture. At the same time, NGO efforts were uneven across villages, with some subcontracted organisations performing their roles more effectively and consistently than others, particularly in villages where they had stronger existing contacts. Notably, training was almost exclusively given to male farmers. Female farmers who practiced SRI reported learning the skills in their role as day labourers.

Our interviews indicated how some villages and individuals benefited from closer attention from extension operatives, particularly those villages and individual farmers who had a longer history of NGO–farmer interactions, where NGOs felt they had a stronger chance of mobilising ‘success stories’ for reporting to their superiors. Given that NGOs and field-level operatives were paid according to recorded successes, all involved in the program were extremely keen to project a strong record of accomplishment, as has been noted in comparable studies [24]. As an example, in one relatively prosperous village located along the main road, the local NGO concentrated its activities in this accessible geographic cluster, particularly with established farmers who had medium to larger landholdings and with whom they had established relationships. Several kilometres to the south, away from the main road, a second village that was part of the program had seen little extension activity. Only a single large landowner with a strong educational background suggested he would use the method in the following kharif season, while other farmers noted their unwillingness to continue, given an absence of accessible advisory expertise, failing tools and recurrent water shortages.

Similarly, the distribution of resources under the program was uneven. First, while some farmers received direct cash transfers in the first year, others received in-kind incentives such as seeds or fertiliser. The former direct cash subsidies were prevalent only in the first year of the program and seemingly were delivered primarily to larger farmers who were quickest to enrol in the program. The three farmers who reported the highest subsidies of Rs 1000 per acre owned a minimum of 5 acres of irrigated land, were well-educated, belonged to higher castes and had strong connections to previous agricultural extension initiatives. Other small to mid-sized farmers clustered in villages that had strong ties to the local NGO received Rs 500 per acre. Conversely, those with the lowest landholdings typically reported either undelivered cash subsidies or the provision of small quantities of seeds and/or fertiliser instead. This points to how a problematic design in extension strategies can compound risks, leading to stratification of benefits and an increased tendency towards neglect or disadoption of agricultural innovations.

5. Conclusions

The decision to promote the system of rice intensification across large areas of Telangana through public extension activities appeared to match smallholder needs in the region, namely, a management approach that could deliver higher productivity and water conservation in rice production. However, the promotion of SRI as a ‘best-bet’ option for the region was largely undertaken without full consideration of the social diversity of the target population and the impacts this might have on user experience. As Sinclair notes, failure to consider diverse socio-ecological niches can result in innovations not being suitable for many in the area and providing little opportunity to learn which potential options suit different contexts [8].

This appears to have been the case with SRI across six study villages in Mahabubnagar. Our research showed that the high diversity of smallholder farming contexts within what was otherwise relatively consistent agroecological parameters strongly shaped who could use SRI effectively. This created a situation in which farmer-reported agronomic successes—higher yields and lower aggregate water consumption—did not translate into prolonged adaption of the method. Rather, a mix of social and institutional factors combined with the agroecological context drove the widespread disadoption of SRI once the targeted extension program had ended. Three points are important here. First, disadoption occurred despite the devotion of significant public resources for the dissemination of SRI. Second, different

groups of smallholder farmers identified different constraints that undermined their ability to use the SRI approach, suggesting that socio-ecological variations across the smallholder population drove different disadoption trajectories simultaneously over the study area. Third, the failure to account for the social dimensions of technology adoption in extension design meant that the risks smallholders faced in practice were insufficiently recognized by project managers.

It is important to emphasise that we do not dispute how SRI represents a potentially valuable option for smallholder farmers. Rather, we argue that context matters, and insufficient attention to socio-cultural factors can lead to ineffective policy and failed innovation uptake. As Giller et al. [25] note in the context of conservation agriculture, it is essential to ask “if, when and for whom” a technology may prove appropriate and useful. To date, insufficient attention has been given to the social preconditions for success with the SRI method because the focus of proponents is typically focused narrowly on the agronomic dimensions of SRI [4]. Our concern is that overconfidence in the agronomic superiority of a method such as SRI can lead to the unfortunate assumption that adoption will be relatively smooth and sustained at scale. Instead, to avoid the experience of mass disadoption that we recorded in the case study, we argue that considerably more attention must be placed on the specific conditions that might make SRI work among smallholder constituencies.

On this basis, three implications for agricultural innovation design and extension stand out, both in terms of SRI and more generally. First, the prevalence of significant diversity across smallholder farming systems cautions us against ‘silver bullet solutions’ that might otherwise be assumed to apply at scale. On the contrary, it suggests the need for the development of ‘baskets of options’ from which diverse groups of farmers can choose options for subsequent adaptation to their particular social and field-level contexts [26].

Second, provisional innovations should be designed and trialled with pre-emptive attention paid to “social, economic, environmental, cultural, technological, infrastructural and institutional contexts”, including impacts upon gender, generational and socio-economic vectors of differentiation [27]. While demanding, such wide-spectrum design considerations can help avoid diffusing innovations that have low adoption rates, particularly among the more marginal smallholders for whom—in theory—they are designed. Failure to proactively engage with these considerations, moreover, risks propagating innovations that can inadvertently exacerbate rural inequalities [24]. In the case of SRI, this would involve agricultural extension agencies purposefully considering four interlocking social determinants of capacity to work with SRI, namely, access to land, labour, water and networks while paying close attention to pertinent gender differentials within each category. As Figure 1 illustrates, extension services would need to consider the questions associated with each of these dimensions as assiduously as agronomic considerations, ideally working with smallholders to ensure that conducive conditions exist prior to a shift in cultivation strategies.

Third and finally, our work reinforces the longstanding emphasis that smallholder farmers need to be more fully and openly integrated into both the design and extension of agricultural development strategies, including setting the criteria by which success is judged [28]. As noted above, some examples of retroactive co-learning were noticeable within the studied case, wherein NGO instructors were formally teaching a modified AWD process by the final year of implementation. This modification suggested that farmer risk profiles and preferences were being incorporated into the program post-facto but only in its closing stages. In this respect, the onus is on both researchers and extension agencies to engage in more effective dialogue about the potential challenges faced by farmers—both male and female—including the social contexts that either facilitate or hinder the efficient usage of new techniques and technologies.

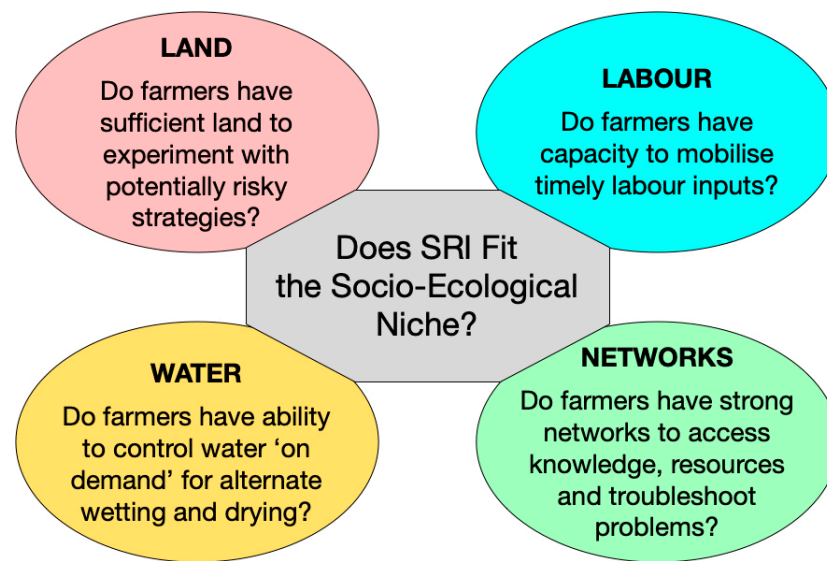


Figure 1. The socio-ecological niche of SRI.

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