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To cite this article: Espérance Zossou, Kazuki Saito, Alidou Assouma-Imorou, Kokou Ahouanton & Bitrus Dawi Tarfa (2021) Participatory diagnostic for scaling a decision support tool for rice crop management in northern Nigeria, *Development in Practice*, 31:1, 11-26, DOI: [10.1080/09614524.2020.1770699](https://doi.org/10.1080/09614524.2020.1770699)

To link to this article: <https://doi.org/10.1080/09614524.2020.1770699>



Published online: 04 Jun 2020.



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# Participatory diagnostic for scaling a decision support tool for rice crop management in northern Nigeria

Espérance Zossou, Kazuki Saito, Alidou Assouma-Imorou, Kokou Ahouanton and Bitrus Dawi Tarfa

## ABSTRACT

RiceAdvice is a decision support tool with potential to improve rice productivity and profitability of smallholder farmers in sub-Saharan Africa. A rapid appraisal of agricultural innovation systems approach was used to assess opportunities and constraints in scaling the tool. Qualitative and quantitative data were collected through semi-structured interviews, multi-stakeholder workshop, and questionnaires distributed to 368 farmers in Kano State, northern Nigeria. Results show that scaling RiceAdvice requires: (i) improved access to financial and input supply services through partnerships; (ii) identifying and testing business models where RiceAdvice can be used; and (iii) a dissemination approach where female service providers reach female farmers.

## ARTICLE HISTORY

Received 19 June 2019  
Accepted 21 January 2020

## KEYWORDS

Environment (built and natural) – Agriculture, Food security; Technology – ICT; Sub-Saharan Africa

## Introduction

Rice is one of the staple food crops in sub-Saharan Africa (SSA). It has become a strategic commodity (van Oort et al. 2015) and plays an important role in the economy and culture of West African countries. However, despite its importance, local rice production lags its demand. Currently, around 40% of rice consumed in SSA is imported (Saito et al. 2015a), an approach that can drain foreign currency reserves and provoke poverty and food insecurity. Many countries in SSA struggle to increase domestic rice production and achieve self-sufficiency.

## *The agricultural innovation system (AIS) perspective*

There are two ways to augment rice production: expand the cultivation area and increase land productivity (Saito et al. 2013). This article focuses on enhancing land productivity, since there is huge potential for higher rice yield in SSA (Niang et al. 2017). Numerous studies on crop management have reported that improved practices can increase rice yield (e.g. Saito et al. 2015b). However, increasing smallholder farmers' land productivity in SSA is complex: it involves multiple stakeholders across multiple dimensions (biophysical, technological, socio-cultural, economic, institutional, and political) and interactions across different levels (international, national, regional, district, village, farm, and field) (Schut et al. 2015). Therefore, a system of thinking, such as the AIS perspective, is needed to address these complex relationships and improve agricultural productivity.

Unlike more conventional, linear approaches to research and development, AIS applies participatory and inclusive methods that focus on learning among farmers, testing and modifying technologies, and building social cohesion. The participatory approach gives more attention to the requirements of farmers and various stakeholders at the national and sub-national levels in agricultural development projects (Bentley 2009; Zossou et al. 2012). It also empowers participants by

providing them with the skills, knowledge and experience they need to improve their farming resilience and efficiency (Karl 2000; Newig, Pahl-Wostl, and Sigel 2005; Carr, Blöschl, and Loucks 2012). Another important feature of AIS is that it enhances the engagement of different stakeholder groups from different levels, allowing them to identify, prioritise and alleviate constraints to improving productivity (Foran et al. 2014).

To diagnose AIS, Schut et al. (2015, 2016) proposed using a rapid appraisal of agricultural innovation systems (RAAIS) approach to analyse different agricultural dimensions (biophysical, technological, socio-cultural, economic, institutional and political), stakeholder levels (e.g. farm, village, district, regional and national) and constraints and interests of different stakeholder groups (farmers, extension agents, NGOs, government, researchers, etc.) to improve agricultural productivity in SSA.

RAAIS is a diagnostic tool used to guide the analysis of complex agricultural problems and innovative capacity of an agricultural system. By using RAAIS, Schut et al. (2015, 2016) were able to better understand crop protection and sustainable intensification of agricultural systems.

### ***The RiceAdvice tool***

Rice production in SSA is impacted by macronutrient deficiencies and poor nutrient management practices (Diagne et al. 2013; Saito et al. 2013, 2018). Poor nutrient management practices by farmers are caused by limited access to fertilisers, extension services, or recommendations for effective nutrient management practices (Saito et al. 2015b, 2018). Further, the currently available fertiliser recommendations in SSA are associated with fixed application rates that do not consider variability in soil nutrient supply, climate, crop sequences, residue management, or a farmer's financial resources.

To overcome these limitations, an android-based application, "RiceAdvice", was developed in 2014 by the Africa Rice Center (AfricaRice) following the successful pilot of a web-based decision support tool for nutrient management in Senegal (Saito et al. 2015b). RiceAdvice was validated and disseminated by research and development partners in several countries in West Africa (Saito and Sharma 2018). It has been periodically improved and updated based on feedback from partners and users to provide advice on fertiliser management. This advice is based on farmers' responses to questions concerning their rice production system, rice variety, availability of irrigation water, previous crop management, previous rice yield as well as fertiliser availability and local market price. RiceAdvice has improved rice productivity and profitability for smallholder farmers (Saito and Sharma 2018), and as of October 2019, over 66,000 recommendations were generated from RiceAdvice (authors, unpublished data). The major challenge now is how to scale-up and scale-out this innovation to enhance its uptake.

Scaling out involves disseminating technologies or practices from place-to-place, whereas scaling up deals with the institutional environment responsible for enabling or limiting the adoption of technologies or practices (Hendrickx et al. 2015). Although recent advances in information technology and mobile communication have helped public extension workers and farmers generate local and specific crop (rice) management recommendations, most rice farmers in SSA don't own smartphones and tablets and have limited internet access. Therefore, it is important to identify and develop innovative business models and impact pathways that provide a framework for the analysis of complex agricultural problems that involve multiple dimensions, levels and stakeholder perceptions (Klerkx, van Mierlo, and Leeuwis 2012).

In this study, we use the RAAIS approach to assess constraints and opportunities to scaling up and scaling out RiceAdvice tool usage in Kano State in northern Nigeria, one of the priority areas for rice research and development intervention in the country. We aim to use the approach to: (i) assess farmers' perceptions of RiceAdvice and if there are any benefits, and (ii) show constraints and opportunities to scale-out and scale-up RiceAdvice within and across different stakeholders.

## Material and methods

### *Study site*

This study was conducted in Kano State, northern Nigeria. Kano State is dominated by Hausa people, who are predominantly Muslims. It has a tropical savanna climate with an average rainfall of 980 mm per year, which mostly falls from June through to September. National agricultural research institutes and partners selected this state a priority intervention area for rice research and development. Five (Bagwai, Bunkur, Garun Mallam, Kura, and Warawa) out of 47 local government areas (LGAs) were chosen for piloting RiceAdvice, as they are key rice-producing areas under irrigated conditions.

RiceAdvice has been disseminated by trained service providers to farmers in these LGAs since 2016, after on-farm validation in 2014 and 2015. The service providers include youths – less than 45 years old in most cases – trained to generate recommendations using RiceAdvice, and public extension workers who supervised the youths and provided RiceAdvice recommendations to farmers. Youths were paid using funds from agricultural development projects, while public extension workers were supported with fuel and per diems. In total, there were 74 service providers, including 62 youths: 7,327 farmers (on average 98 farmers per service provider) received recommendations from RiceAdvice in 2016.

### *Data collection*

Data were collected from December 2016 to March 2017 using the RAAIS method (Schut et al. 2015), which combines qualitative and quantitative data collection and analysis techniques to allow critical triangulation and validation of data with different groups of stakeholders. Seven categories of rice value chain stakeholders relevant for scaling RiceAdvice were identified: rice farmers, services providers, research organisations, NGOs/civil societies, rice seed companies, local authorities/government and local communication agents. The local communication agents, rural radio broadcasters and “village criers”, were involved because of their commitment to agricultural extension programmes in SSA and their availability in rural communities (Zossou et al. 2015). Qualitative and quantitative data were collected through three main steps:

Step 1: Semi-structured interviews from 22 December to 29 December 2016.

Step 2: Multi-stakeholder workshop from 27 February to 1 March 2017.

Step 3: In-depth interviews from 6 March to 20 March 2017.

The semi-structured interviews collected information on the functioning of the RAAIS, including linkage among stakeholder groups, effectiveness of policies and other institutions, and constrains and enablers for scaling of RiceAdvice. The multi-stakeholder workshop aimed to identify, categorise and analyse constraints and challenges of RiceAdvice scaling. The in-depth interviews focused on rice farmers and service providers to assess their perception of RiceAdvice, farmers’ level of implementing RiceAdvice recommendations, and the benefits.

Participants in the multi-stakeholder workshop were different from those in the semi-structured interviews and in-depth interviews to provide triangulation among the representatives of the surveyed stakeholder groups.

#### *Step 1: semi-structured interviews*

Focus group discussions were conducted with each of the seven stakeholder groups. For each group, at least five participants were selected by the research team from AfricaRice together with the Kano Agricultural and Rural Development Authority and the National Agricultural Extension and Research Liaison Services at the Ahmadu Bello University. In the seven sessions there were 35 participants, including only two females (Table 1), despite efforts to have gender-balanced representation. This

**Table 1.** Rice value chain stakeholders that attended the semi-structured interviews (step 1) and multi-stakeholder workshop (step 2).

Stakeholder	No. of participants in step 1	No. of participants in step 2	Name of organisation
Farmers	5	6	Farmers' organisations in local government areas in Kano State
Service providers	5	6	KNARDA, local government areas in Kano State
Research organisation	5	6	IAR-ABU ZARIA, IFDC, KNARDA
NGOs/civil society	5	3	SG 2000 Nigeria, MARKETSII, WARD HEAD
Seed company	5	6	Value Seed, Seed Project Company, GREEN SAHEL, GREEN SPORE AGRIC
Local authority/ government	5	3	Kano local government areas (Bagwai and Bunkure)
Local communication agents	5	3	Express Radio, KNARDA/DD Media, NAERLS ABUZARIA

Notes: KNARDA = Kano Agricultural and Rural Development Authority; GREEN SAHEL and GREEN SPORE AGRIC are seed companies; IAR-ABU ZARIA = Institute for Agricultural Research, Ahmadu Bello University Zaria; IFDC = International Fertilizer Development Centre; SG 2000 = Sasagawa Global 2000; MARKETS II is a USAID project that promoted rice production in Kano; WARD HEAD is local traditional head of a community; KNARDA/DD Media is Kano Agricultural and Rural Development Authority Deputy Director Media; NAERLS ABUZARIA is National Agricultural Extension & Research Liaison services, Ahmadu Bello University.

is due to religious and socio-cultural limitations that restrict women from communicating with men outside their families. The women were asked about their knowledge on RiceAdvice, their perception of the problem and feasible or desirable solutions for scaling RiceAdvice. Each session took around two hours.

### **Step 2: multi-stakeholder workshop**

The multi-stakeholder workshop had 33 participants, with at least three representatives from each stakeholder category (Table 1). Two participants were female. Thirteen sessions were conducted over two days and included: (i) identifying constraints and challenges, (ii) categorising constraints and challenges, and (iii) exploring specific and generic entry points for scaling RiceAdvice (Table 2). During sessions 4–11 (Table 2), outputs from the homogeneous groups (actors from a same

**Table 2.** Summary of sessions held during the multi-stakeholder workshop (step 2).

Session	Objective
<b>S1:</b> Introduction	Brief objectives and agenda of the workshop.
<b>S2:</b> Individual brainstorming	Identify main constraints and challenges as experienced by individual stakeholder.
<b>S3:</b> Top five constraints in homogeneous groups	Identify and rank main constraints as experienced by each stakeholder group.
<b>S4:</b> Identify the type of constraints and challenges	Categorise constraints according to different dimensions.
<b>S5:</b> Categorise constraints along structural conditions	Categorise constraints along categories of structural conditions that can enable or constrain innovation.
<b>S6:</b> Categorise constraints across administrative levels	Gain insight into the multi-level dynamics of stakeholder constraints and challenges.
<b>S7:</b> Identify relationships between constraints	Identify relationships between the constraints and identify key central constraints.
<b>S8:</b> Categorise constraints along the value chain	Categorise constraints along segments of the rice value chain.
<b>S9:</b> Reflection on stakeholders' involvement in the scaling process	Explore the objectives assigned/to be assigned to stakeholder groups within the framework of RiceAdvice dissemination.
<b>S10:</b> Categorise constraints along the solving levels	Explore what constraints can be solved individually, easily and to identify time frame for addressing them.
<b>S11:</b> Prioritise constraints along research-for-development domains	Subdivide and prioritise constraints under research-for-development domains that can support addressing them.
<b>S12:</b> Reflection on entry points for innovation	Identify entry points in addressing prioritised constraints.
<b>S13:</b> Reflection on strategy for RiceAdvice scaling and conclusion	Develop strategy of scaling of RiceAdvice and its improvement.

stakeholder group) were reported to the plenary sessions for discussions that led to a consensus. During sessions 12–13, participants were asked to select one working group based on their affinity to the following research-for-development domains: (i) innovations for dissemination/scaling, (ii) institutional/political innovations, and (iii) innovation for gender responsive actions. The group discussions (Table 2) were followed by a plenary session for interactive exchanges among different stakeholder groups.

### Step 3: survey questionnaire

From the 7,327 farmers who received RiceAdvice-generated recommendations and 75 service providers who gave recommendations to farmers, 368 and 75 participants were selected for interviews, respectively. A stratified simple random sampling was used to ensure farmers were represented in each LGA. A sampling coefficient (survey sample size per total number of farmers reached by RiceAdvice) was calculated and multiplied by the total size of each group reached in each LGA. A simple random sampling was then carried out to select the respondents in each LGA. Farmers and service providers were asked about their socio-demographic information (Table 3), farmers' level of implementation of the recommendations from RiceAdvice, their perception of RiceAdvice, and benefits of using RiceAdvice.

**Table 3.** Definition of variables and socio-economic profile of rice farmers and service providers.

	Description	Parameter	Rice farmers (n = 368)	Service providers (n = 63)
Age	Respondent age	Mean ± standard deviation	38 ± 10.	31 ± 8.1
Gender	Female	% of farmer/service provider observations	2	0
	Male	% of farmer/service provider observations	98	100
Group/association membership	Yes	% of farmer/service provider observations	57	43
	No	% of farmer/service provider observations	43	57
Group	Hausa	% of farmer/service provider observations	99	100
	Yoruba	% of farmer/service provider observations	1	0
Marital status	Married	% of farmer/service provider observations	85	48
	Single	% of farmer/service provider observations	15	52
Household size	Number of individuals	Mean ± standard deviation	8.2 ± 4.9	6.8 ± 3.5
Education level	None	% of farmer/service provider observations	2	0
	Read/write in local language	% of farmer/service provider observations	1	0
	Koranic school <sup>a</sup>	% of farmer/service provider observations	84	3
	Primary school	% of farmer/service provider observations	8	13
	Secondary school	% of farmer/service provider observations	4	49
Religion	University	% of farmer/service provider observations	1	35
	Muslim	% of farmer/service provider observations	99	100
Main activity	Christian	% of farmer/service provider observations	1	0
	Rice production	% of farmer/service provider observations	83	51
Production of other crops	Production of other crops	% of farmer/service provider observations	11	6
	Livestock	% of farmer/service provider observations	2	2
	Crafts	% of farmer/service provider observations	0	8
	Housewife	% of farmer/service provider observations	1	0
	Driver/motorbike taxi	% of farmer/service provider observations	3	0
	Trade	% of farmer/service provider observations	0	24
	Agricultural services provision	% of farmer/service provider observations	0	10
	Size of rice farm	ha	Mean ± standard deviation	2.3 ± 2.2
Access to agricultural extension	Yes	% of farmer/service provider observations	85	–
	No	% of farmer/service provider observations	15	–
Access to training	Yes	% of farmer/service provider observations	58	–
	No	% of farmer/service provider observations	42	–
Access to inputs	Yes	% of farmer/service provider observations	55	–
	No	% of farmer/service provider observations	45	–
Years of experience	Number of years	Mean ± standard deviation	14.51 ± 7.5	–
Household income	US\$r per year	Mean ± standard deviation	1714 ± 856.4	–

Notes: Data from in-depth interviews. <sup>a</sup> Literacy in Arabic and study of Koran and Islamic law over two to three years.

## **Data analysis**

An analytical framework composed of five dimensions was used: (1) farmers' level of implementation of the recommendations from RiceAdvice, their perception, and benefits; (2) analysis of the dimension of constraints within/across the stakeholder groups; (3) causes of constraints using structural conditions for innovation; (4) levels, domains, and timeframe required to address the constraints; and (5) the type of innovation required to address constraints.

For dimensions 1 and 2, descriptive statistics mean comparison tests (Kruskal–Wallis test, t-test) and binomial logistic regression model were performed. The Kruskal–Wallis test is a non-parametric test, an alternative test to a one-way analysis of variance test, and is used with one nominal variable and one ranked variable. It tests whether the mean ranks are the same in all the groups. The Sustainable Livelihood Approach (DFID 1999) was used to categorise the benefits from RiceAdvice listed by farmers and service providers to assess the contribution that technology adoption made to their livelihoods (human, financial, physical, social, and natural assets).

For dimensions 3, 4, and 5, histograms were used with means and frequencies to analyse the dimension of constraints, causes, and opportunities for intervention. Qualitative analysis (based on the research team experiences and perceptions during focus group discussions, participant observations, photography, and semi-structured interviews) was used for all five dimensions of the analytical framework to deepen and strengthen the statistical analysis.

Constraint linkage was analysed by network mapping constraints using analysis sub-categories as attribute values in Gephi v.0.9.2. (Bastian, Heymann, and Jacomy 2009; Schut et al. 2016) and the mean degree of the constraint network.

## **Results**

### ***Sample characteristics of farmers and service providers***

The interview data (Table 3) showed that more than 98% of farmers and 100% of service providers were males. As there were few female farmers, this study did not consider gender in the quantitative analyses. Rice farmers and service providers were, on average, between 38 and 31 years old and mostly of Hausa ethnicity. The main activity of both farmers (82%) and service providers (51%) was rice production. Education level was low for farmers compared to service providers. About 6% farmers and 84% service providers were educated beyond primary school. Farmers had, on average, 14 years of agricultural experience and farmland of around two hectares. The average annual household income was US\$1,714 for farmers. Only 24% of farmers had an android phone.

### ***Use of RiceAdvice and its potential impact on rice cultivation practices and livelihood***

All interviewed farmers appreciated the recommendations generated using RiceAdvice and 97% were willing to pay for the service. About 74% suggested service payment should be made in cash, while 26% suggested payment should be made as a portion of the rice paddy profits after harvesting. Farmers were willing to pay on average US\$8.90 for the service. This twice the average amount expected by service providers (US\$4.80). All service providers were willing to make RiceAdvice service an income-generating activity. However, about 48% of farmers disagreed with having to rely on service providers and the follow-up process to apply the recommendations.

Among the farmers, 90% followed the fertiliser application recommendations given by RiceAdvice (e.g. amount and timing to apply fertilisers). The 10% who failed to closely follow the recommendations could be partially due to the farmers' high level of illiteracy and their dependence on service providers for follow-up.

The results from binomial logistic regression analysis (Table 4) showed that the ability of farmers to implement the recommendations were determined by education level, access to inputs (e.g. mineral

**Table 4.** Determinants of farmers' levels of implementation of the recommendations from RiceAdvice: random effects binomial logit regression estimates.

Independent variable	Coefficient	standard error	$P >  z $
Education level	6.25	1.30	0.000***
Access to input	3.99	1.01	0.000***
Group/association membership	-0.49	0.99	0.616
Years of experience in rice farming	-0.15	0.08	0.064**
Access to agricultural training	4.29	1.28	0.001***
Age	-0.18	0.07	0.008***
Farm size	0.41	0.29	0.167
Income	$-4.95 \times 10^{-7}$	$2.24 \times 10^{-6}$	0.825
Log likelihood: -19.74			

Notes: Data from in-depth interviews. Number of observations = 368.

fertilisers) and agricultural training, age, and years of experience. Farmers with a higher level of education and easy access to mineral fertilisers tended to closely follow RiceAdvice recommendations, and access to agricultural training tended to have a positive effect on how farmers implemented recommendations. Older and more experienced farmers (more than 45 years old and more than 15 years in rice production) were the less likely to follow the recommendations.

Rice farmers who received RiceAdvice recommendations noted changes in fertiliser application rate, yield, and income (Table 5). More than 90% of farmers noted a decrease of more than 25% on the amount of nitrogen-phosphorus-potassium and urea fertiliser inputs they used before using RiceAdvice. About 84% noted an increase of more than 25% in their rice yield, leading to a higher income. All farmers noted an increase in income of more than 25%. Thus, RiceAdvice improved efficiency of mineral fertiliser use for rice cultivation.

About 91% of farmers shared their experience with colleagues after receiving recommendations using RiceAdvice. On average, each farmer extended their experience to seven people, and an average of five out of seven of these people were willing to use RiceAdvice.

Figure 1 presents the distribution of potential benefits categorised in the five livelihood capitals (financial, human, natural, physical, and social) for the users of RiceAdvice (farmers and service providers), and Table 6 describes users of RiceAdvice response regarding the five livelihood capitals as benefits. Farmers and service providers noted an improvement in their livelihoods, specifically in human, social, financial, and physical capitals (Figure 1). In regards to human capital, the major benefit of RiceAdvice was enhanced skills and knowledge in rice production (81% of rice farmers) and use of android phone/tablet (95% of service providers). In social capital, it is clearly shown that social relationship and information exchange were improved. In financial capital, income generation was listed as a major benefit.

## Constraints perceived by stakeholders in the process of RiceAdvice scaling

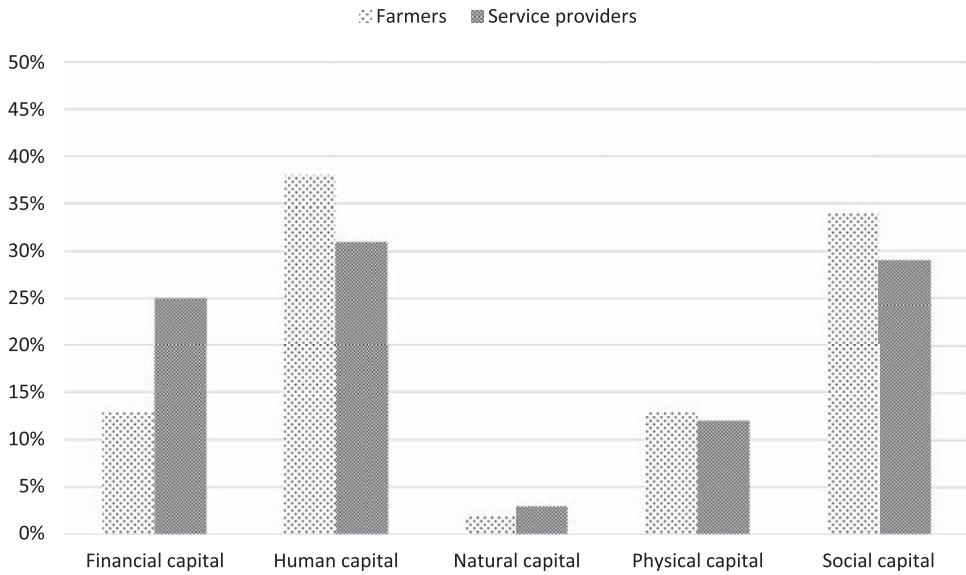
### Overall analysis of constraints

In session four of the multi-stakeholder workshop, the most important dimensional constraints to scaling up and scaling out RiceAdvice indicated by the stakeholders were: institutional (40%),

**Table 5.** Percentage of farmers who perceived changes on use of fertiliser, yield and incomes.

	$0 \leq x^a < 25\%$	$25\% \leq x < 50\%$	$50\% \leq x < 75\%$	$x \geq 75\%$
Reduced NPK (kg/ha)	10%	31%	55%	4%
Reduced urea (kg/ha)	6%	27%	62%	6%
Increased yield (kg/ha)	15%	34%	19%	32%
Increased income (US\$)	0%	70%	20%	10%

Notes: Data from in-depth interviews. Number of observations = 368. <sup>a</sup> % of amount of reduced fertiliser used after introduction of RiceAdvice, compared with before use of RiceAdvice, or % of increased yield or income after introduction of RiceAdvice compared with before use of RiceAdvice.



**Figure 1.** Percentage of benefits from RiceAdvice categorised by livelihood capitals for rice farmers and service providers. Notes: The sum of the percentages of the five capitals for the same stakeholder is 100%. Data from in-depth interviews.

economic (20%), technological (18%), socio-cultural (17%), and biophysical (5%). These constraints were consistent with the results from the semi-structured interviews: institutional (35%), economic (23%), technological (22%), socio-cultural (15%), and biophysical (5%).

The causes of constraints were more related to the absence or poor functioning of institutions (29%); the absence or limited capabilities of resources (29%); the absence or poor interaction and collaboration of stakeholders (25%); and the lack or poor quality of infrastructure and assets (17%). The stakeholders indicated that about 60% of constraints could be easily solved and required interventions at village (34%), national (34%), household (20%), district (6%), or regional (6%) levels.

The segments of the rice value chain affected by constraints were: (i) input and service supply (46%), (ii) production (23%), (iii) marketing and retail (23%), and (iv) credit (8%). About 40% of constraints could be solved by rice value chain stakeholders, and the remaining 60% require collaboration between research and development and policy actors. About 54% of constraints could be addressed within the short term (less than one year). Only 11% of constraints would need a long time (more than five years) to be addressed.

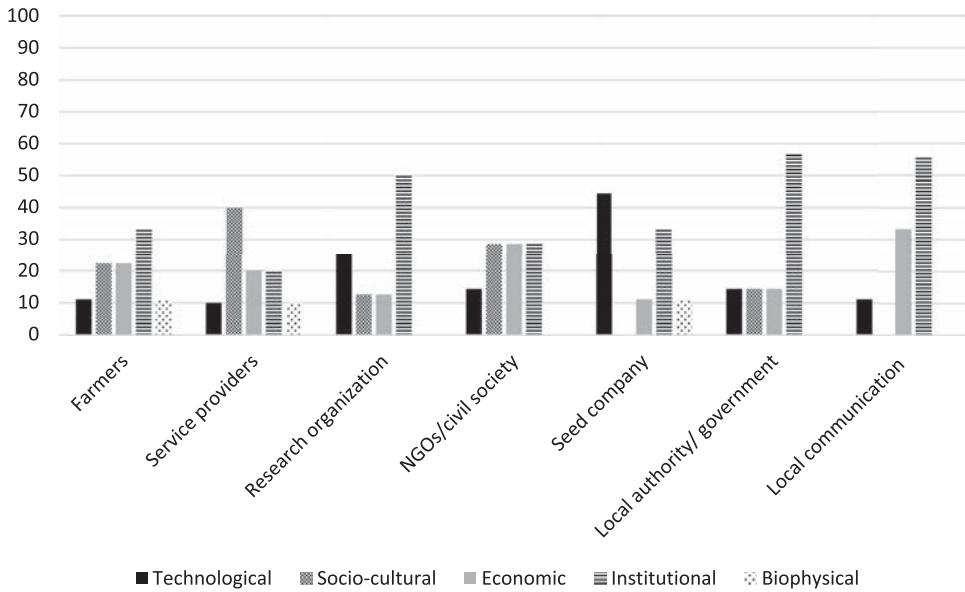
**Constraints analysis for each stakeholder group**

Constraints faced by farmers (Figure 2) were institutional (33%, e.g. availability of farming inputs, such as fertilisers and seeds); economic (22%, e.g. lack of or limited cash to purchase fertiliser); and socio-

**Table 6.** List of farmers’ and serviced providers’ benefits from use of RiceAdvice categorised using the sustainable livelihood approach framework

Capital	Description
Economic/ financial	More cash; increase income; improved access to foods and goods; increased financial resources for ceremonies; can pay school fees; increased saving; support extended family, improved access to equipment/machinery
Human	Knowledge on rice production and android phone/tablet use enhanced, good health, improved nutrition, happiness, less labour intensive, time efficiency
Natural	Soil, land
Physical	Expansion of farm land, increased number of cattle, access to electricity
Social	Social relationship, information exchange, institutional linkage and support, commitment

Note: Data from in-depth interviews.



**Figure 2.** Dimension of constraints according to different key stakeholders.

Note: Data from multi-stakeholder workshop.

cultural (22%, e.g. resistance to change from traditional practices). Constraints faced by service providers were socio-cultural (40%, e.g. female farmers have difficulty accessing male service providers for recommendations from RiceAdvice and vice versa); economic (20%, e.g. financial cost to transport service providers as well as their communication and follow-up activities); and institutional (20%, e.g. access of inputs by farmers).

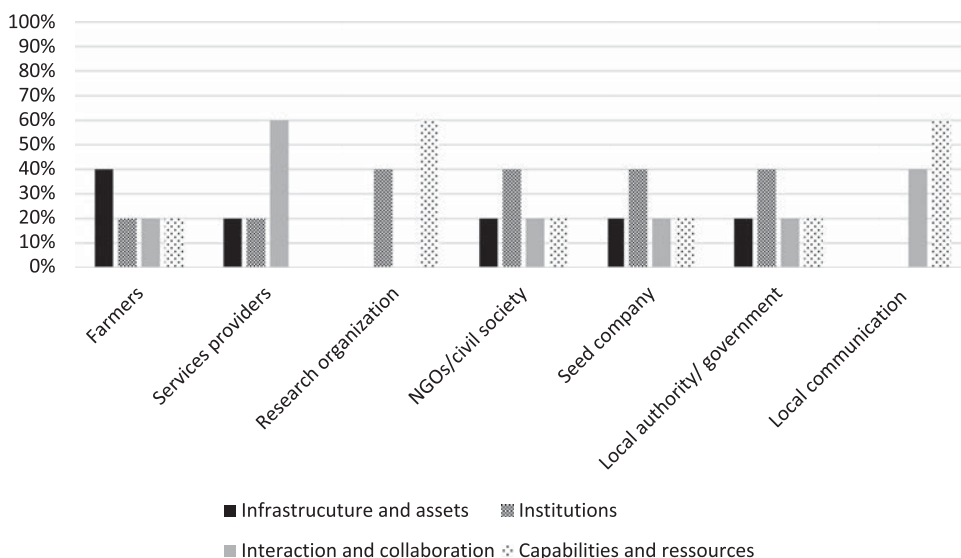
Research stakeholders encountered two major constraints: institutional (50%, e.g. low literacy level of farmers and youths providing the service); and technological (25%, e.g. language barrier as RiceAdvice does not have local language capabilities). NGOs and civil society groups encountered three major constraints: socio-cultural (28%, e.g. availability of women service providers); economic (28%, e.g. farmers' affordability to purchase inputs); and institutional (28%, e.g. farmers' poor access to farming inputs).

Seed companies encountered two key constraints: technological (44%, e.g. limited technical knowledge of software operation); and institutional (33%, e.g. accessibility of inputs by farmers). Local authorities encountered one major constraint: institutional (57%, e.g. limited involvement of local/traditional institutions in agricultural research and development).

Local communication agents encountered two constraints: institutional (56%, e.g. lack involvement of media personnel in agricultural research and development); and economic (33%, e.g. financial cost for mass awareness).

The causes of constraints (Figure 3) showed diversity across different stakeholder groups. Constraints experienced by farmers are more related to lack of or poor quality of infrastructure and assets (40%), which may relate to poor input supply systems. The largest proportion of constraints experienced by service providers were related to the absence or poor interaction and collaboration between stakeholders (60%). For example, religion in this area hinders female farmers' access to male service providers.

The causes of constraints identified by stakeholders from the research sector were more related to the absence or limited capabilities of resources (60%), and the absence or poor functioning of institutions (40%). These could be related to limited capacity of public extension systems. NGOs/civil society, seed companies and local authorities experienced constraints where causes were more related to the absence or poor functioning of institutions (40% for each group).



**Figure 3.** Causes of constraints across different key stakeholders.

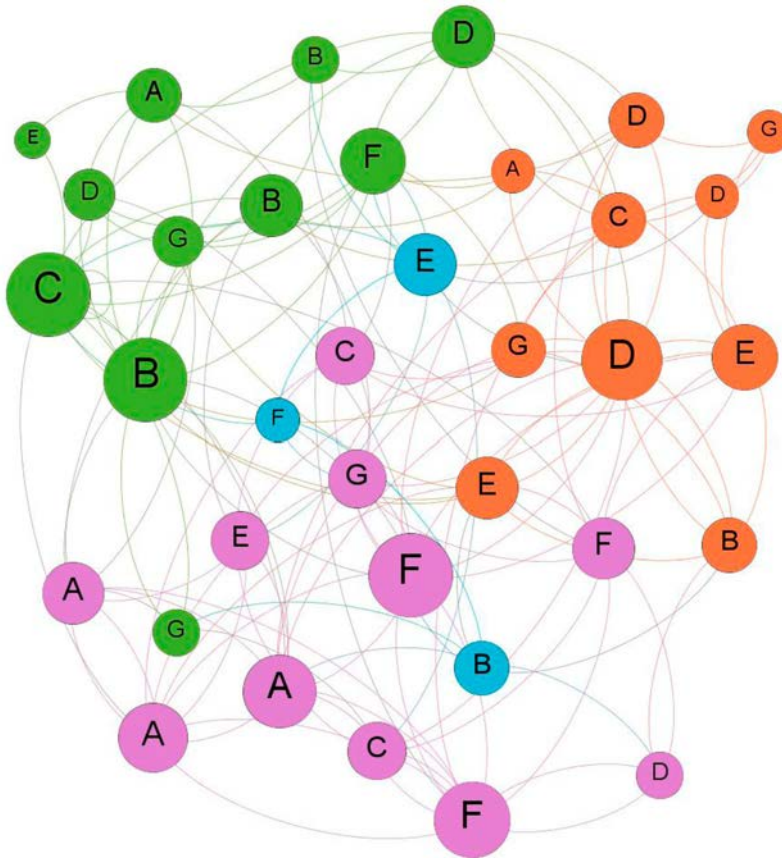
Notes: Data from multi-stakeholder workshop.

The causes of constraints identified by local communication stakeholders were more related to the absence of or limited capabilities and resources (60%). Respectively 80%, 80%, 60%, and 60% of service providers, local communication agents, local authorities, and research stakeholders' constraints could be easily addressed. Constraints indicated by research, local communication agents, seed company and farmer, (80%, 80%, 60%, and 60%, respectively), could be solved in collaboration with other research development and policy actors. Addressing farmers' constraints was perceived as difficult and would require middle-term (5–10 years) intervention, while other stakeholders' constraints were perceived as easy to resolve and would require short-term (<5 years) intervention.

### **Constraint linkage analysis**

During session seven of the multi-stakeholder workshop, stakeholders jointly identified and connected relationships between constraints (Figure 4). Overall (Table 7), constraints faced by local authority/government have a high mean degree of connectivity (6), followed by constraints faced by farmers (5) and those faced by seed companies (4).

Constraint networks (Figure 4) show four clusters of constraints that are most related to each other. The first big cluster (violet) shows constraints of financial resources for scaling of RiceAdvice, which were experienced or perceived by farmers, service providers, seed companies, local communication agents, research organisations, and local authorities/government. Examples include limited financial resources to buy fertilisers, electronic materials (tablet, smartphone), farms, and dissemination/scaling tools (rural radio, farmer field day, videos, etc.). The second cluster (green) shows constraints in accessing inputs, including farmers' limited access to adequate inputs (seed, fertiliser) and the "gratuity mind". The third cluster (brown) showed two constraints to scaling RiceAdvice: a high rate of illiteracy experienced by all stakeholder groups and access to service providers (e.g. limited female service providers and limited access to RiceAdvice by female farmers). The fourth cluster (blue) shows constraints of farmers' initial resistance during the first exposure to the technology. These four constraints (violet, green, brown and blue) were confirmed during the in-depth interviews in the following proportions: 81%, 79%, 69%, and 68% for farmers, respectively, and 97%, 94%, 93%, and 82% for service providers, respectively.



**Figure 4.** Interrelations between constraints.

Notes: Letters indicate stakeholder groups: A = rice farmer; B = service provider; C = research organisation; D = NGO/civil society; E = seed company; F = local authority/government; G = local communication agent. Nodes sizes indicate the relative connectivity of the constraint. Colours (violet, green, brown, or blue) indicate constraints that are the most related. Data from multi-stakeholder workshop.

### **Entry points for innovation to succeed in scaling up and scaling out RiceAdvice**

During the multi-stakeholder workshop, participants in homogenous groups were asked to identify key entry points in three domains: (i) actions for dissemination, (ii) institutional/political actions, and (iii) gender-responsive actions to address the prioritised constraints. Results showed that the constraints could be addressed through institutional/political actions (57%), dissemination (40%), and gender responsive actions (3%). [Table 8](#) summarises suggested key entry points.

For institutional/political actions, organising farmers' groups was considered a first step entry point to scaling up and scaling out RiceAdvice adoption and can be facilitated to create a link

**Table 7.** Nodes, ties and mean degree of constraint connectivity for stakeholder groups.

Stakeholder group	Nodes	Ties	Mean degree of constraint linkages
Farmers	5	25	5.0
Service providers	5	17	3.4
Research organisation	5	16	3.2
NGOs/civil society	5	19	3.8
Seed company	5	22	4.4
Local authority/government	5	30	6.0
Local communication	5	15	3.0
Total	35	144	4.1

Note: Data from multi-stakeholder workshop.

**Table 8.** Entry points for the process of RiceAdvice scaling.

Entry points for institutional/political actions	Entry points for dissemination	Entry points for gender-responsive actions
(1) Organising farmers through farmers groups/associations (if none exist). (2) Linking farmers' groups/associations with service providers for RiceAdvice. (3) Linking farmers' groups/associations to financial institutions for solving financial issues related to inputs. (4) Linking farmers' groups/associations with agricultural input agencies for organising group-based procurement system for agricultural input. (5) Linking farmers groups/associations with seed company. (6) Involving local leaders at village level in RiceAdvice scaling activities.	(1) Mobilising funds for disseminating RiceAdvice to farmers. (2) Demand creation through awareness campaign to rice farmers on the benefits from RiceAdvice using rural radio, video, TV programmes (can include farmers' voices), posters in local language, field day (use of demonstration plots), and local communication tools such as town criers. (3) Development of business models for private advisory service (e.g. including RiceAdvice fees in other services (processing, credit); includes seed company and other agricultural input agencies). (4) Present RiceAdvice and its achievements in local agriculture sector and to any other scaling partners that can disseminate. (5) Strengthening service providers on their skill and knowledge of rice production and use of RiceAdvice. (6) Building/strengthening collaboration with public extension agents to capitalise local extension service experiences.	(1) Involving female farmers' association for identifying female service providers. (2) Training female service providers on use of RiceAdvice. (3) Creating female farmers' awareness through local authorities and female farmers' organisations. (4) Facilitating women's access to credit.

Note: Data from multi-stakeholder workshop.

with RiceAdvice service providers, input suppliers, and financial services. For dissemination actions, funding is needed to create demand, build capacity, and develop business models. Strong collaboration between private advisory services and public extension systems is needed to ensure that private advisory service follows recommendations that are supported by the local government. For gender-related actions, female service providers are needed to support female farmers.

## Discussion

Farmers who used RiceAdvice in this study increased their rice production yield and income and reduced their fertiliser inputs. This finding confirms previous results from on-farm trials conducted in Senegal River Valley, which showed similar increasing trends in rice yield and profit when farmers used a web-based decision support tool on nutrient management (Saito et al. 2015b). However, the study in Senegal was piloted at a small-plot level and benefits beyond financial capital were not assessed. This study shows that the advantages of RiceAdvice go beyond financial capital by also assessing its impact on human and social capitals. This alone justifies the need for increased effort to scale-up and scale-out RiceAdvice as an innovative agricultural tool in northern Nigeria.

Foster and Rosenzweig (2010) noted that the success of an innovation requires availability, affordability, and profitability. Although farmers used RiceAdvice recommendations to reduce fertiliser application rate and boost their income from rice production (which are linked with affordability and profitability), the level of implementation depends on farmers' socio-demographic status, such as education level, access to inputs (mineral fertilisers), agricultural training, age, and years of experience. Like previous studies, these findings confirm that the adoption of an innovation is influenced by individual's differences in socio-demographic status (Yokouchi and Saito 2016).

To reduce inequality in availability and affordability of RiceAdvice among farmers, capacity development is needed for the illiterate and those with limited access to agricultural training. Farmers with limited access to mineral fertiliser can be linked with financial services. Older and more experienced

farmers might find it difficult to change their practices and demonstration plots might be needed. Some of these interventions were identified as key entry points in the multi-stakeholder workshop.

This study cannot address gender issues at farmer level because gender barriers were not visible at the beginning of dissemination in 2016, as trained male service providers could not access female farmers. In SSA in general, and particularly in predominant Muslim countries, women are negatively affected by socio-cultural and religious constraints, which forbid them from communicating freely with men outside their families (Zossou et al. 2017). Preliminary results and findings from monitoring and evaluation dissemination process show that several female farmers' groups nominated female service providers to enhance female farmers' use of RiceAdvice from 2017 onwards. The contribution of female farmers' groups to the process of scaling out and scaling up RiceAdvice is important to overcome gender bias in sustainable rice production in Nigeria, particularly in Kano State.

A previous study in West Africa showed that most knowledge and information on rice farming technologies is acquired via word-of-mouth from peers (Zossou et al. 2017). This study found that around 90% of farmers shared their experience with their peers through verbal communication. But, generating recommendations using RiceAdvice requires digital gadgets (smartphone, tablet) and knowledge of how to use RiceAdvice, neither of which were provided to farmers by service providers. Consequently, rapid farmer-to-farmer knowledge dissemination might be limited for RiceAdvice and will require other channels for innovative dissemination, such as service providers working with farmer groups so farmers can learn how to use it. However, in the survey about half of the farmers reported that the need to rely on service providers to follow-up on recommendation was a disadvantage. This could imply the need for innovative service delivery models, such as ordinary mobile phones (e.g. text and voice messages), or strengthening the capacity of farmers to directly use RiceAdvice. Also, engaging with and enhancing the capacity of farmer organisation leaders as potential actors in strengthening agricultural extension is important because of their social capital in rural areas (Zossou et al. 2017). Their support for the use of RiceAdvice would convince farmers within their communities more effectively than suggestions from outsiders.

Results from the semi-structured interviews and multi-stakeholder workshop indicated that major constraints to scaling up and scaling out RiceAdvice were institutional rather than economic, technological, socio-cultural or biophysical, and the causes of constraints were mostly related to the absence or poor functioning of institutions and the absence or limited capabilities of financial resources. The need for institutional innovation is also evident from the constraint relationships shown in [Figure 4](#). Further, during the multi-stakeholder workshop, stakeholders agreed that about 60% of the constraints could be solved through collaboration between research and development and policy actors. These findings are consistent with previous RAAIS studies, which showed the need for institutional innovation to address agricultural systems intensification in Africa (Schut et al. 2015, 2016; Muilerman, Wigboldus, and Leeuwis 2018).

Institutional innovation for scaling RiceAdvice requires partnerships among stakeholder groups. Some partnerships, such as public and private financial services, are essential to improving farmers' access to financial services, while others provide farmers with inputs such as seed and fertilisers.

Establishing a partnership between RiceAdvice and the Nigeria Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) would lead to effective scaling up and scaling out of RiceAdvice. Plans are underway to expand NIRSAL services to rapidly increase the number of farmers receiving financial support. NIRSAL targets farmers' groups rather than individual farmers. At the moment, they estimate the costs of fertiliser application based on blanket recommendations and the, transfer the cost of fertilisers to farmers as credit. By partnering with NIRSAL, RiceAdvice could be included in their financial service to farmers.

RiceAdvice could also be used for contractual arrangements with out-grower schemes, such as rice mills. Farmers could purchase fertiliser inputs based on RiceAdvice recommendations prior to the rice growing season and then be charged the input and service cost when they sell paddies to the millers. However, strong collaboration between local and national authorities and private agricultural advisory service is needed for RiceAdvice to be accepted as the official tool used by public and private

extension services. This partnership could be further expanded to other service enterprises like seed companies, input dealers, and agricultural machinery servicing. Further, local farmers' groups and associations can identify their service providers for dissemination of RiceAdvice and pay for the service as part of their membership fees.

This study clearly shows that farmers are willing to pay for RiceAdvice recommendations. However, difficulty in accessing credit/inputs at the beginning of rice growing season is a major challenge that would restrict farmers from paying for the service (Tanaka, Diagne, and Saito 2015). Further, the farmers' "gratuity mind" limits their willingness to pay for the service. Therefore, we recommend the service cost be integrated into other services or membership fees in farmers' groups or associations. These approaches, as well as other innovative service delivery mechanisms and business models, need to be developed and tested to succeed in scaling up and scaling out RiceAdvice.

## Conclusion

In this study, RAAIS was used to identify constraints and opportunities to scale-up and scale-out RiceAdvice. In-depth interviews were also used to assess the perception of RiceAdvice from farmers and service providers, farmers' ability to implement RiceAdvice recommendations, and the benefits.

Farmers using RiceAdvice saw an increase in yield and income from rice production and a reduction in fertiliser inputs. Positive impacts were also received by beneficiaries' (farmers and service providers) human and social capitals. This justifies the need for increased effort in scaling RiceAdvice as an innovative agricultural tool in northern Nigeria.

Factors that determined a farmers' ability to implement RiceAdvice recommendations included education level (positive), access to inputs like mineral fertilisers (positive), access to the agricultural training (positive), age and years of experience of rice farmers (negative). To ensure effective RiceAdvice use, various actions need to be adopted by rice value chain stakeholders, such as capacity development, improved financial service systems, and field demonstrations.

The RAAIS analysis showed that the major constraint on adoption of RiceAdvice is the absence or poor functioning of institutions, the absence or limited capabilities of resources, and the absence or poor interaction and collaboration among stakeholders. Addressing these constraints to scale-up and scale-out RiceAdvice requires further research on: (i) improving access to financial services and input supply services through partnerships with various stakeholders; (ii) identifying and testing business models where RiceAdvice is used by service providers as part of income-generation activities; and (iii) establishing a targeted dissemination approach for RiceAdvice, which includes working with female service providers to reach female farmers and those who could not follow-up on the recommendations due to socio-demographic factors. The success of scaling up and scaling out RiceAdvice could have a positive impact on improving rice productivity in northern Nigeria where rice is recognised as one of the flagship crops for food security.

## Acknowledgements

We are grateful to all rice value chain stakeholders in Kano State in Nigeria involved in the data collection during this study.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

This study was supported by Global Rice Science Partnership (GRISP); the CGIAR Research Program on Rice (RICE); African Development Bank under the project support to Agricultural Research for Development of Strategic Crops in Africa [2100155022217]; and Japanese government.

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