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Factors affecting interactions between different key actors in improved rice varieties innovation system in the Eastern Zone of Tanzania

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This study examines factors affecting the interactions between different key actors in the innovation system of improved rice varieties in the Eastern Zone of Tanzania. A parallel mixed design was used to collect the data from a sample of 340 randomly selected rice farming households and 34 purposively selected key informants from actor groups involved in rice innovations. Information was collected using structured and semi-structured interviews, focus group discussions, and documentary review. Factors affecting interactions between farmers and other key actors were analyzed using a binary logistic model and chi-square test, meanwhile, content analysis was used to analyze the qualitative data. The findings show that household income, farming systems, leadership, innovation platforms, coordination bodies, trust, human and financial resources, ICT facilities, and transportation means were the factors that affected interactions between different actors in the system. Equally, limited financial resources were reported to have affected every actor group's ability to interact in the system, thus significantly constraining the implementation of linkage activities designed to facilitate actors' interactions along the improved rice varieties value chain. This study speaks to policymakers on formulating strategies for financial resource mobilization that will strengthen availability and accessibility of finance by actors and enable the implementation of linkage activities (e.g., innovation platform establishment, enhancement of ICT facilities, and improvement of transport means, among others) which, in turn, will strengthen actors' interactions in the system and improve rice production.

Keywords: actors, factors, interaction, innovation system, improved rice varieties

Introduction

Innovations are increasingly becoming key drivers of agricultural growth and development across the world. However, new agricultural innovations in developing countries have not been widely adopted. This has led to the realization by innovation experts that innovations can neither be delivered nor scaled up in an *ad hoc* manner (Mbo'o-Tchouawou et al. 2016); thus leading to the search for new frameworks popularly known as innovation systems (ISs). An IS is a group of organizations and individuals involved in the generation, diffusion, adoption, and use of new knowledge and institutions (the rules of the game e.g., laws, regulations, beliefs, customs, and norms) and policies that govern the way these interactions and processes take place (Anandajayasekeram and Gebremedhin 2009). A core understanding in agricultural innovation system thinking is that multi-actors (farmers, extensionists, input suppliers, financial institutions, researchers, policymakers, among others) contribute to agricultural innovations and that it is a combination of the quality and skills of the individual actors, and also essentially, the quality of their interaction, which determines the capacity to innovate (Gildemacher and Wongtschowski 2015).

Importantly, IS frameworks put interaction of different actors and their ideas at the centre of innovation processes (Mulema 2012; Sulaiman 2015) viewing it as 'the bread and butter' of the innovation because it facilitates the exchange of knowledge rooted in individuals in the network (Rajalahti, Janssen, and Pehu 2008). The literature on ISs asserts that interaction between multitudes of actors strongly facilitates the generation of relevant agricultural innovations to agro-ecological areas and socio-economic demands of farmers (Chaminade and Edquist 2010; Kiefta, Harmsen, and Hekkert 2017). This kind of interaction also speeds up the dissemination and adoption of innovation to increase agricultural production and productivity. The importance of the interaction of multitudes of actors can also be read in Abagamu's argument (2000) which proposes that for agricultural innovations to be relevant to local condition and highly adoptive, researchers, extension officers, farmers, and other actors must play pertinent roles in identifying research problems and adapting recommendations to local conditions.

One area where the IS approach has been tried in Tanzania is in the rice sector. The Government of Tanzania formulated the National Rice Development Strategy (NRDS) in 2009. The strategy emphasizes the interactions of multi-actors in rice innovation processes. Likewise, the linkage between researchers, extension officers, and farmers was effected through the establishment of Zonal Information and Extension Liaison Units at the zonal research centres, with enhanced communication capability (United Republic of Tanzania – URT 2009a). Despite these efforts, there has been a persistent lack of or weak interactions between these actors in the generation, dissemination, and utilization of rice innovations in Tanzania (URT 2013; URT 2016a). Mgumia (2015), on his part, is concerned that the key actors of innovation including researchers, the private sector, farmers, extension service providers, and non-government organisation (NGOs) are still operating in isolation in Tanzania.

At the same time, factors affecting actors' interactions have been largely overlooked, specifically in the innovation system of improved rice varieties (IRVs) in

Tanzania. The IS studies conducted in Tanzania by Maerere et al. 2010; Szogs, Cummings, and Chaminade 2011; Rwambali 2012; Mgumia 2015; Wambura et al. 2015; Mkula 2018, among others did not focus on improved rice varieties innovation system (IRVIS) leaving a gap in what possible factors affecting actors' interactions in IRVIS in the country are. Besides, studies on rice IS (Emodi 2010; Suchiradipta and Raj 2014) in other countries have also inadequately reported on factors affecting actors' interactions. In this connection, the researchers argue that relevant stakeholders including policymakers in Tanzania are still not well informed about empirical factors affecting interaction among actors in the IRVIS. It is, therefore, germane to identify the significant factors affecting interaction among actors in the IRVIS in order to come up with strategies including policies for enhancing interaction among various actors in IRVIS for the purpose of increasing rice production and productivity in the country. This study answers the question: What are the socio-demographic characteristics of farmers, institutional, and infrastructural factors that affect the interactions among key actors in the IRVIS in the Eastern Zone of Tanzania (EZoT)? The hypothesis was set in the null form (Ho) as follows: There is no significant influence of socio-demographic characteristics of farmers, institutional and infrastructural factors on the interactions among key actors in the IRVIS in the EZoT.

Theoretical and conceptual frameworks

Since its emergence in the mid-1980s, the National Innovation System that is limited within the boundaries of a nation (Saravanan and Suchiradipta 2017), consisting of many actors, networks, and complex institutional setups (Rwambali 2012), and covering all sectors of the economy in a nation (Aerni et al. 2015), other system-level analyses have emerged. These include the Regional Innovation System used when a region is the unit of analysis (Wieczorek and Hekkert 2012); Sectoral Innovation System which often goes beyond national borders (Wieczorek and Hekkert 2012) but its focus is much more narrow (Porter 1990), and it can be defined as 'the set of new and established products and the set of agents carrying out market and non-market interactions for the creation, production, and sale of those products' (Malerba 2002); and Technology Specific Innovation Systems (TSIS) which focuses on technologies and not on sectors, and can be defined as a network of actors interacting in a specific technological area under particular institutional factors that enable or constrain these agents' interactions (Hardeman and Vertesy 2013).

For this particular work, a TSIS approach is used. The TSIS frameworks adopted in this paper are based on the structural analysis and systemic problem frameworks. The main reason for using a structural analysis framework is that it explicitly recognizes the interactions and knowledge flows among various actors and emphasizes that institutional and infrastructural factors are vital in enabling or constraining interactions among actors in the ISs (Sulaiman 2008). Sulaiman (2015) asserts that the interactive system is made of individuals and organizations that demand and supply knowledge; and institutions and infrastructure that enable or affect these agents to interact and exchange knowledge. Furthermore, a systemic problem framework was used to support the structural analysis framework. The systemic problem framework identifies the factors that hinder the interaction between actors which in turn inhibit the development and smooth functioning of ISs (Wieczorek and Hekkert 2012).

According to the literature, the systemic problems can generally be categorized into infrastructural, institutional, interaction (network failure), and actor capability problems (Chaminade, Intarakumnerd, and Sapprasert 2012; Kiefta, Harmsen, and Hekkert 2017). The institutional factors in ISs studies (Sulaiman 2015; Turner et al. 2015) 'encompass a set of common habits, routines, and shared concepts used by humans in repetitive situations (soft institutions) organised by rules, norms, and strategies (hard institutions)'. Other institutional factors in ISs include the type of leadership (good or bad), coordination bodies, a lack of trust, and lack of strong farmer organizations that can protect farmers' interests or link farmers with other actors in the network (Bayissa 2015).

On the other hand, there are three types of infrastructural problems which have also been underscored in ISs studies: (i) lack or poor physical infrastructure such as roads, telecommunication networks, bridges, harbours; (ii) lack of skilled personnel or the inadequate number of staff (human infrastructure) (e.g., policymakers, researchers and extension officers); and (iii) lack of financial infrastructure such as subsidy on input supply, grants, banks, micro-finance institutions, the expenditure of national budgets on agriculture and research, credit scheme for small farmers, etc. (Bayissa 2015; Kiefta, Harmsen, and Hekkert 2017; Turner et al. 2015; Wieczorek and Hekkert 2012). Other IS scholars have added the socio-demographic factors as among the factors that can enable or constrain significantly the interactions of actors in the IS processes (Emodi 2010; Mbo'o-Tchouawou et al. 2016). Therefore, farmers' demographic factors were added in this study as one of the systemic problems which could affect farmers in interaction with other actors in the system. Figure 1 conceptualizes factors affecting interaction among actors.

The ISs approach offers a framework that enables to identify what inhibits actors from interacting and facilitates the generation, diffusion, and adoption of agricultural innovations. It prescribes that the policies put in place by policymakers should target systemic problems that impede the system from optimum operation (Kiefta, Harmsen, and Hekkert 2017). The main premise of this paper is that there are demographic, institutional, and infrastructural factors that inhibit actors from interacting in the IRVIS that in turn prevent the IS from desirable performance and hence low rice production.

In the context of this study, interaction is used to mean relationships and collaborations between different organizations in pursuing the commonly shared objectives of generating, disseminating, and adopting IRVs to improve rice production and productivity. Meanwhile, various factors refer to the systemic problems which are mainly grouped into demographic characteristics of

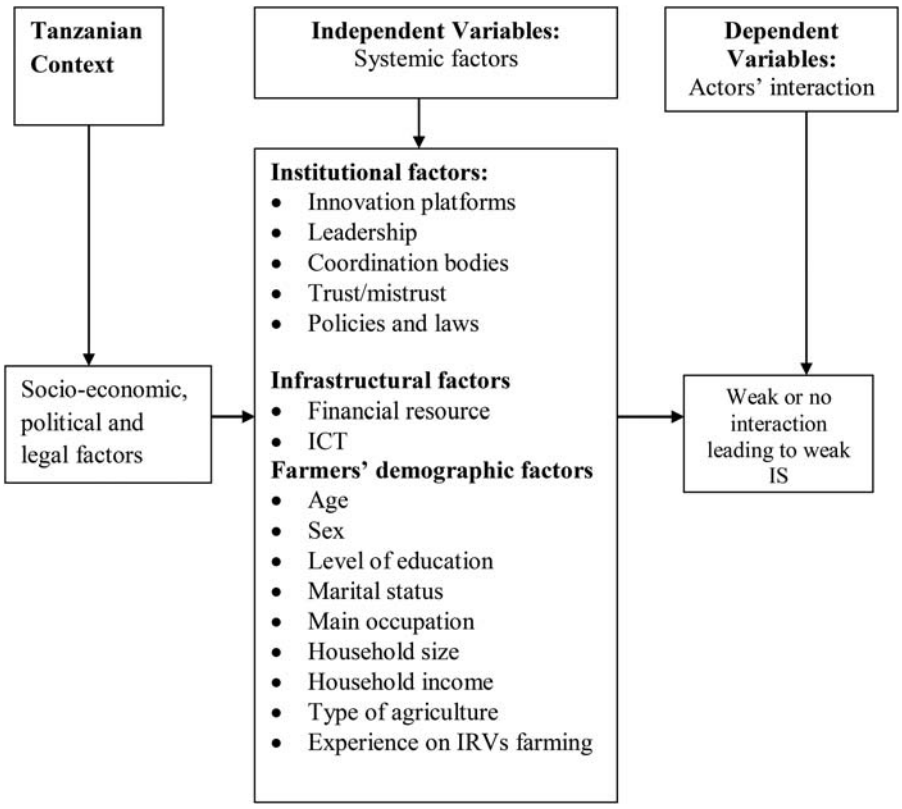

Figure 1: A conceptual framework of factors affecting actors' interaction in IRVIS.
Source: Author (2020)

farmers, institutional and infrastructural factors that hinder interaction among players in the IRVIS (see Figure 1).

Methodology

Description of the study area

This study was carried out in the EZoT. The zone is composed of four regions namely Morogoro, Coast, Tanga, and Dar es Salaam Regions. The zone was purposely selected due to various reasons as cited by Charles, Mattee, and Msuya-Bengesi (2020). Firstly, the zone is one of the areas that are leading to rice production in Tanzania. Secondly, there are many development partners such as Japan International Cooperation Agency (JICA), United States Agency for International Development (USAID), and the World Bank that have been facilitating and sponsoring training on rice innovations. Thirdly, the zone is home to several agricultural research institutes such as Kilombero Agricultural Training and Research Institute (KATRIN) and Dakawa/ Cholima centre that are engaged in training, researching, and breeding of rice varieties. Finally, the presence of Sokoine University of Agriculture (SUA), Ministry of Agricultural Training Institutes (MATI) Ilonga, and Mkindo Farmers Training Centre (MFTC) that train farmers on agricultural technologies including IRVs made the zone an appropriate site for research.

Research design and sampling procedures

This study used parallel mixed design to identify the factors affecting interactions between different actors in the IRVIS. According to Creswell (2014), a parallel mixed design allows the researcher(s) to collect both quantitative and qualitative data concurrently, analyze them separately, and mix the results during the overall interpretation of the two sources of data. The study population constituted smallholder rice farmers and other actors involved in IRVIS in the EZoT. The study used a sample size of 340 (out of 3040) randomly selected rice-farming household heads in the villages of Mkindo in Mvomero District Council, Mkula in Kilombero District Council, Jitengeni in Korogwe District Council, and Visezi in Chalinze District Council . These villages were deliberately selected because they were among the villages that represent areas where IRVs produced by research institutes in the EZoT were grown (Charles, Mattee, and Msuya-Bengesi 2020). The sample size of rice farming households was calculated by using the equation below established by Kothari (2004):

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq}$$
$$= \frac{(1.96)^2 \times 0.5 \times 0.5 \times 3,040}{(0.05)^2(3,040-1) + (1.96)^2 \times 0.5 \times 0.5} = 340$$

where: n is the sample size; N is the population of rice farming households; Z is the z statistic for a level of confidence (95%); e is the level of precision; and p and q are sampling distribution of the proportion of success and failure respectively.

A purposive sampling technique was also adopted in the selection of a total of 34 key informants (Table 1). These key informants were heads and/or representatives of the actor groups (such as farmer cooperatives/ farmer group, directorate of policy planning – DPP, research institutes, agricultural training institutes, extension, district councils, market traders, and seed agencies) who have been involved in the innovation of IRVs.

Data collection

The structured interview method was used in collecting both quantitative and qualitative data from 340 randomly selected rice-farming household heads. The interviews were conducted face to face by using a standardized interview schedule that contained open and closed-ended questions concerning factors inhibiting farmers to interact with other actors in the IRVIS. Semi-structured interviews were administered to the key informants to get insights about the main factors that are impeding actors' interactions in the IRVIS. In this category, a checklist of typically open-ended questions recapping the main theme of the study was prepared in advance. Also, Focus Group Discussions (FGDs) of farmers were conducted for triangulating data collected by using structured interviews. One FGD was organized in each study village. Each FGD was composed of between 6 and 12 smallholder rice farmers. Participants of the FGDs were enlisted by considering their experience of farming IRVs. Finally, scholarly publications such as books, journal papers, theses/dissertations, and government publications were used to fact-check and corroborate data collected through structured and semi-structured interviews and FGDs.

Data analysis

Quantitative data from rice farming household heads were coded and analyzed using the Statistical Package for Social Sciences (SPSS) spreadsheet version 20 to produce inferential statistics which included binary logistic regression and chi-square test (x^2). The binary logistic model used to analyze the factors affecting interactions between farmers and other key actors in IRVIS was written as follows:

$$\log\left(\frac{pi}{1-pi}\right)\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots\ldots\ldots \beta_{16} x_{16;}$$

where: *pi* is the probability of the *i*th respondent interacting with other key actors in IRVIS. β_0 is constant, β_1 to β_{16} are coefficients of the independent variables, while X_1 to X_{16} are independent variables entered in the binary logistic regression model.

The binary logistic model was used for this study because the dependent variable (interaction) was dichotomous and thus measured based on whether a farmer interacted or did not (coded as 1 = interacted; 0 = did not interact). The independent variables were measured as follows:

1. Age of head of household in years.
2. Sex (1 = Male, 2 = Female).
3. The level of education of the household head was measured based on the level of literacy (1 = No formal education, 2 = Primary education, 3 = O-level secondary, 4 = Advanced secondary, 5 = Tertiary education).
4. Marital status (1 =Single, 2 = Married).
5. Main occupation (1= herder, 2 = farmers, 3 = agro-pastoralist, 4 = business, 5 = wage employment)
6. Household size is the number of persons who reside in the same homestead, have the same cooking arrangements and are answerable to the same household head.
7. Household income as a total income obtained from different sources of income in 2017 in Tanzanian shillings.
8. Farming system (1 = rain-fed, 2 = irrigated).
9. Experiences in growing IRVs in years
10. Innovation platform (1= not important constraint, 2 = important constraint)
11. Leadership (1= not important constraint, 2 = important constraint)
12. Coordination body (1= not important constraint, 2 = important constraint)
13. Trust (1= not important constraint, 2 = important constraint)
14. Acts or policies (1= not important constraint, 2 = important constraint)
15. ICT facilities (e.g., radio, TV, mobile telephone, and web sites) (1= not important constraint, 2 = important constraint)
16. Financial resources (1= not important constraint, 2 = important constraint)

Table 1: Key informants interviewed from different categories of actors.

Actor/organization	Key informants
Director of Directorate of Policy and Planning (DPP) in Ministry of Agriculture (MoA).	1
Directors of Research Institutes	2
Director of ASA	1
QDS producers	2
Director of Tanzania Official Seed Certification Institute (TOSCI)	1
Principals of MATI Ilonga and MFTC.	2
District Agricultural Irrigation and Cooperative Officers (DAICOs)	4
Manager and loan Officers of Banks	2
Village and Ward Extension Officers	7
Rice traders	4
Agro-dealers at district level	4
Rice milling plant owners in the four Districts	4
Total	34

According to Hair et al. (2014), before the estimation of the model parameters, it is crucial to look into the problem of multicollinearity among the explanatory variables. Tolerance and Variance Inflation Factor (VIF) were used to detect whether a predictor had a strong linear relationship with the other predictor(s) (Field 2009). Pseudo R-square, specifically Cox and Snell and Nagelkerke R^2 statistics, were used to explain the proportion of the variation in the dependent variable to that of the independent variable in the model. Additionally, Hosmer and Lemeshow's measure was used to assess how well the chosen model fits the data (Field 2009). Cross-tabulation and x^2 were computed to check whether factors constraining smallholder rice farmers to interact with financial institutions were statistically different across villages. On all the statistical tests, the decision was determined by a significance level of 0.05.

Content analysis was used in analysing the qualitative data collected from structured and semi-structured interviews and FGDs. The content analysis mainly involved the transcription of recorded information, interpretation, and clustering them into themes based on the conceptual description of ideas. Pseudo-names were used in reporting the participants to protect their identity.

Results and discussion

Factors affecting interactions of farmers with other actors in IRVIS

Table 2 shows a binary logistic regression model of the socio-demographic characteristics of farmers, institutional and infrastructural factors that affect farmers in their interaction with other actors in the IRVIS in the EZoT. The results show that the VIF for all variables in the model ranged from 1.078 to 1.913, indicating the absence of multicollinearity in the model equation. Field (2009) pointed out that 'although there are no hard and fast rules about what value of the VIF should cause concern, a value of 10 is a good value at which to worry'. Subsequently, results in Table 2 show the tolerance values ranging from 0.523 to 0.927 which is an indication of the absence of a problem of multicollinearity. According to Field (2009), the tolerance value of 'below 0.1 indicates serious problems and suggests that values below 0.2 are worthy of concern'.

The −2 log likelihood was 352.773 implying that the addition of explanatory variables delineated more of the variance in the outcome. The value of Chi-square was 76.47 with df = 14 and $p = 0.000$ and hence it was statistically significant ($p \leq 0.05$), implying that the independent variables had a significant influence on the dependent variables. Moreover, the p-value test statistic of Hosmer and Lemeshow result was non-significant ($p = 0.463$), indicating that the fitting effect between the data and model is good. The rule of thumb for accepting a logit model is that the p-value of Hosmer and Lemeshow must be greater than 0.05 (Pallant 2011). Secondly, the Chi-square statistic of Hosmer and Lemeshow was 7.705 and df = 8 which is statistically significant at the 5% confidence level, implying that all the predictors that have been included in the model are capable of jointly predicting farmers' interactions in the IRVIS. Furthermore, Nagelkerke $R^2 = 0.205$ and Cox and Snell $R^2 = 0.283$ implied that the factors studied described the interactions among actors at 20.5% to 28.3%.

The results in Table 2 indicate that household income, farming system, financial resources, ICT, leadership, and trust significantly influenced farmers' interaction in IRVIS. Household income had a beta coefficient of 0.001 and was statistically significant ($p = 0.001$) on affecting farmers' interaction with other actors in the IRVIS. This means that, as the income of the household increases, the chance of the head of a household to interact with other key actors goes up. In this regard, farmers with high income are more likely to interact with other actors involved in the innovation of IRVs. These findings correspond with those obtained by Chiligati (2010) in the Western Agricultural Research Zone, Tanzania which revealed that the low income of farmers was among

Table 2: Factors affecting interactions of farmers with other actors in IRVIS.

						Collinearity statistics	
Variable	B	S.E.	Wald	Sig.	Exp(B)	Tolerance	VIF
Sex of respondent	−0.329	0.280	1.375	0.241ns	0.720	0.870	1.149
Age of respondent	0.002	0.010	0.033	0.856ns	1.002	0.882	1.133
Education level	0.206	0.425	.235	0.628ns	1.229	0.863	1.159
Marital status	−0.575	0.311	3.430	0.064ns	0.562	0.866	1.154
Main occupation	−0.252	0.303	0.695	0.404ns	0.777	0.873	1.145
Household Size	−0.050	0.054	0.835	0.361ns	0.951	0.827	1.209
Household income	0.001	0.001	11.072	0.001*	1.000	0.827	1.210
Farming system	0.716	0.167	18.348	0.000*	2.047	0.927	1.078
Experience on IRVs	0.001	0.001	0.659	0.417ns	0.999	0.911	1.097
Financial resources	−0.617	0.294	4.403	0.036*	0.540	0.862	1.160
ICT	−0.807	0.290	7.766	0.005*	0.446	0.825	1.212
Innovation platform	1.100	0.789	1.945	0.163ns	3.004	0.523	1.913
Leadership	−1.622	0.504	10.365	0.001*	0.197	0.789	1.268
Coordination bodies	1.269	0.803	2.494	0.114ns	3.556	0.531	1.883
Trust	−0.706	0.357	3.922	0.048*	0.494	0.564	1.774
Acts or policies	0.214	0.381	0.316	0.574ns	1.239	0.537	1.862
Constant	1.568	2.259	0.482	0.487	4.798		

Note: −2 log likelihood = 352.773; Nagelkerke $R^2 = 0.205$; Cox & Snell $R^2 = 0.283$; Model Chi-square = 76.47; df = 14, $p = 0.000$; Hosmer and Lemeshow Test: chi square = 7.705, df = 8, $p = 0.463$; *Significance at 5%, and ns. = Not significant

the major hindrances to farmers' participation in agricultural research activities. Low income denies farmers to afford a full recommended dose of inputs (e.g., quality certified seeds, fertilizers, and agrochemicals) for the adoption of IRVs. As a result, most farmers lack interest in participating in linkage activities along the IRVs value chain.

The type of farming system did affect farmers' interactions in IRVIS and the variable had a positive beta coefficient of 0.716 which was statistically significant ($p = 0.000$). This implies that farmers who practiced irrigated farming systems had a higher chance of interaction with other actors than farmers who practiced rain-fed agriculture in the innovation of IRVs. At the same time, participants in FGDs revealed that most of those who were involved in IRV linkage activities such as seminars, workshops, field trips demonstrations, demonstration plots, field exchange/ tours, agricultural shows, and field days to exchange information and experiences on IRVs by researchers, NGOs, agricultural training centres among others were mainly members of farmers' cooperatives from irrigation schemes.

Leadership and trust had beta of −1.622 and −0.706 respectively and were significant ($p = 0.001$ and $p = 0.048$ respectively). The two variables negatively influenced the interaction between farmers and other actors in IRVIS. That is farmers who indicated leadership and trust as important constraints had no interaction with other actors, while those who showed leadership and trust as not important constraints had interaction with other actors in the IRVIS. Put differently, poor leadership and mistrust hindered farmers to interact with other actors in the IRVIS. Farmers in FGDs pointed out that the selection of farmers for attending training, demonstration plots, study tours, and exchanges was influenced by nepotism and favouritism. Thus, only relatives or friends of leaders of farmers' cooperatives and extension officers were always selected to participate in these events by leaders of farmers' cooperatives in collaboration with village and ward extension officers. Similarly, due to the diversified work of extension staff like being involved in tax collection from farmers for the government, most farmers did not trust them. This mistrust influenced negatively the linkage of farmers with extension agents in the IRVIS. This finding is in line with that of the studies by Gebremeskel (2010), Bayissa (2015), and Saint Ville, Hickey, and Phillip (2017), which reported that mistrust between smallholder farmers and extension agents severely, hindered their linkage to bring agricultural innovation.

Information Communication Technologies (ICTs) had a negative beta coefficient (−0.807) and was statistically significant ($p = 0.005$) on affecting the interaction between farmers and other actors in the IRVIS. Thus, farmers who indicated ICT as not a constraint had a higher chance of interaction with other actors than those who indicated ICT as a constraint. This finding shows that farmers who had low access to ICTs such as e-mail, internet, phone, radio, television (TV), and print materials had a low chance of interacting with other actors in the system. Furthermore, during FGDs in Mkula and Visezi villages, it was agreed that most smallholder rice farmers had not yet been connected to both print and electronic media. Interactions of farmers with other actors in the IRVIS were conducted through face-to-face interaction such as workshops, seminars, and field days. However, these were very occasional events and involved few farmers, especially those who were members of farmers' cooperatives in irrigation schemes.

Other scholars have shown that ICTs have the potential to connect actors in networks through the facilitation of communication and exchange of information (Kapange 2010). For example, the development of ICTs brings farmers close to market actors and gives them the potential to bargain as well as use the information to make informed choices about marketing. Similarly, a study by Asenso-Okyere and Mekonnen (2012), found that ICTs enabled farmers to have strong interactions with market actors in many African countries including Ethiopia, Kenya, Malawi, and Mozambique, Uganda, and Nigeria. Sanyanga et al. (2012) in their study in Togo, Sierra Leone, and Senegal revealed that Réseau Ouest et Centre Africain du Riz (ROCARIZ) network model was an efficient institutional innovation that enabled actors to interact with each other through using rural radio and other innovative channels to market seed rice and grain rice. Similarly, Freeman and Qin (2020) in Uganda found that farmers with access to ICTs facilities, in particular, cell phones had a greater opportunity to interact with their social network ties. Such ICT facilities enabled farmers to move between numerous information sources, shifting between in-person experts, for example, extension officers and ICT-based information sources.

Financial resources had a negative beta coefficient of −0.617, and the variable was statistically significant ($p = 0.036$). This implies that access to credit negatively affected farmers' interaction with other actors in the IRVIS. Farmers who indicated financial resources as an important constraint had a low likelihood of interacting with other actors in the IRVIS. During the FGDs in Mkindo and Jitengeni villages, participants agreed that the low rate of using technologies like certified seeds of IRVs and their production packages was due to a lack of adequate funds to purchase them. Moreover, participants in FGDs in all study villages pointed out that the prices of certified seeds (Tshs 2000–2500 per kg), fertilizers (Tshs 52,000–63,000 per bag of 50 kgs), herbicides such as 2 – 4D, rice bugs, and roundup (Tshs 12,000 per litre) were too high and were unaffordable to many smallholder farmers. There was also no subsidy for certified seeds of IRVs. All these problems hindered the interactions of farmers with researchers, agro-dealers, NGOs, extension agents, and seed agents such as the Agricultural Seed Agency (ASA), and Quality Declared Seed (QDS) producers.

In response to the question of constraints that farmers faced in interacting with financial institutions for accessing credit, farmers cited bureaucracy at the banks and inadequate knowledge on loans (Table 3). The two reasons cited showed a significant association with villages ($p = 0.000$). This implies that factors hindering

farmers from accessing credit from financial institutions differ from one village to another. So residing in a given village determines the type of factors of not interacting with financial institutions for accessing credit.

This was further clarified during the FGDs where participants expressed the fact that smallholder farmers had no land to use as collateral to secure loans since commercial banks did not accept leasehold or customary owned land as collateral. Participants in FGDs further bitterly complained that the interest rates charged by the banks were too high. A key informant also mentioned that:

> Banks are ready to provide loans to individual smallholder rice farmers; however, their readiness is constrained, among other factors, by farmers' farms being rain-fed, uncertain markets and variable prices of rice, and lack of collateral. All these have indeed affected the interaction of our Bank with smallholder rice farmers. (Macha, a loan Officer National Microfinance Bank, Turiani Branch, 05/06/2018)

This finding is in line with the view of the government (URT 2009b) which found that farmers had limited access to agricultural credit due to not being creditworthy. Furthermore, commercial banks which are the biggest lenders were reluctant to approve investments in the agriculture sector owing to its high risk. Similarly, the findings of this study are consistent with the works of Neef et al. (2006); Abate et al. (2011); Klerkx, van Mierlo, and Leeuwis (2012); and Bayissa (2015) which argue that poor farmers have little opportunity to interact with credit institutions due to huge bureaucracies and inadequate farmers' awareness, hence low use of modern technologies.

Factors affecting interaction of policymakers with other actors in IRVIS

A key informant from the DPP in MoA cited inadequate budget for rice innovations and the inadequate staff as having affected their interactions with other actors in the network of IRVs. This key informant was quoted as saying:

> The government has been allocating inadequate budget and at the same time it has not releasing all the allocated money to facilitate policymakers' interactions with other actors during the formulation and implementation of policies related to rice innovations. In this regard, policymakers cannot redesign and reintroduce policies related to rice innovations according to the received feedback from end-users/farmers. (Mulokozi in Dodoma city, 20/08/2018)

He further, said:

> The number of staff is inadequate when compared to the number of agro-ecological zones to be covered in the country.

The weak interaction between the policymakers and other actors in the IRVIS portrays a situation in which stakeholders' views are not adequately taken into consideration in policy formulation. This is contrary to the requirement of the IS perspective and a disincentive to the development of the rice industry in the country. The IS perspective 'emphasizes the need for all stakeholders to work together toward the development of public policies seeking to promote systemic innovation in response to complex and multidimensional challenges, such as household food security, rural development, and environmental change' (Saint Ville, Hickey, and Phillip 2017). An IS thinking 'emerged as a useful way to help policymakers to broaden their focus from technological innovation towards enhancing interactions between actors and how their institutional and policy contexts might create enabling environments to foster innovation' (Klerkx, van Mierlo, and Leeuwis 2012). There is a need for the Tanzanian government to increase and release all the allocated budget for rice innovation to improve interactions of policymakers and other actors in the IRVIs. In this connection, policymakers would better inform and empower other players by producing more pluralistic and inclusive public policies capable of delivering desired outcomes.

Factors affecting interaction of the research institutes with other actors in IRVIS

Key informants in KATRIN and Cholima Centre underscored the importance of interaction between researchers and other actors, especially during the stages of defining the research agenda and translating the research results into technologies and practices. However, they mentioned inadequate funds, a limited number of researchers, and insufficient means of transport as being among the major factors which inhibited their interaction with other actors in the IRVIS. One key informant from Cholima Centre said:

> There is often a lack of frequent interactions between researchers and other key actors during the generation and dissemination of IRVs. Research institutes lack means of transport and have been facing the problem of inadequate funds to support adequate face-to-face interaction between us and other actors in the networks. (Nkonyara, Research Officer in Dakawa village, 05/06/2018)

Similar results were reported by Agbamu (2000) on agricultural research–extension linkage systems in Nigeria and Tanzania; Kingamkono, Nkuba, and Schouten

Table 3: Factors constraining farmers to access credit from financial institutions.

	Factors				
Village	Huge bureaucracy	Inadequate knowledge	Total	Chi-square	*p*-value
Mkula	22 (15.2%)	17 (25.8%)	39 (18.5%)		
Mkindo	30 (20.7%)	14 (21.2%)	44 (20.9%)		
Visezi	51 (35.2%)	3 (4.5%)	54 (25.6%)	24.306	0.000*
Jitengeni	42 (29.0%)	32 (48.5%)	74 (35.1%)		
Total	145 (100.0%)	66 (100.0%)	211 (100.0%)		

Note: * significant at 5%

(2003) on networking and diversification of agricultural research funds in Tanzania; Doamekpor (2006) on research – extension – farmer interface in the cassava industry in the Volta Region, Ghana; Chiligati (2010) on factors influencing research – extension – farmer linkages in Tanzania; Bayissa (2015) on institutional factors affecting the linkage of knowledge institutes with farmers in agricultural research in Ethiopia; and Semwenda (2016) in his study in Hai District, Kilimanjaro Region on challenges facing agricultural extension in the current institutional context.

Factors affecting interaction of agricultural training institutes with other actors in IRVIS

Key informants from MATI Ilonga in Kilosa and MFTC in Mvomero revealed that their institutes had limited finance and infrastructural resources (such as hostels, classrooms, seminar rooms) for engaging in farmers' and extension staff training on IRVs. It was pointed out that limited financial resources were a result of an inadequate government budget on facilitating farmer training on IRVs and their production packages. Similarly, the Acting Principal of MFTC said:

> There are many smallholder rice farmers who wish to take courses at our centre, but because of limited infrastructure, we cannot accommodate all of them. Also, some development partners such as Japan International Cooperation Agency (JICA), and United States Agency for International Development (USAID) have been sponsoring some short courses, but we sometimes fail to facilitate the training because of limited space. (Byalugaba at MFTC in Mkindo village, 05/06/2018)

Factors affecting interaction of extension with other actors in IRVIS

All the interviewed extension officers indicated that their limited number affected their interaction, especially with farmers in the study area. The study found that the limited number of extension agents was not because the trained and qualified extension agents were not available, but it was due to the limited budget of the government to employ enough extension agents. By then, there was a high number of unemployed trained and qualified extension agents from SUA and other agricultural training institutes in the country.

Equally important, the extension officers revealed that they were engaged in numerous non-extension responsibilities assigned to them by their supervisors or employers. Those activities included tax collection at local markets, acting as ward or village executive officers for a long time, and supervising health campaigns in their villages or wards. These non-extension services prevented them from serving as potential intermediaries by facilitating partnerships, building coalitions of different actors, and linking farmers with other farmers, researchers, agribusiness, market actors, and training in the network. This is similar to the findings of the studies by Belay (2008), Chiligati (2010), Wigboldus and Lee (2011), Klerkx, van Mierlo, and Leeuwis (2012), Daniel (2013), and Bayissa (2015) which showed that the interaction of extension officers with other actors in agricultural innovation is affected by engagement of extension officers in non-extension activities assigned to them by their supervisors. These kinds of additional responsibilities overburden them and consume their time which would have been spent linking with farmers and other actors in the IS.

In this connection, extension officers further reported to have not been receiving funds from the government for facilitating their extension activities. They mentioned the lack of adequate finance and means of transport which they could use to reach the farmers. For example, only 2 out of 7 visited extension officers had motorcycles. Furthermore, extension officers cited poor communication infrastructure as a constraint that severely hampered their interaction with farmers. Extension officers were found to have little or no access to publications, TV, telephone, or radio services for long-range communications with farmers. Finally, as it has been explained in the previous sections, extension officers flagged the existence of mistrust developed by farmers towards them as a hindrance to their interactions with farmers. This is contrary to the IS perspective where all actors are required to have a positive relationship with each other in the process of creating strong linkages that will bring about innovations in agriculture for enhanced food security (Abate et al. 2011; Belay 2008; Wigboldus and Lee 2011).

Factors affecting interaction of district councils with other actors in IRVIS

All interviewed DAICOs in the four district councils cited problems of allocation of insufficient funds and delay of approval and release of funds for activities of IRVs innovation as inhibiting their interaction with other actors in the IRVIS. They reported that in some years the Government could not budget and release funds for rice innovation activities. These findings concur with those of Chiligati (2010) and Semwenda (2016) who found that Local Government Authorities (LGAs) suffered from insufficient funds and delayed release of approved funds for linkage activities in agricultural innovations. This has been affecting interactions among actors, which in turn causes low agricultural production.

It was also revealed by District Agricultural, Irrigation and Cooperative Officers (DAICOs) that there were no innovation platforms or institutionalized coordinating bodies at national or regional, and local levels. The DAICOs further pointed out that innovation platforms would create space where each platform member could access different experts and enhance their skills on IRVs. The findings of this study support the conclusions of Belay (2008), Gebremeskel (2010), Wigboldus and Lee (2011), and Bayissa (2015) that weak interaction among actors in innovation activities emanated from lack of innovation platforms and institutionalized bodies for coordination. On the other hand, the findings of this study are contrary to the Agricultural Sector Development Programme Phase Two (ASDP II). This phase proposed the establishment of commodity clusters 'comprising three to six districts with a proven potential for that specific commodity as well as the presence of value chain actors (such as farmers, traders, processors, and service providers) meeting in a multi-stakeholder innovation platform' (URT 2016b). The findings are also

contrary to the IS perspective which requires the existence of multi-stakeholder innovation platforms that bring together groups of individuals (who often represent organizations) with different backgrounds, expertise, and interests to provide them with space to learn, put forward their needs and preferences, and negotiate the type of innovations that are technically feasible, economically viable and socio-culturally and politically acceptable (Davies et al. 2018; Mulema 2012; Sulaiman 2015; Tropical Agriculture Platform 2016; Tucker et al. 2014; Tui et al. 2013).

Factors affecting interaction of market actors with other actors in IRVIS

Agro-dealers, rice traders, and millers revealed various factors including lack of interest and absence of innovation platforms as the major factors that hampered their interaction with other actors in the IRVIS. What emerged out of FGDs in the study villages is that traders and millers interacted with farmers only when they were buying paddy. Researchers in research institutes also reported to have been informing agro-dealers, rice traders, and millers, to participate in IRVs research development, but their response has been negative. One key informant in KATRIN was quoted saying:

> Rice traders and millers seem to be busy with money-making activities. They do not seem to see the importance of interaction during the generation of IRVs. This has made us lose interest in inviting them to participate in the generation of IRVs. We feel bad when we invite them and they do not attend. (Kessylian Research Officer at KATRIN, 13/06/2018)

This finding is in line with that of Shetto (2008) in Tanzania who found that input stockists and market traders had neither the time nor interest to interact with researchers except where there were tangible benefits. Weak interaction of market traders who have frequent linkages with end-users (farmers and consumers) of the technology (the IRVs) can largely cause researchers to generate IRVs that do not meet the agro-ecological and socio-economic demands of the end-users. It is important, therefore, that agro-dealers, traders, and millers change their mindset and start participating in the IRVs generation to provide the needed attributes in IRVs by end-users (farmers).

Factors affecting interaction of seed multipliers with other actors in IRVIS

Interviews with informants from ASA, QDS, and TANSEED International Ltd cited insufficient funds as one of the major factors inhibiting them from interacting with researchers, TOSCI, extension officers, and farmers. A key informant from ASA confirmed this by pointing out that:

> Lack of sufficient funds from the government hampered our capacity of producing and distributing enough quality seed of IRVs to farmers, and to conduct seminars with extension officers and farmers on the importance and use of the quality seed. (Thomas, ASA Morogoro Municipality on 08/02/2019)

The Marketing Manager of quality seed of IRVs from ASA added that:

> Lack of sufficient funds hindered our linkage with farmers through marketing the seed physically or through ICT related facilities such as the radio, internet, TV, web portals, and print media. (Julius, ASA Morogoro Municipality on 08/02/2019)

Factors affecting interaction of TOSCI with other actors in IRVIS

Interactions between TOSCI and other actors in IRVIS were hampered by several institutional problems as identified by interviewees. Firstly, high charges by TOSCI were a barrier to those willing to engage in producing or multiplying seeds of IRVs. For instance, interviewees from ASA, TANSEED International Ltd, and QDS projects cited charges by TOSCI as among the factors that demoralized many of them from engaging in producing quality certified seeds of IRVs. A similar case was recorded by Eastern and Southern Africa Small Scale Farmers' Forum – ESAFF (2013) which observed that charges by TOSCI may be costly for breeders since they do not cover the full inspection costs. Secondly, interviewees from TOSCI cited lack of reliable means of transport and inadequate financial and human resources as factors inhibiting them from interacting with other actors in fulfilling their role of controlling seed quality. This was confirmed by smallholder rice farmers who blamed TOSCI for its failure to control poor quality rice seeds. One farmer in Visezi village said:

> We wonder why the government has failed to control fake seeds. We have been receiving fake seeds from ASA for three consecutive years – the improved seed varieties that are of poor quality with low germination and mixture of other varieties. Kindly, immediately after our conversation, visit our plots so that you can see for yourself the problem of poor quality due to the mixture of other varieties. (Anna in Visezi village on 10/01/2019)

This finding is similar to the report of the United States Agency for International Development – USAID (2013) which estimated that in Tanzania 25% to 30% of the certified seed used was 'fake seed'. The causes of fake seed included lack of adequate quality control of the market by TOSCI. This problem resulted from TOSCI being confronted with limited transport facilities, financial and human resources. Bartels, Koria, and Vitali (2016) reported that 'threshold levels of human and capital resources are crucial as they form the basis of innovation and development'. Therefore, lack of financial resources, quality, and technically trained human resources in sufficient numbers in general, the opportunities for innovativeness and processes to be more efficient and effective are curtailed.

Systemic problems in relation to structural elements

This section links the identified systemic problems with structural elements. It has been argued that problems within any innovation system are caused by issues within the systems' elements or their properties (Wieczorek and Hekkert 2012). This study, therefore, identified three types of systemic problems in relation to the structural system of IRVs that inhibit interaction among actors and the system from functioning well in general namely socio-demographic, actors, institutional, and infrastructural problems (Table 4). Each of the problems

could be caused by the absence of the structural dimension in the system, for example, extension workers were few (presence aspect) or by its inappropriate attributes, for example, weak or no enforcement of policies, laws, and regulations caused poor leadership and lack of the establishment of the suggested innovation platforms.

One of the advantages of identifying the systemic problems in relation to structural elements of the system is to

Table 4: Identified systemic problems related to structural elements.

Actor type	Systemic problems	Structural elements
Smallholder farmers	• Low household income	Infrastructure/ demographic factor
	• Smallholder farmers face insufficient financial resources access	Actors/infrastructure/ Institutions
	• Inadequate ICT facilities access	Infrastructure
	• Type of agriculture – highly dependent on rain-fed agriculture	Demographic factor
	• Poor leadership	Institutions
	• Lack of trust (Mistrust/distrust between farmers and extension officers).	Actors/Institutions
Policymakers	• Inadequate budget for innovations of IRVs	Infrastructure
	• Inadequate number of staff	Actor
Research institutes (KATRIN and Cholima Center)	• Inadequate funds due to inadequate government budget and dandling donors' funds	Infrastructure
	• Insufficient means of transport	Infrastructure
	• Limited number of staff/researchers	Actors
Agricultural training institutes (MATI Ilonga and MFTC)	• Limited financial resources due to inadequate government budget – most of the time depending on grants from NGOs which also not reliable sources	Actors/infrastructure
	• Limited infrastructure (e.g., hostels, classrooms, seminar rooms) for accommodated more farmers willing to attend training. Hence more farmers not getting training on IRVs timely.	Infrastructure
Extension	• Inadequate Number of extension officers	Actors
	• Engagement of extension officers in non-extension responsibilities.	Actors/institutions
	• Lack of funds for facilitating extension activities – the government does not budget money for facilitating extension activities in rural.	Actors/Infrastructure
	• Lack of reliable means of transport.	Infrastructure
	• ICT facilities access – little or no access to media and publications for long-range communications with farmers.	Infrastructure
	• Mistrust developed by farmers towards extension agents.	Institutions
District councils (DAICOs and DAOs)	• Inadequate financial resources due to inadequate government budget	Infrastructure
	• Delay of approval and release of funds for activities of IRVs by the central government.	Actors/infrastructure
	• Lack of innovation platforms and coordination bodies.	Institutions
Enterprise (Agro-dealers, Traders, and Millers)	• Lack of interest to interact	Actors
	• Lack of innovation platforms that should bring together all actors including, among others, agro-dealers, traders, and millers.	Institutions
Seed Multipliers (ASA, TANSEED & QDS-producers)	• Inadequate number of staff	Actors
	• Low ability or capability of some staff to perform their duties – due to lack of skilled personnel or negligence.	Actors
	• Lack of sufficient funds	Infrastructure
TOSCI	• Charges by TOSCI discouraged ASA, TANSEED, and QDS from interacting with TOSCI.	Institutions
	• Inadequate financial resources.	Infrastructure
	• A limited number of human staff.	Actors
	• Infrastructural constraints, for example, transport means.	Infrastructure

facilitate the formulation of policy instruments. From the results indicated in Table 4, policymakers can now beware of the identified structural problems and integrate them into the policy instrument designed for IRVIS. Wieczorek and Hekkert (2012) suggested that for the systemic instruments to address the types of systemic problems, policymakers should focus on goals that are strongly linked with the typology of the problems (Table 5). In other words, linking the systemic problem and structural elements, Wieczorek and Hekkert (2012) conceptualized the problems that arise in the context of an innovation system as related to issues of presence (presence or absence of structural elements) or capability (capacity or lack of capacity of structural elements).

Conclusions

From the research findings, several conclusions can be made. Firstly, the findings show that household income, farming system, poor leadership, lack of innovation platforms and institutionalized coordinating bodies, mistrust, inadequate human and financial resources, ICT facilities, and transportation means are important factors affecting interactions among actors in the IRVIS. However, among all these factors, financial resources appeared in every actor group. The study noted the inadequate financial resource mobilization strategies for investing in IRVIS. Equally, the intention of the National Agricultural Policy of 2013 for the government to strengthen commercial banks, money lending companies, and financial intermediaries/rural/community banks (e.g., Village Community Banks, savings and credit cooperative societies) by making them responsive to agricultural development has not yet been realized. Governmental institutions (such as research institutes, MATIs, ASA, and TOSCI) and LGAs (DAICOs, district agricultural officers, ward and village extension officers) were still largely depending on the central government budget. Secondly, the study concludes that concepts of ISs like innovation platforms are just reflected in the government documents but not in reality. Thirdly, the development of ICT was still not yet adequately done. Actors were still depending on physical linkage mechanisms (physical events) to interact which resulted in weak or no interactions, especially between farmers and other actors. Finally, the small number of extension officers and the act of being assigned non-extension responsibilities by their supervisors hindered them from interacting effectively with other actors in the IRVIS.

Recommendations

Based on the research findings and conclusions, the following recommendations are given for improving the IRVIS. Firstly, in addressing the inadequate financial resources that limited interactions among actors in the IRVIS, it is recommended that: (i) The Government of Tanzania should increase the budget allocations and release the entire approved budget meant for facilitating innovation of IRVs; (ii) Research institutes, ASA, TOSCI and DPP should not continue depending solely on the government budget, instead, they should prepare competitive and fundable research project proposals to donors to secure money for facilitating their interactions in IRVIS; (iii) There should be specialized banks, for example, agricultural banks that are set up to serve exclusively the poor farmers. In connection to this, there should be a formalization of ownership of the rural land to enable smallholder rice farmers to use it as collateral to obtain loans from commercial banks and agricultural banks. Secondly, there should be strong and reliable enforcement mechanisms for public policies and national development strategies. This will, however, require, that there be deliberate and greater budgetary support by the government and other development partners towards the implementation of both policies and mechanisms, without which mainstreaming of ISs concepts in public agricultural policies and national development strategies run the risk of becoming rhetorical with no real implementation. Thirdly, the Government and development partners should establish formal rice innovation platforms at both local and national levels and provide enough budgets or funding that will bring together all stakeholders to interact regularly. The overall objective is to ensure the informed participation of a broad range of stakeholders in the innovation of IRVs in the country. Fourthly, the Tanzania Government should increase the budget for electrifying villages to make ICT facilities (radio, television, phones, internet, phone networks etc.) easily available in all areas of the country. Besides, tutors in MATIs, researchers in research institutes and universities, extension officers, and staff from ASA, among others, should be financially facilitated to access these ICT facilities for long-range communication among themselves and with other actors, especially farmers. Likewise, television and radio programmes on agriculture should combine the use of mobile phones to provide room for farmers to ask follow-up questions, give comments and suggestions, and get immediate feedback. In this connection, actors can interact in the rice network via the use of

Table 5: Goals of systemic instruments per (type of) systemic problem.

Systemic problem	(Type of) systemic problem	Goals of systemic instrument
Actors problems	Presence?	1. Stimulate and organize the participation of relevant actors
	Capability?	2. Create space for actors capability development
Interaction problems	Presence?	3. Stimulate occurrence of interactions
	Capability?	4. Prevent too strong and too weak ties
Institutional problems	Presence?	5. Secure presence of hard and soft institutions
	Capability?	6. Prevent too weak and too stringent institutions
Infrastructural problems	Presence?	7. Stimulate physical, financial, and knowledge infrastructure
	Capability?	8. Ensure adequate quality of the infrastructure

Source: Adopted from Wieczorek and Hekkert (2012)

ICT which reduces social isolation that they would otherwise face. Finally, there should be a recruitment of staff with the requisite knowledge of rice production and IS concepts and practices in the TARI centres, DPP, TOSCI, ASA, and agricultural training institutes.

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References

Abate, T., B. Shiferaw, S. Gebeyehu, B. Amsalu, K. Negash, K. Assefa, M. Eshete, S. Aliye, and J. Hagmann. 2011. "A Systems and Partnership Approach to Agricultural Research for Development – Lessons from Ethiopia." *Agriculture Journal* 40 (3): 213–220.

Aerni, P., K. Nichterlein, S. Rudgard, and A. Sonnino. 2015. "Making Agricultural Innovation Systems (AIS) Work for Development in Tropical Countries." *Sustainability* 7: 831–850.

Agbamu, J. U. 2000. "Agricultural Research–Extension Linkage Systems: An International Perspective." Agricultural Research and Extension Network Paper No. 106a. London: ODI. http://www.rimisp.cl/agren03/documentos/agren106.pdf.

Anandajayasekeram, P., and B. Gebremedhin. 2009. "Integrating Innovation Systems Perspective and Value Chain Analysis in Agricultural Research for Development: Implications and Challenges." Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project Working Paper 16. ILRI (International Livestock Research Institute). Nairobi, Kenya.

Asenso-Okyere, K., and D. A. Mekonnen. 2012. "The Importance of ICTs in the Provision of Information for Improving Agricultural Productivity and Rural Incomes in Africa." Working Paper 2012-015: January 2012. United Nations Development Programme. Regional Bureau for Africa.

Bartels, F. L., R. Koria, and E. Vitali. 2016. "Barriers to Innovation: The Case of Ghana and Implications for Developing Countries." *Triple Helix* 3: 12. doi:10.1186/s40604-016-0040-y.

Bayissa, D. D. 2015. "Investigating Key Institutional Factors Affecting the Linkage of Knowledge Institutes with Farmers in Agricultural Research in Ethiopia." *American Journal of Human Ecology* 2 (4): 16–32.

Belay, K. 2008. "Linkage of Higher Education with Agricultural Research, Extension and Development in Ethiopia." *Higher Education Policy* 21 (2): 275–299.

Chaminade, C., and C. Edquist. 2010. "Rationales for Public **Policy** Intervention in the Innovation Process: A Systems of Innovation Approach." In *The Theory and Practice of Innovation Policy, an International Research Handbook*, edited by R. Smits, S. Kuhlmann, and P. Shapira, 95–114. Cheltenham: Edward Elgar.

Chaminade, C., P. Intarakumnerd, and K. Sapprasert. 2012. "Measuring Systemic Problems in National Innovation Systems: An Application to Thailand." *Research Policy* 41 (8): 1476–1488.

Charles, S. J., A. Z. Mattee, and C. P. Msuya-Bengesi. 2020. "Interactions Among Actors in Improved Rice Varieties Innovation System in the Eastern Zone of Tanzania." *African Journal of Science, Technology, Innovation and Development*. doi:10.1080/20421338.2020.1804117.

Chiligati, J. E. 2010. "Factors Influencing Research –Extension – Farmer Linkages in Tanzania: A Case of the Western Agricultural Research Zone." MSc. Dissertation., Sokoine University of Agriculture, Morogoro.

Creswell, J. W. 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 4th ed. Thousand Oaks, CA: Sage.

Daniel, E. 2013. "Assessment of Agricultural Extension Services in Tanzania: A Case Study of Kyela, Songea Rural, and Morogoro Rural Districts." Internship Report in Plant Sciences, CSA.

Davies, J., Y. Maru, A. Hall, I. K. Abdourhamane, A. Adegbidi, P. Carberry, K. Dorai, et al. 2018. "Understanding Innovation Platform Effectiveness Through Experiences from West and Central Africa." *Agricultural Systems* 165 (14): 321–334.

Doamekpor, P. K. 2006. "The Research – Extension – Farmer Interface in the Cassava Industry in the Volta Region: The Communication Link." *AIAEE 22nd annual Conference proceedings*, Clearwater Beach, FL.

Emodi, A. I. 2010. "Analysis of Rice (Oryza spp.) Innovation System in Southeast Nigeria." PhD Thesis., University of Nigeria, Nsukka.

ESAFF. 2013. A Scoping Study Report on Seeds and Agriculture Research Processes in Tanzania: The Case of Small Scale Farmers' Participation in Setting Research Agenda Participation. Supported Under the EU Funded INSARD Project.

Field, A. 2009. *Discovering Statistics Using SPSS*. 3rd ed. Thousand Oaks, CA: Sage.

Freeman, K., and H. Qin. 2020. "The Role of Information and Interaction Processes in the Adoption of Agriculture Inputs in Uganda." *Agronomy* 202 (10): 1–16.

Gebremeskel, B. K. 2010. "Rice Value Chain in Metema District, North Gondar, Ethiopia: Challenges and Opportunities for Innovation." MARLDS Thesis., Addis Ababa University, Addis Ababa.

Gildemacher, P., and M. Wongtschowski. 2015. *Catalysing Innovation: From Theory to Action*. KIT Working Papers.

Hair, J. F., W. C. Black, B. J. Babin, and R. E. Anderson. 2014. *Multivariate Data Analysis*. 7th ed. Essex: Pearson Education Limited.

Hardeman, S., and D. Vertesy. 2013. "An Analysis of National Research Systems (III): Towards a Composite Indicator Measuring Research Interactions." Deliverable for WP2 of the Research Project "COMPOSITES_4_IU" Commissioned by DG-RTD. Publications Office of the European Union, Luxembourg.

Kapange, B. 2010. "ICTs and National Agricultural Research Systems – The case of Tanzania." https://pdfs.semanticscholar.org.

Kiefta, A., R. Harmsen, and P. M. Hekkert. 2017. "Interactions Between Systemic Problems in Innovation Systems: The Case of Energy Efficient Houses in the Netherlands." *Environmental Innovation and Societal Transitions* 24: 32–44.

Kingamkono, N. M., M. J. Nkuba, and C. Schouten. 2003. "Networking and Diversification of Agricultural Research Funds." In *Managing Research for Agricultural Development: Proceedings of the National Workshop on Client Oriented Research 27–28 May 2003, Moshi, Tanzania*, edited by M. N. Lema, C. Schouten, and T. Schrader, 94–106. Division of Research and Development/ Ministry of Agriculture and Food Security: Dar es Salaam.

Klerkx, L., B. van Mierlo, and C. Leeuwis. 2012. "Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions." In *Farming Systems Research Into the 21st Century: The New Dynami*, edited by I. Darnhofer, D. Gibbon, and B. Dedieu, 457–483. Dordrecht: Springer.

Kothari, C. R. 2004. *Research Methodology. Methods and Techniques*. New Delhi: New Age International Publishers.

Maerere, A. P., C. L. Rweyemamu, K. P. Sibuga, E. R. Mgembe, E. G. Rwambali, and S. Nchimbi-Msolla. 2010. "Analysis of the Agricultural Science, Technology and InnovationSystem: Banana (Musa Spp.) Case Study in Tanzania." *Acta Horticulturae* 179: 851–858. doi:10.17660/ActaHortic.2010.879.94.

Malerba, F. 2002. "Sectoral Systems of Innovation and Production." *Research Policy* 31: 247–264. doi:10.1016/S0048-7333(01)00139-1.

Mbo'o-Tchouawou, M., E. Waithanji, L. Mulei, and J. Karugia. 2016. "Using an Analytical Model to Explore Potential Gendered Dimensions in Agricultural Innovation Systems." Working Paper No. 39. The Regional Strategic Analysis and Knowledge Support System (ReSAKSS), East and Central Africa (ECA).

Mgumia, A. H. 2015. "Transformation of Agricultural Technology Development Approaches in Tanzania." PhD Thesis/dissertation., Sokoine University of Agriculture, Morogoro.

Mkula, N. D. 2018. "Interaction Among Actors and its Influence on Quality Sugarcane Production in Tanzania: A Case of Kilombero Outgrowers Sugarcane Scheme." PhD Thesis., Sokoine University of Agriculture, Morogoro.

Mulema, A. A. 2012. "Organization of Innovation Platforms for Agricultural Research and Development in the Great Lakes Region of Africa." PhD Thesis., Iowa State University Ames, IA.

Neef, A., F. Heidhues, K. Stahr, and P. Sruamsiri. 2006. "Participatory and Integrated Research in Mountainous Regions of Thailand and Vietnam: Approaches and Lessons Learned." *Journal of Mountain Science* 3 (4): 305–324.

Pallant, J. 2011. *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS Program*. 4th ed. Berkshire: Allen and Unwin.

Porter, M. E. 1990. *The Competitive Advantage of Nations*. London: Macmillan.

Rajalahti, R., W. Janssen, and E. Pehu. 2008. "Agricultural Innovation Systems: From Diagnostics toward Operational Practices." Agriculture and Rural Development Discussion Paper No. 38. Washington, DC: The International Bank for Reconstruction and Development.

Rwambali, E. G. 2012. "Agricultural Technology Innovation System: A Case of TARP II-SUA and Banana Research Project in Tanzania." PhD Thesis., Sokoine University of Agriculture, Morogoro.

Saint Ville, S. A., M. G. Hickey, and E. L. Phillip. 2017. "How Do Stakeholder Interactions Influence National Food Security Policy in the Caribbean? The Case of Saint Lucia." *Food Policy* 68: 53–64.

Sanyanga, S., M. Sie, A. Diagne, M. Ndjiondjop, D. S. Yawovi, M. M. Coulibaly, and P. Y. Adegbola. 2012. "An Institutional Innovation for Agricultural Technology Adaptation and Adoption: Rice in West and Central Africa." *Sociology Study* 2 (11): 848–867.

Saravanan, R., and B. Suchiradipta. 2017. "Agricultural Innovation Systems: Fostering Convergence for Extension." MANAGE Bulletin 2, National Institute of Agricultural Extension Management, Hyderabad.

Semwenda, A. J. 2016. "Challenges Facing Agricultural Extension in the Current Institutional Context: The Case of Hai District, Kilimanjaro Region." MARD Dissertation., Sokoine University of Agriculture, Morogoro.

Shetto, M. C. 2008. "Strategies for Scaling-Up Outputs of Research on Natural Resources Management: The Case of Rainwater Harvesting Research in Tanzania." PhD Thesis., Sokoine University of Agriculture, Morogoro.

Suchiradipta, B., and S. Raj. 2014. "Agricultural Innovation Systems (AIS): A Study of Stakeholders and Their Relations in System of Rice Intensification (SRI)." *The Journal of Agricultural Education and Extension* 21 (4): 343–368.

Sulaiman, V. R. 2008. "Extension from an Innovation System Perspective." *Paper presented at the IFPRI conference "advancing Agriculture in Developing Countries through knowledge and innovation," held in Addis Ababa*, Ethiopia, 7–9 April 2008. https://vtechworks.lib.vt.edu/bitstream/handle/10919/70144/6833_Sulaiman_Extension_from_an_ISP.pdf?

Sulaiman, V. R. 2015. "NOTE 13: Agricultural Innovation Systems." https://www. google.com/search.

Szogs, A., A. Cummings, and C. Chaminade. 2011. "Building Systems of Innovation in Less Developed Countries: The Role of Intermediate Organizations Supporting Interactions in Tanzania and El Salvador." *Innovation and Development* 1 (2): 283–302.

Tropical Agriculture Platform. 2016. *Common Framework on Capacity Development for Agricultural Innovation Systems: Synthesis Document*. Wallingford: CAB International.

Tucker, J., B. Cullen, A. Amsalu, and E. Ludi. 2014. "Innovation Platforms to Enhance Participation in Rainwater Management: Lessons from The Nile Basin Development Challenge with a Particular Focus on Political Economy and Equity Issues." Colombo: CGIAR Challenge Program on Water and Food (CPWF). Research for Development (R4D) Series 11.

Tui, S. H. K., A. Adekunle, M. Lundy, J. Tucker, E. Birachi, M. Schut, and L. W. A. Klerkx. 2013. *What are Innovation Platforms? Innovation Platforms Practice Brief 1*. Nairobi: ILRI.

Turner, A. J., L. Klerkx, K. Rijswijk, T. Williams, and T. Barnard. 2015. "Systemic Problems Affecting Co-Innovation in the New Zealand Agricultural Innovation System: Identification of Blocking Mechanisms and Underlying Institutional Logics." *NJAS – Wageningen Journal of Life Sciences* 69: 5–13.

URT. 2009a. *National Rice Development Strategy (Final Draft): Ministry of Agriculture Food Security and Cooperatives*. Dar es Salaam: Government Printers.

URT. 2009b. *A Study on Transforming Agriculture in Tanzania. Final Report. President's Office, Planning Commission*. Dar es Salaam: Government Printers.

URT. 2013. *National Agriculture Policy. Ministry of Agriculture Food Security and Cooperatives*. Dar es Salaam: Government Printers.

URT. 2016a. *National Five Year Development Plan 2016/17–2020/21: "Nurturing Industrialization for Economic Transformation and Human Development." Ministry of Finance and Planning*. Dar es Salaam: Government Printers.

URT. 2016b. *Agricultural Sector Development Programme Phase Two (ASDP II): Government Programme Document. Ministry of Agriculture*. Dar es Salaam: Government Printers.

USAID. 2013. "SeedCLIR Tanzania." Pilot Report Produced for the United States Agency for International Development by the USAID Enabling Agricultural Trade (EAT) Project, Implemented by Fintrac Inc.

Wambura, R. M., P. K. Doamekpor, D. L. Mwaseba, C. P. Msuya, D. M. Masinde, L. J. Mwanga, and G. M. Iranga. 2015. "Promotion of Agricultural Innovation Systems Approach: Policy Implications for Maize Extension and Advisory Services in Tanzania." *Tanzania Journal of Agricultural Sciences* 14 (2): 112–118.

Wieczorek, J. A., and P. M. Hekkert. 2012. "Systemic Instruments for Systemic Innovation Problems: A Framework for Policymakers and Innovation Scholars." *Science and Public Policy* 39: 74–87.

Wigboldus, S., and J. Lee. 2011. Going for Gold in Innovation Partnerships Responsive to Food Insecurity – the Role of Knowledge Institutes. Policy Paper. Wageningen UR Centre for Development Innovation.