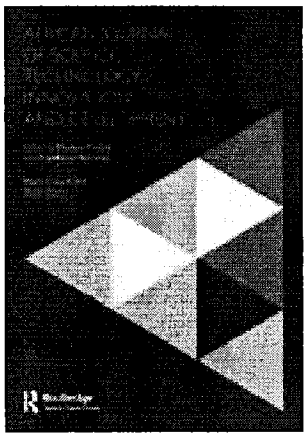

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The application of the agricultural innovation system approach in technology development in Tanzania: researchers' perceptions and practices

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The application of the agricultural innovation system approach in technology development in Tanzania: researchers' perceptions and practices

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This paper examines the perceptions of researchers towards features of the innovation system approach. It also examines the extent of incorporation of these features into Tanzania's existing National Agricultural Research System (NARS). Both qualitative and quantitative data were collected from 100 purposefully selected researchers from 13 public and three private research institutes, and one university. Most (81%) of the researchers perceive end-users (farmers) as an important actor. Other actors such as intermediary organisations (extension), regulatory bodies and entrepreneurs are perceived as important by half (50%) of the researchers. On the other hand, most of the researchers perceive the roles of these actors to be similar to the traditional roles of actors under NARS. The indicators used in measuring the success of agricultural innovation were mainly associated with the pattern of adoption and productivity potential of technologies, suggesting that a linear model of innovation is still dominant in NARS. We conclude that the mode of agricultural innovation under NARS in Tanzania is in transition from a linear to a system model of innovation. The study suggested that policies should be redesigned to include wider participation of stakeholders in agricultural innovation; the mandate and capacity of extension services should be expanded to include facilitation of innovation; and indicators of monitoring and evaluation should be all-inclusive to include technical and social changes.

Keywords: Linear mode of innovation, system mode of innovation, entrepreneurs, intermediaries, end-users, indicators of successful innovation

JEL classification: O13, O31, O55

Introduction

In the last four decades, theoretical and practical approaches in promoting agricultural innovations have been evolving from a 'linear' mode of innovation, which entails production and exchange of knowledge (mostly technical) to a 'systems' mode of innovation (Sumberg 2005, 22–23, Chema et al. 2003, 38). A 'system' is perceived as a collection of related elements that function jointly to achieve the desired results (Lundvall 1992, Hall et al. 2006, 7, 2005, 1). The major drivers to the change have been due to economic liberalisation of 1980s that liberated private economic initiative (IMF 1986, 6–7). The ultimate emergence of a public–private relationship in agricultural innovation increases the involvedness of multiple actors and non-linear changes. Innovation requires the interaction of many developers, possessors and users of knowledge (Skarstein 2005, 341, Carney 1995). In addition, current national responsibilities in achieving globally predetermined development targets such as the Millennium Development Goals demanded an increase in the scope of expectations from research and development (R&D) to include a contribution to broader developmental goals such as poverty alleviation, food and nutrition security, and environmental sustainability (Anandajayasekeram 2011, 1–4).

The new roles of R&D and extension services have created the demand for broadening the scope of the actors of innovation to include actors previously not defined by research arrangements such as various combinations of researchers, enterprises, farmers, development workers and policy actors from the public and private sectors (Hall 2005, 3, 2006, 17) and institutions (Lundvall 2004). These changes have necessitated the evolution of organisational framework from the National Agricultural Research System (NARS), which represented a linear approach, to an Agricultural Innovation System (AIS) framework, which represents a more inclusive approach (World Bank 2006, 27, Hall 2005, 3, Chema et al. 2003, 38). An AIS approach recognises the innovative performance of an economy as an outcome of interaction among multiple actors (private sector, research institutions, universities etc) and how they interplay with social institutions such as legal frameworks (Hall et al. 2005, 5) rather than the isolated efforts of individual institutions.

Studies show that the countries of sub-Saharan Africa (SSA), have adopted features of AIS in their institutional arrangements for research and innovation such as public–private linkages in agricultural research (Samberg 2005, 24), innovation platforms (Hounkonnou et al. 2012) and interactions among actors of innovations (Spielman 2005,

Ortiz et al. 2013). In Tanzania, and particularly in the agricultural sector, this can be related to the Client Oriented Research and Development Approach (CORDEMA) adapted in 2003, aimed at facilitating public and private providers of agricultural research to be able to provide more relevant and effective services. Also Agricultural Sector Development Programme (ASDP) launched in 2003 (URT 2003), which created a favourable environment for commercial activities, public and private roles in improving supporting services and strengthening marketing efficiency for agricultural inputs and outputs. However, despite the great potential of AIS approaches in enhancing the significance and efficiency of agricultural research, in practice the success will depend on how well the new approaches are applied and adapted to the diverse local conditions. In Tanzania, for example, despite government efforts through CORDEMA and ASDP, the traditional reliance on achieving growth by supporting smallholder agriculture through the local government extension services is not sufficiently changed (Thornton et al. 2011, 49).

Thus, under NARS where R&D is a central component of innovation, researchers' knowledge on the actors of the innovation system and their roles can be used to enhance partnerships and prompt alignment of R&D with other appropriate actors of innovation as the need arises.

This study therefore intended to examine the perceptions of researchers in R&Ds towards features of system mode of agricultural innovation. The specific questions addressed by this study are what researchers' perceptions on elements of AIS are: the components (actors), the relationship and interactions within the actors, and the indicators for successful innovation.

The agricultural innovation system: A conceptual framework

The agricultural innovation system approach as applied to agricultural sectors by Hall et al. (2006) originated from the national system of innovation developed by Lundvall, (1992). The agricultural innovation system approach provides a framework that enables one to analyse complex relationships among the agents, social and economic institutions from a diverse background. It takes a view of innovation as a process that recognises multiple sources of knowledge and interaction that are guided by social and economic institutions such as values, norms and legal frameworks (OECD 1997).

Scholars have differentiated AIS from NARS using various institutional features including the roles of actors/partners, the relationships involved, the selection of partners, the work plan, policy focus, the knowledge produced and indictors of performance (Hall et al. 2005, 3). However, Anandajayasekeram et al. (2009) using an innovation system perspective (ISP), grouped these features into three elements namely: (1) The components (actors) of the system; (2) the relationships and interactions between these components; and (3) the competences, functions and outcome of interaction among the components. To what extent researchers understand the importance of these elements as factors contributing to agricultural innovation will be investigated in this article.

The components (actors) of the agricultural innovation system

The mainstream actors under NARS that are responsible for the transfer of knowledge include R&D, extension services, and the end-users. This arrangement is effective where there is only one source and one user of knowledge. The mechanism for innovation under NARS is technology transfer, which is predominantly government driven. AIS, on the other hand, involves well-connected and coordinated actors mainly from five different domains (Table 1): research, entrepreneur, diffusion, markets or demand and infrastructure (CABI/CTA/KIT/VRLIE/WUR 2006, Rajalahti et al. 2008, 4). Apart from policies and markets as triggers of innovation, AIS stresses the importance of stakeholders and also the importance of organisations and policies that are sensitive to demands and agendas from stakeholders (Hall 2005). Therefore, researchers' understanding of the scope of the actors and their contribution in innovation is a essential for the features of AIS to be effectively incorporated and applied in agricultural technology development.

The relationships and interactions between components (actors)

The ISP element shows how the relationships of the actors in AIS are diverse, evolving and flexible, determined by the nature of the context or available resources (World Bank 2006, Hall 2005). These elements of ISP cannot be

Table 1: Possible actors of an agricultural innovation system

Actors	Roles
Research	Generates knowledge, it can be either research institutes, universities, private research
Intermediary	Intermediary organisations/ knowledge transmitters, extension workers, farmers and traders organisation, private consultants, NGOs and CBOs
Entrepreneur	Produces and sells products (mainly to intermediary users of knowledge) farmers, commodity traders, processing industries related to agriculture, transporters, input and service suppliers
Infrastructure	Policy–making agencies, regulatory bodies, banking and financial system, transport and marketing infrastructure and education system
Markets or demand	Consumers of different types: retailers, wholesalers, (Standards, volume, price quality) and end–users.

Adapted from CABI/ CTA/KIT/ VRLIE/ WUR, (2006)

compared to NARS where the relationships of actors are narrow, hierarchical, and in most cases predetermined by the institutions' roles. In addition, the performance of the innovation process in AIS is determined by institutional context rather than technical change as is the case for NARS (Hall et al. 2005). 'Institutions' under the innovation system framework refer to common habits, routing, practices, rules or laws (Edquist 1997). Hence, for effective agricultural innovation, the changes required, be they institutional, managerial or/and organisational, should be well institutionalised and internalised by researchers. Due to uncertainties (external factors) and rapid advancements in science, the successful innovation system is characterised by having organisations that are flexible and networked in such a way that they can form new patterns of partnerships in response to emerging challenges.

The indicators for successful innovation

Indicators of performance of innovation process measure the competencies, functions, processes, and knowledge produced as a result of interactions among components. Under AIS, the indicators of performance include technical, scientific, and codified indicators, which are similar to that of NARS. But in addition, AIS also includes social change such as organisational and institutional development and change in behaviours (Hall et al. 2005).

Methods

Selection of respondents

This study involved researchers from public and private agricultural research institutions; 13 government Agricultural Research Institutions (ARIs), which are located in seven agro-ecological zones; two private R&D institutions which deal with three major cash crops: coffee and tobacco: Tanzania Coffee Research Institute (TaCRI) and Tobacco Research Institute of Tanzania (TORITA). Others include three Livestock Research Institutes (LRIs), which deal with pastures, livestock, and animal vaccines; and one university – Sokoine University of Agriculture (SUA). At SUA only five relevant Departments were covered by the study, and these are the Department of Crop Science and Production, the Department of Soil Science, the Department of Food Science and Technology, and the Department of Animal Science and Production, all in the Faculty of Agriculture; and the Department of Veterinary Medicine and Public Health which is in the Faculty of Veterinary Medicine.

According to Crawford et al. (2011), all the agricultural research institutes in the country had a total of 318 researchers, comprised of 223 (70%) males and 95 (30%) females, while the five selected Departments (at SUA) had 175 researchers comprised of 161 (92%) males and 14 (8%) females. Therefore, the total population of researchers was 493. From this population, a sample of 100 researchers was purposively selected from all R&D institutions with the assistance of Heads of Department or Officers in Charge. The criteria for the selection included work experience of at least 5 years. The sample intensity was theoretically acceptable based on Boyd et al. (1981) and Bailey (1994).

Data collection and sources

Three data collection methods were employed by this study: structured questionnaire survey which involved both closed and open questions; key informant interviews and documentary analysis from reports and published literature. The first two methods were used for collection of primary data, and the third method was used for the collection of secondary data. The main focus of the questions in the questionnaire survey was on the respondents' perceptions on the important key actors of AIS, their roles and indicators for successful innovation. The respondents' perceptions on reasons for R&D to commercialise and sell research results directly to the end-users were measured on a Likert scale.

Data analysis

The qualitative data were analysed through a meaning categorisation (Kvale 1996) whereby the information was broken down into meaningful units of information and grouped according to themes. Furthermore, detailed analysis and synthesis was done on documentary materials so as to get information that could help to explain the situation on the ground regarding agriculture innovations system. This involved review and synthesis of research reports, annual reports, and policies such as ASDP and CORDEMA. Quantitative data were analysed using Statistical Package for Social Science (SPSS) version 16. Quantitative data collected through structure questionnaire survey were analysed through descriptive statistical analysis. Descriptive statistical analysis was used in exploring the data for distribution of response, central tendencies and dispersion. Cross tabulation was also performed to ascertain responses and percentages. Cross tabulation is a powerful way of communicating information and the commonest data presentation mode (Pallant 2005). For likert scale data, the average score was calculated as a sum of scores of each respondent divided by the number of the respondents. Mean score calculated ranged between 1 and 5, hence scale 3 was selected as cutting point. Therefore, all values equal to or below 3 were collapsed and assigned '0' and values above 3 were collapsed and assigned '1'; this allowed each response to be dichotomised into two categories: Disagreed and Agreed, respectively. A non parametric, one-sample Chi-square test was employed at 5% level of significance (Pallant 2005) to examine whether any association existed between these categories (agree or disagree).

Results and discussion

The perceived important actors in agricultural innovation

Among the five key components (actors) of AIS, a significantly larger percentage (81%) of respondents perceived end-user (p = 0.0001) as an important actor, and about half of the respondents, perceived entrepreneur (54%), extension (50%) and regulatory agents (51%) as important though not statistically significant (Table 1). The fact that 46% of the respondents did not recognise entrepreneurs as important actors in the innovation process (needed for multiplication and commercialisation of technology) implies that a substantial number of respondents were ill informed about the importance of the entrepreneur domain in agricultural innovations. These results indicate that involvement of entrepreneurs in the existing mode of innovation is limited. However, R&Ds were found to commercialise and sell some of the technology directly to the end-user as reported by other studies in industrial R&Ds (Mwamila and Diyamett 2009). In addition, a significant number (64%) (p = 0.005) of the respondents did not consider financial institutions as important actors (Table 2), which implies the dominance of government-driven innovation mind-set by the majority of respondents. Hence, most researchers perceived end-users as a more important actor than entrepreneurs or other actors, which illustrates the traditional thinking of linear mode of innovation.

The perceived roles of key actors in agricultural innovation

The respondents' perceptions on the roles of each actor were synthesised, analysed and grouped into two sets of roles. The first set comprises the traditional roles of actors under NARS, which were predetermined by the research system or defined by the institutions; these were categorised as group A (Table 3); and the second set includes roles that are context based (or evolving) hence flexible (group B). Generally, with the exception of the end-user (where the reported roles fit the criteria for group A only), the perceived roles for the other actors fall under both groups A and B. However, the roles that were mentioned by the majority reflected the traditional roles of NARS (group A). Furthermore, a substantial number of respondents failed to mention the roles of some of the mentioned actors: end-users (45%), extension (48%) and entrepreneurs (22%) (Table 3) This observation implies that even respondents who could identify important actors of innovation were uncertain about the roles of the actors they identified. The following are detailed discussions for each of the actors but they do not specify the roles of such actors.

Entrepreneur: While nearly half (46%) of the respondents did not consider entrepreneurs as important actors in innovation (Table 2), 22% of the respondents cited entrepreneurs as important actors in innovation, but they could not indicate any roles devoted to this actor (Table 3). This makes a total of 68% of the respondents who were not sure about the roles of entrepreneurs in innovation. Regarding the 54% of the respondents who recognised entrepreneurs as important (Table 2), about 56% of them reported roles under category A, while only 22% mentioned roles of entrepreneurs under group B (Table 3). Again this implies that only 22% of 54%, which is equivalent to 12% of all the respondents, had system perspectives on agricultural innovation. The fact that these new and evolving roles (group B) were perceived by few respondents implies that there is need for such dissimilar actors as entrepreneurs (private sector) and R&D (public) to interact and collaborate in innovation. According to the World Bank (2006), one of the functions of AIS is to enhance interactions and relationships between culturally and institutionally dissimilar actors in order to reduce cultural and/or social barriers between actors and foster agricultural innovation. Thus, a cross-checking question was posed to examine whether the respondents perceived the existence of any gaps (cultural or cognitive) between R&D and entrepreneurs, and what their suggestions were as to who could effectively bridge the gaps, and through what functions.

The results showed that most (92%) of the respondents perceived the existence of a gap (cultural or cognitive) between R&D and entrepreneurs. The distribution of the respondents on the proposed actors who could effectively bridge the said gap varied significantly (Chi-square (χ^2) = 33.109, p = 0.0001), whereby half of the respondents (52%) suggested extension services providers (agricultural extension staff and ZIELU) could do better (Table 4). According to the national guidelines, extension services are mainly dealing with knowledge transfer in the form of information (URT 2009a, URT 2008). Except for the 'specific unit within the R&D' and 'consultancy',

Table 2: Researcher's perceptions on the important actors in AIS, Tanzania. (n = 100)

Components/Actors of AIS	% of respondents as:		χ^2	p
	Important	Not important		
Entrepreneurship firms/ companies	54	46	0.640	0.424
Regulatory agents	51	49	0.091	0.763
Technology transfer intermediary or extension service	50	50	0.000	1.000
End–users (farmers)	81	19	38.44	0.0001*
Financial institutions	36	64	7.840	0.005*

*Statistically significant at 5% level

Table 3: Respondents' perceptions on the roles of key actors of agricultural innovation in Tanzania (n = 100)

Actors	Group	Perceived roles for each of the actors	% of respondents
	A	Transform technology into products	46
		Dissemination of new technologies	10
Entrepreneurs	B	Determine the market potential of new technologies	11
		Source of research idea	11
	C	None	22
Total			100
Financial	A	Support technology transfer activities	14
institutions		Provide research funds	39
	B	Provide credit facilities to end-user	47
Total			100
	A	Certification of the product	29
Regulatory		Regulate standard, monitor quality	59
bodies	B	Market regulation (linkages and enabling environment for partnership)	6
	C	None	6
Total			100
Intermediary	A	Provide extension services	28
(Extension)	B	Articulate demand and support of entrepreneurs	24
	C	None	48
Total			100
Market/Demand	A	Users of new technologies	37
(End-users)		Source of new research ideas through feedback	11
		Assess practicability of the new technologies	7
	C	None	45
Total			100

Group: A = Traditional roles, B = Evolving roles, C = The respondents who mentioned the actors

the rest of the mentioned roles (reported by 74% of the respondents) were referring to linking R&D and end-users and not entrepreneurs. This implies that the mind-set of most of the respondents is still oriented to the traditional linear mode of innovation, with limited commercial perspective of innovation. The incorporated features of AIS through programmes, if any, are not yet internalised in the minds of many researchers, therefore extension services continue to be a major intermediating layer between the source and users of knowledge.

Infrastructures (financial institutions and regulatory bodies): Almost two-thirds (64%) of the respondents did not consider financial institutions as an important actor in innovation (Table 1). However, for regulatory bodies, out of 51 respondents who cited financial institution as an important actor, most (88%) of these respondents assigned roles that are defined by institutional roles reflecting the traditional NARS (Table 2). In both cases, limited understanding among most of the respondents on the importance of these actors and their roles in innovation might undermine the effectiveness of the features of AIS in agricultural development in Tanzania.

Intermediary (extension): It was interesting that with this actor, about half (48%) of the respondents who indicated extension as an important actor in innovation, could not associate this actor with any roles (Table 3). The remaining 28% indicated the role which is predetermined by the institutional role (group A), whereas only 24% cited facilitating roles (demand articulation and support of entrepreneurs) in the sense that they do not reflect the conventional transfer functions; instead they reflect more of the facilitation functions, which reflect the system nature of innovation (Hall et al. 2005). Half of the respondents did not consider extension as an important actor in innovation.

Demand sector (end-user): The majority (81%) of the respondents perceived end-users as an important actor (Table 2), where as 37% of the respondents perceived end-users as recipients of technology (group A) (Table 3), implying that R&Ds do not only generate new knowledge but they also multiply and disseminate such knowledge to end-users. However, with the exception of a few highly sophisticated technologies (such as biotechnology-based technologies) multiplication and commercialisation of research results are not within the capacity and even mandate of R&Ds (URT 2010). These results are indications of a system (transition) failure, a situation whereby private firms (including entrepreneurs) are unable to adapt to new technological development (Smith 2000: 95), hence R&Ds perform multiple functions of generation, multiplication and dissemination of technologies.

Accordingly, an additional question was set to verify the motive of R&D of engaging in the commercialisation of research results. The respondents were asked, "*Why are the public R&Ds directly engaged in technology transfer and commercialisation?*" The respondents' perceptions of this question were examined using five-point Likert scale items (Table 5). The results indicate that a significant percentage (69%) of the respondents strongly agreed (with a mean score of 3.88) that lack of developed markets for the research findings was one of the major reasons for R&D to commercialise and sell technologies directly to the end-users (χ^2 = 17.33, p = 0.0001).

Furthermore, a substantial but statistically insignificant number of respondents cited other reasons including unclear institutional technology transfer guidelines, the existence of sophisticated technologies, lack of entrepreneurship skills, and technologies that demanded skilled personnel as responsible for the R&D to commercialise and sell research results directly to the end users.

These findings suggest that the private sector is either not willing or is unable to invest in the agricultural sector because of the inability of the sector to adopt new but sophisticated technologies, hence a transition failure (Smith 2000, 95) or the economic features of the technologies generated by R&D being a public good are rendered unattractive to entrepreneurs (Alston et al. 1999). Hence, these results confirm the existence of market and system failures within the agricultural knowledge infrastructure that compel actors such as R&D to perform market-oriented or entrepreneurial roles. As a result, the roles of the entrepreneur have been shifted to R&D (Table 5); consequently researchers perceive an entrepreneur as not being an important actor in innovation (Table 1).

Indicators in measuring a successful agricultural innovation process

Three levels of success were used to measure understanding of the respondents on the indicators of performance for innovation processes, namely successful, partially successful and unsuccessful. For this study, successful innovations refer to technologies that are made available commercially to potential clients by the private sector. Studies illustrated that the private sector appeared to be the most effective provider of goods and services because of its stronger links with clients (Carney 1995). Thus indicators that are commercially oriented and which capture social or behaviour changes assured not only the availability and assimilation of the technology by the end-users but also they measured application of features of AIS. These indicators were considered as indicators for successful innovation. Partially successful innovations referred to technologies that were multiplied and disseminated in an informal and unsustainable way, such as project-based interventions; this is particularly because project interventions always target a limited number of users and have a short timespan. Unsuccessful innovations involved technologies that were not moved or transferred from R&D to the end-users.

Table 6 shows that the indicators which were reported by 67% of the respondents (for successful and partially successful innovations) were mainly associated with the pattern of adoption and productivity potentials of the technologies such as the number of adopters, an increase in productivity and technology disseminated. Only five (5%) respondents cited indicators of social change including the introduction of a commercial perspective to commodities that traditionally were regarded as public commodities (i.e. available in the shops). From these observations, most researchers are accustomed to quantitatively oriented measurements or changes rather

Table 4: Intermediaries suggested by the researchers and their roles (n = 100)

Intermediary suggested	% of respondents	Roles
Agricultural Extension staff	38	Linking research and end user Enhance adoption of technologies through demonstration and exhibition
Specific unit within R&D	21	Facilitate common understanding of researchers and administrators about commercialisation of technologies Develop commercialisation strategies (protection, packaging, negotiate market and fundraising)
Independent unit outside R&D	22	Harmonise stakeholders Transfer information from research to end-users
ZIELU	14	Package information and prepare extension materials Serve as a bridge between research and other stakeholders Promote new technology through farmers day, training and seminar and successful stories
Consultancy	5	Get to know needs of users and search for the answers/solutions from research

Key: ZIELU Zonal Information and Extension Liaison Unit

Table 5: Reasons for R&Ds to commercialise research results directly to end users (n = 97)

Reasons for commercialising and selling research results directly to end users	SD	D	N	A	SA	Mean score	χ^2	p
The technology demanded sophisticated facilities for multiplication	7	19	27	16	28	3.40	0.835	0.361
The technology required high skilled personnel	7	17	22	28	21	3.91	0.167	0.683
Lack of developed market for the technology, entrepreneurs would not take risk	4	7	17	37	32	3.88	17.330	0.0001
Lack of clear institutional guidelines for technology transfer	1	7	34	24	31	3.79	1.742	0.187
Lack of entrepreneurial skills	6	4	26	39	20	3.66	5.568	0.018

than qualitative in assessing performance of innovation. This is supported by many reports and working documents (MAFSC and MLFD 2011, URT 2009b), which indicate that the indicators used were mainly the number of adopters, the productivity of the technology, the number of technologies disseminated and successful stories of individual beneficiaries. The aspects of behaviour and social changes, which are equally important in measuring successful innovation, are less used.

However on the other hand, the 35% of respondents who ranked performance of R&D in innovation as unsuccessful related failure in innovation with inadequacy in institutional and organisational arrangements of R&D for innovation (Table 5). This observation implies that the respondents recognise the importance of policies (national and institutional) in providing an enabling environment and forming an integrated component of the successful innovation system, which is a typical feature of AIS. This is unlike for the traditional NARS, where the role of policy focuses mainly on resource allocation and priority setting (World Bank 2006, Hall 2005).

As for the indicators for success and partial success, (such as technology dissemination through project interventions) and indicators for unsuccessful innovation (indicator of inadequacy in institutions policies and arrangements), it should be noted that the successful innovations were those which were implemented under project intervention levels and which addressed institutional and organisational inadequacy related to agricultural innovation operationally (such as incentives schemes, capacity building, etc.). Hence, it is likely that researchers (respondents) who participated in these projects were the ones who were aware of the importance of actors of AIS and their roles.

Implications and recommendations

Currently, the agricultural innovation system (AIS) is viewed as a more practical approach to enhancing economic utilisation of agricultural technologies than the traditional linear mode of innovation under the national agricultural research System (NARS). However, effective adoption of the features of AIS requires that researchers understand the importance of the features of AIS and become actively involved. The findings from this study indicate that end users (farmers) were perceived as the most important actors of agricultural innovation. Entrepreneurs, regulatory bodies and extension services were perceived by half of respondents as the second most important, while financial institutions were perceived as less important. Therefore, policies should be redesigned to advocate and accommodate wider stakeholder participation, including the private sector, in technology development and dissemination, thereby encouraging the partnership between R&D and the private sector.

The roles of the actors of innovation systems as perceived by most of the respondents appeared to be similar to the traditional roles under NARS with only a few cited roles that can be associated with AIS. This suggests that the researchers' transfer-of-technology

Table 6: Perceived indicators for measuring successful agricultural innovation

Level of success of innovation	Assigned indicators	% of respondents
Successful		
	Available in shops	3*
	Large number of adopters	20
	Increase in productivity	4
	No reason	6
Sub-total		33
Partially successful		
	Fewer adopters and /or those who demanded the technology (at R&D)	13
	Technologies needed specialised knowledge and facilities for mass production hence not attractive to entrepreneurs/ they are only available (sold) at R&D	2*
	Technology disseminated through demonstration, trials, or is distributed to the end–users through project interventions.	10
	No reason	9
Sub-total		34
Unsuccessful		
	The commercial perspective on agricultural technologies is not well developed, farmers perceived agricultural technology as a public good, are not willing to pay for it	10
	Lack of appropriate policy, incentives, guidelines or model for technology transfer	9
	Lack of incentives and guidelines to involvement of entrepreneurs, extension service and end–users in technology development and dissemination	9
	Lack of funds and capacity for technology transfer and commercialisation	9
	Poor coordination among R&D units and misunderstanding between researchers and administrators	2
Sub-total		35
Total		100

* Indicator related to social changes (institutional/managerial/ organisational)

mind-set is still predominant. Consequently, most respondents believe that extension services (workers) would do best in bridging the claimed gap between R&D and entrepreneurs as actors in innovation. This confirms the misconception of the researchers about the roles of the key actors in the innovation system. The perceived facilitation roles played by extension indicate the potential for extension services in adapting emerging and indispensable roles in innovation. Therefore, the mandate and capacities of agricultural extension services should be expanded to include facilitation of innovation through exploring both technical and institutional innovation, and organisational and managerial innovations, at least for the time being, while the research system is in transition from a linear to a system mode of innovation.

Furthermore, most of the researchers measured success in innovation by using indicators associated with the pattern of adoption only, regardless of the sustainability of the dissemination approach used, whereas very few researchers used social and behavioural change as an indicator of measuring success in innovation. Hence, the government should re-design the indicators of performance used in monitoring and evaluation (M&E) of public R&D activities, and extension services to become more inclusive in capturing both technical and social changes.

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