

How do extension agents of DAE use social media for strengthening agricultural innovation in Bangladesh?

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Abstract. Agricultural innovation is essential for improving the livelihoods of resource-poor farmers in developing countries such as Bangladesh. Within an Information and Communication Technology (ICT) strategy for agricultural development, social media is considered a means of networking, collaboration and co-learning, and thereby supporting innovation processes. However, it is not known how extension agents of the Department of Agricultural Extension – the largest public sector organisation – have been utilising social media to strengthen agricultural innovation. Data were collected using a survey with 140 extension agents and key informant interviews with 20 extension agents who worked in the eastern region of Bangladesh. The findings indicated that extension agents mostly used social media to learn professional tasks and to some extent technical knowledge. Extension agents considered social media as a means of supporting innovation functions, such as entrepreneurial activities, market formation, resource mobilisation and legitimisation. However, the use of social media did not support second loop learning as well as system interaction.

Keywords: Extension agents, social media, agricultural innovation

Introduction

Agricultural innovation is considered an essential requirement to ensure higher productivity and sustainable development in developing countries, including Bangladesh (Rajalahti 2012). The agriculture sector is an indispensable part of the national economy, accounting for a contribution of 11.7 percent GDP and 42.7 percent employment in Bangladesh (BBS 2016). The Department of Agricultural Extension (DAE) – the most significant public sector agricultural extension organisation in Bangladesh – plays active roles in providing various services to farmers so that they can utilise their resources optimally to achieve sustainable agricultural and socio-economic development (DAE 2016a). DAE has undergone several reforms to optimise its performance and tackle contemporary farming challenges (Chowdhury et al. 2014). The recent National Agricultural Extension Policy (NAEP) focuses on collaboration and partnership among agri-stakeholders. The ultimate goal is to support mutual learning and understanding, linking producers, entrepreneurs with potential markets, consumers and other actors in the agriculture value chain (MoA 2012). The policy measures of NAEP are in line with the principles and practices of Agricultural Innovation System (AIS) thinking, although there was no specific reference to the AIS perspective.

According to the contemporary body of knowledge and practices, extension services are no longer conceptualised as a component of the traditional 'knowledge triangle' i.e. tripartite linkages among research, education and extension, but realised within a bigger picture of AIS (Rivera & Sulaiman 2009). This change broadens the space for participation of various stakeholders and involves an interactive and dynamic way of dealing with the complex nature of agriculture in a constantly changing environment (Rajalahti 2012). Actors with diverse interests share, negotiate and co-produce knowledge to better understand and manage complex agricultural issues (Klerkx et al. 2011; Leeuwis & Aarts 2011). Agricultural innovation is the outcome of AIS (Klerkx et al. 2012), and public extension agencies serve as an 'engine for promoting innovation' (Rivera & Sulaiman 2009). The public extension agency, therefore, needs to transform its role as a bridging and brokering organisation. Thus, it would connect different actors (potential knowledge sources) to form a network and offer a 'platform' for knowledge creation, sharing and utilisation. Besides, it should facilitate knowledge mobilisation for social and economic change (Sulaiman & Davis 2012).

Social media unleashes the potential for initiating agricultural innovation (Kaushik et al. 2018). It provides opportunities for networking, collaboration, as well as the enhancement of rapid communication among people over geographical distances (Stanley 2013). Social media is considered a valuable tool that provides opportunities to share knowledge, enhance interaction, and support development as a discursive and negotiated process among different stakeholders (McNamara et al. 2011; EU SCAR 2013). The extension agents of DAE have been increasingly using social media (GoB 2016) after the political manifesto 'Digital Bangladesh' of the Government of Bangladesh (AIP 2009) and DAE's mandate for promoting Information and Communication Technology (ICT) in extension services (MoA 2012). Since 2016, DAE has been encouraging extension agents to use social media as a means of enhancing linkages with other agricultural stakeholders (e.g. farmers, extension personnel, researchers, input dealers), supporting

collaboration and partnership and facilitating knowledge mobilisation and agricultural innovation. DAE has adopted several organisational strategies such as increasing professional use of social media by instructing extension agents to open Facebook accounts, which can be connected to DAE's Facebook account (DAE 2016b; DAE 2016c). In addition, the government of Bangladesh has been encouraging employee responsible for delivering public services to utilise different social media platforms in their professional services (GoB 2016). Extension agents of DAE, therefore, have been using Facebook, YouTube, Twitter, Instagram, and LinkedIn. Facebook is the most used social media (Kamruzzaman 2017).

There are only a few studies (e.g. Kamruzzaman et al. 2018) related to social media use by extension professionals in Bangladesh. Given the current policy on ICT adoption for agricultural development as well as new strategies of DAE to utilise social media in extension services, the objective of this research is to understand how extension agents of DAE are leveraging the potential of social media for strengthening agricultural innovation.

Theoretical framework

The innovation system concept emerged from decades of intellectual debates and was introduced in the agricultural and rural development discipline recently (World Bank 2006). An innovation system can be defined as:

The network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect the system's behaviour and performance (WB 2006, p. vi-vii).

Agricultural innovation is an interactive process of acquisition of knowledge and learning (WB 2006). Learning is a process to support multiple and evolving collaboration of different groups of stakeholders and organisations with different identities, backgrounds and interests. Knowledge is shared, negotiated and mediated to create a new and common understanding of existing ideas regarding a complex agricultural problem (Chowdhury et al. 2014).

Learning requires linkages among different knowledge sources (Sharma et al. 2014), which may be in various forms from extremely scientific and technical, to tacit, coded and contextually embedded (WB 2006). The ability of stakeholders and organisations to innovate is mostly determined by how well, and efficiently, different sources of knowledge are interacted and negotiated (Aerni et al. 2015). However, the development of new understanding and practices through learning is not only the condition for innovation (Klerkx et al. 2012). It calls for rearrangement of marketing strategies, lobbying mechanisms, effective resource management and sufficient funding opportunities for the new practices (Leewis 2004; Klerkx et al. 2012). Moreover, there should be synchronisation between new practices and new arrangements (Klerkx et al. 2012). Therefore, two theoretical lenses were considered in explaining the potential use of social media for strengthening agricultural innovation. These are social learning and functions of innovation.

Social learning

The concept of social learning was first introduced by Miller & Dollard (1941) and later developed by Sears (1951) and Bandura (1977) that focused learning through imitation of others' behaviour. It is recognised as passive social learning. Active social learning is principally a dialogical way (i.e. sharing, negotiation and co-creation) of learning, which is widely accepted as a more effective way of learning (Pahl-Wostl et al. 2007). The contemporary thoughts of social learning as elicited by other theories of learning such as organisational learning (Argyris & Schon 1978), situated learning (Lave & Wenger 1991), community of practice (Wenger 1998), situated cognition (Jacobson 1996) and collaborative learning (Daniels & Walker 1996) highlighted the important contribution of active social learning for innovation and social change. Reed et al. (2010) mentioned three criteria to examine social learning.

A change in understanding Individuals must demonstrate that a change in understanding has taken place either at surface level e.g. via recalling new information or at a deeper level e.g. change in an attitude or world view. Change in the surface level of understanding can be denoted as the first loop of learning that seeks solutions within the current framework of organisational strategies (Argyris & Schon 1974). On the contrary, change in world view is an outcome of the second loop of learning by which organisational staff start questioning and modifying the underlying roles, policies, principles and norms of the organisation (Argyris 1977).

Through social interaction Learning should occur through social interaction and processes among members within the network either by direct interaction e.g. conversation, or by other means e.g. social media and telephone.

Situated within wider social unit or community of practice Ideas or beliefs acquired by the members of the small group involved in the learning process must be diffused to other members of the wider social unit or community of practice to which they belong.

Functions of innovation

In technology-driven innovation processes, the emerging technology has to follow some functions to be included in the regime (Jacobsson & Bergek 2004; Hekkert et al. 2007). Hekkert et al. (2007) proposed seven functions to support innovation processes from a system's perspective. These functions are imperative for a new way of arranging the context to support technical change. Among seven functions, three are explained and fulfilled by social learning. These are knowledge development, knowledge diffusion through networks and guidance of the search. This research, therefore, adopted the four remaining innovation functions of Hekkert et al. (2007), which are interrelated and often performed simultaneously.

Entrepreneurial activities (EA) Entrepreneurs turn the potential new knowledge and network into concrete practical action to take benefit of new business and economic opportunities. Encouraging entrepreneurial activities requires enough supporting environment and inputs through knowledge development and lobbying.

Market formation (MF) In order to sustain an innovation, it requires protected space, which could be achieved by providing a niche market. Additionally, the crude innovation can be protected by tax reduction and formation of roles (i.e. legitimacy) to provide advantages for competition with embedded innovation.

Resources mobilisation (RM) Resources can be in several forms, such as financial, physical, human, and natural which are to be engaged for generation and well-functioning of innovation.

Creation of legitimacy/counteract resistance to change (L) Advocacy is imperative to encourage an innovation so that it gets enough focus to be a part of the existing regime. Through advocacy, the innovation would get enough resources to flourish and a favourable market policy for niche protection.

Methods

The research used a mixed-method social research approach to understand how extension agents of DAE are leveraging the potentials of social media for strengthening agricultural innovation. Data were collected from extension agents of DAE serving in Cumilla in the eastern region of Bangladesh from August to November 2016. A list of 560 social media users of DAE staff was prepared and 25% (i.e. 140) of them were randomly selected as the sample of the study. Data collection methods included a quantitative survey of 140 extension agents and qualitative interviews with 20 extension agents. Both extension administrative officers (i.e. Deputy Director, Upazilla Agriculture Officer, Agriculture Extension Officer) and frontline extension officers (Sub Assistant Agriculture Officer) participated in a survey and interviews.

Social learning was investigated qualitatively (Benson et al. 2016) through in-depth interviews with the purposively selected administrative (11) and frontline (nine) officers. The interviews were audio-recorded for accuracy and transcription purposes on the researcher's cell phone. Respondents were asked about what and how new understanding or practices they learned using social media. After that, further discussion delved into their learning processes, change in thinking and planning of activities, and ways of adopting new strategies or practices. The survey method (questionnaire) was employed to investigate the innovation functions. Selected functions were conceptualised by assigning two items for EA, MF, RM, L, respectively. Informed by Hekkert et al. (2011), a five-point Likert scale was adopted with response options, including frequently, sometimes, occasionally, rarely and not at all for each of the items. The questionnaire was pre-tested with 15 respondents and data were collected from 140 respondents.

The recordings of in-depth interviews were transcribed considering the major themes and patterns for social learning criteria identified, manually coded and used to describe the social learning for agricultural innovation. The reliability and validity of the survey instrument were also assessed. The Chronbach's alpha values for innovation functions ranged from 0.741 to 0.859 (Table 1) which was well above the cut off value 0.70 (Bagozzi & Yi 1998). IBM SPSS statistics V-23 was used to analyse the survey data. The items of the innovation functions were coded as five, four, three, two and one for frequently, sometimes, occasionally, rarely and not at all, respectively. The score for each item was entered in the software and the mean, standard deviation and t-value for each innovation function was calculated.

Table 1. Reliability of the survey instrument to examine innovation functions supported by the extension agents of DAE through social media

Innovation functions	Items	Chronbach's alpha
Entrepreneurial activities	I share the success story of farmers with some pictures I share the procedural steps for the new ways of crop cultivation to develop a clear understanding	0.855
Market formation	I share demanding and lucrative information about agricultural produces I share information regarding agencies and potential market sources to link the producers, consumers	0.848
Resource mobilisation	I share required inputs and materials to cultivate different agricultural produces I consider the comments, suggestions given on my social media posts to plan and execute extension activities	0.741
Legitimisation	I share using social media different pictures of my field activities in which local representatives & higher officials of DAE attended I tag departmental colleagues, local representatives, journalists with my posts through social media	0.859

Findings

Social learning new practices for agricultural innovation- findings from qualitative interviews

1. Change in understanding Extension agents of DAE used social media to learn professional tasks and to a lesser extent, technical agricultural knowledge. Extension agents learned how other extension agents were following organisational instructions, and implementing different field activities (e.g. field days, demonstration activities, motivational work and training activities). To some extent, they used social media to learn about cultivation, production strategies and agricultural practices of widely cultivated crops. Frontline extension officers were more interested to learn technical knowledge compared to the extension administrative officers. This might be because frontline extension officers deal with farmers directly for advice and solution for technical problems.

Extension agents used social media to learn in the following ways:

Thinking and reflection Extension agents observed different agriculture and extension service-related posts that influenced them to think about and reflect on professional activities and agricultural practices. When noting activities of other colleagues and stakeholders (e.g. farmers, input dealers) using social media they reflected on and asked questions such as, why others did things in a particular way, what could be the benefits of doing so. Most of the frontline extension officers (e.g. eight out of nine officers) reported this sort of thinking and reflection based on observation of activities represented through social media.

Self-reflection Extension agents reported that observation of activities through social media influenced them to reflect on their own existing practices and execute agricultural plans and activities in the field in a better way. For instance, an Upazilla Agriculture Officer mentioned that he learned through social media that one of his colleagues recommended Dhaincha (Sc name: *Sesbania bispinosa*) seedlings for perching due to its multi-dimensional benefits. This example inspired him to consider similar types of practices in his area. Outside of this, few extension agents tried new things that involve going beyond their assigned job duties and responsibilities and shared their learning experiences using social media. Most respondents (e.g. 17 out of 20) developed a realisation that given similar resources and facilities, they should be able to carry out similar practices.

2. Social interaction Talk-back and commenting were avoided by 80% of extension agents in response to social media posts. The participation and interaction of extension agents were largely dependent upon the type of agricultural information, technologies, and extension activities that were shared by others. A typical pattern to respond to day to day activities shared through social media was the use of short remarks, such as 'good job', 'thanks', 'go ahead'. They got involved in the discussion if there were relatively new ideas or news or strategies (e.g. cultivation of exotic fruit such as dragon fruit, year-round jackfruit) and confusing agricultural topics posted using social media. But a lack of timely interaction between the parties involved in the discussion was a significant drawback for interactive communication in the social media channel.

Extension agents were more comfortable discussing critical questions during face-to-face meetings than using social media. The interviews with most frontline extension officers indicated that they wanted to avoid discussing critical issues using social media as it might involve breaking the cultural values of being humble and respectful to the senior officers and ultimately might have consequences for their performance report. All the interviewed frontline respondents felt shy to ask questions, participate in the discussion or answer questions through social media. Half of the frontline respondents and all frontline women interviewees mentioned that they felt a lack of confidence to answer any query or participate in active discussion. They felt that their answer or conversation might not be entirely correct or scientific. There was concern about sharing comments, which might not be appropriate or expected in the eyes of their senior officers, and ultimately, they might be discredited in such a discussion.

3. Share with wider community of practice Once new practices had been learned using social media, extension agents mostly shared in face-to-face settings. The extension administrative officers took the opportunity to discuss their learning during training and field visits. Frontline extension officers discussed with the farmers about new information when they visited the field. Most extension administrative officers prioritised a prior face-to-face discussion with their subordinate staff and farmers to apply new understanding and practices learned through social media in the field. Usually, extension agents preferred to share through social media about interesting agricultural practices, different ways of conducting existing practices, new crops, new and exceptional varieties which were lucrative, eye-catching, and valuable and more people would like.

Innovation functions to support new practices- findings from quantitative survey

Extension agents of DAE used social media to help perform innovation functions. Thus, they supported new ways of arranging the context for new practices or technology and facilitated agricultural innovation. To support entrepreneurial activities, extension agents shared the success story with some pictures of the farmers who demonstrated skills in cultivating crops, marketing strategies and generating additional income. Besides, if extension agents found something new (e.g. new ways of cultivation or planting seeds) they shared step by step pictures of those activities and wrote a short description. In order to help market formation, they shared the positive and demanding aspects of any new crops through social media. They also tried to find or link a potential market for field and horticultural crops using the social media platform.

Table 2. Differences among extension administrative and frontline officers to support innovation functions using social media

Innovation functions	Position at DAE	Mean	Standard deviation	t-value	Significant difference
Entrepreneurial activities	Administration	3.90	0.85	0.868	No
	Frontline extension	3.76	0.99		
Market formation	Administration	2.91	1.33	-0.349	No
	Frontline extension	2.98	1.08		
Resource mobilisation	Administration	3.81	0.83	1.093	No
	Frontline extension	3.66	0.87		
Legitimisation	Administration	4.17	0.73	3.510	Yes (<0.001)
	Frontline extension	3.66	0.98		

With a view to initiating resource mobilisation, extension agents shared different farming inputs like seeds, specific fertilisers, recommended pesticides, new machinery required to perform agricultural practices and crop production. In some cases, extension agents considered feedback and suggestions received from others and tried to incorporate this in their plans as well as mobilising staff and financial support for application in the field. They also drew the attention of local representatives, media and higher authorities about new practices by tagging them to field activities shared through social media. The research found that extension administrative officers used social media significantly more to legitimise innovative practices and ideas than frontline extension officers (Table 2).

Discussion

The findings indicate that extension agents of DAE used social media to learn new practices and facilitate new arrangements for supporting agricultural innovation. Social media is fundamentally considered a means of collaboration, dialogical communication and conversation (Stanley 2013). It is also regarded as the architecture of participation (Thompson 2008). The findings of the study indicated that two-way communication and active discussion using social media were mostly absent. Extension agents of DAE mostly used social media for the broadcasting of agricultural

information and extension services. Extension agents, mostly frontline extension officers, felt insecure about participating in the critical discussion through social media. The findings were in line with the observation of another organisational study, which substantiated that organisational staff used social media to prove their presence in online media (Leonardi et al. 2013). In another study, it was reported that agricultural stakeholders followed the strategy of pushing-out information by using social media with less motivation for two-way communication (Chowdhury & Hambly 2013). Often, organisations perceive collaboration and conversation through social media as a time-consuming effort. Instead, they prioritise successful outcomes with predetermined end communication strategy (Greenberg & MacAulay 2009). The process of organisational formation and its long term practiced roles, regulations, and norms often determine activities, performance, initiatives and communication patterns of its employees (Paris et al. 2012; Chowdhury et al. 2014). The formal tone and formal language used in organisations are also found to be practiced in the social media platform while dealing with clients' needs (Paris et al. 2012). The staff, especially of financial organisations, are aware of the accountability function of social media and adapt their behaviour based on their organisational hierarchy and goals (Treem 2015).

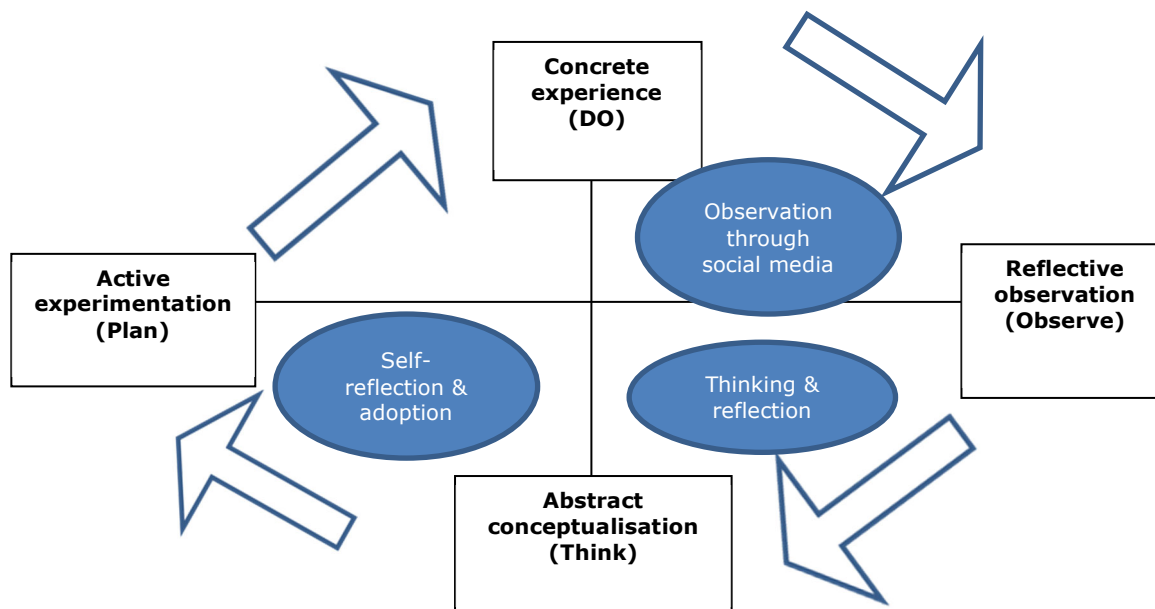
The study of organisational reforms suggests that it is not easy to change organisational roles and institutional procedures, especially for agricultural extension organisations in developing countries (Hounkonnou et al. 2012). Experience from Agricultural Service Support Project and Agricultural Services Innovation Reform Project to reform DAE remarked that the organisational culture of DAE is resistant to accept deep-rooted reform. Therefore, change in DAE's organisational strategies and to adopt a new approach is challenging and limited by political, social, and contextual complexities (Gill et al. 2003). The present study of social learning in DAE showed that extension agents missed the opportunity to connect with other stakeholders (e.g. input dealers, marketing, processing industry) through social media for collaboration and knowledge management. While studying the reform process of DAE towards embracing an AIS approach, Chowdhury et al. (2014) concluded that the administration and policy-making system of DAE were unwilling to reconsider their roles for adopting new approaches. From extension administrative officers to frontline extension officers, extension agents of DAE did not fully utilise the potential for partnership and collaboration with other stakeholders. They preferred to maintain traditional linear knowledge transfer than pursue multidirectional and free flow of agricultural knowledge exchange.

Social media is often claimed as a platform where members of wide networks are weakly bonded with a casual relationship (Hall 2018). According to Materia et al. (2014), social media may not support effective collaboration and mutual understanding because of voluntary, passive and limited participation in online media. In rural settings where extension agents of DAE operate, stakeholders prefer to interact with members and peers already known to them. Rural stakeholders do not conceptualise social media as a platform to meet with new people. To them, trust is the priority to engage in close meeting and discussions (Kaushik et al. 2018). Consequently, they prefer to build strong relationships in non-virtual, face-to-face settings and then switch to communication in virtual media (Gilbert et al. 2010). In this research, extension agents preferred to discuss (if possible) their queries in weekly (at sub-district) and monthly (at district) meetings rather than using the social media platform. Moreover, they preferred face to face than virtual media for sharing their newly learned practices. According to Materia et al. (2014), non-virtual meeting and discussion maximises the effectiveness of subsequent social media discussions. For these reasons, effective discussion and co-learning with stakeholders through social media demands a complementary input from non-virtual settings.

Extension agents learned professional skills, activities and agricultural technical knowledge through social media. The tendency and the process of learning were in line with Kolb's (1984) experiential learning (Figure 1). At first, they observed professional activities and agricultural practices using social media. Meanwhile, extension agents started thinking and reflecting on those agricultural and extension activities. After that, they decided whether the practices or activities were relevant and could be implemented in their working areas. However, the ways extension agents learned and the outcomes of learning were indicative of the first loop of learning. Experts declare that most organisations follow the first loop of learning in their working strategies (McNamara 2006). First loop learning is a problem-solving process where organisational staff search for another strategy to address the problem (Kantamara & Vathanophas 2014). It emphasises increasing efficiency to fulfil well established, and pre-determined sets of objectives i.e. making 'the things right' (Cartwright 2002), and provides short term tangible outcomes (Kantamara & Vathanophas 2014). In a few cases, extension agents learned through critical discussions, challenging their traditional extension services and technical knowledge, thus moved towards the second loop of learning. With this loop of learning, the organisations start to think

out of the box (McNamara 2006) and wonder how to make 'the right things' (Cartwright 2002). Therefore, it is necessary for extension agents to develop strategies to utilise social media for initiating the second loop of learning, which will enable organisations to achieve long term benefits in a sustainable manner (Kantamara & Vathanophas 2014).

Figure 1. Relations of extension agents' social learning for innovation with Kolb's (Kolb 1984) learning cycle



Extension agents of DAE used social media to support activities for new arrangements such as entrepreneurial activities, market formation, resource mobilisation and legitimisation. They shared the success of different agricultural activities using social media. This sort of sharing developed confidence among the entrepreneurs about the probable support and cooperation from DAE to practice innovation. The evidence from small and medium enterprise (SME) research by Handayani & Lisdianingrum (2011) in Indonesia indicates that social media has expanded the network of entrepreneurs through its different features, such as business profile, connecting with various social media pages and groups. Extension agents might use social media to form the probable market and niche protection of innovation. Scholars inform that several organisations and companies have found social media as a revolutionary tool for marketing and promotion of their newly launched product among customers leaving aside the traditional channel of marketing (Michaelidou et al. 2011).

The instructions of DAE to extension agents for sharing agricultural information, materials, strategies, and plans with DAE Facebook page and personal account (DAEb 2016; DAEC 2016) had augmented some sorts of flow of information and resource mobilisation through social media. Extension agents used social media as new and promising means of legitimising agricultural innovation. The extension administrative officers had more scope for legitimisation. Since they collaborated and coordinated with other stakeholders and organisational units for implementing agricultural programs, their endorsement to practices and innovations shared using social media had more influence in legitimisation. As they commented on and endorsed messages shared through social media, it usually carried value for viewers and participants of the platform. Evidence from other developing countries such as Uganda, Tanzania, and Madagascar confirm that social media can influence the agricultural policy process through sharing agricultural knowledge and information collected from diversified sources (Pedrick 2014).

Although the study did not accentuate the gender variation in using social media, women were found to some extent different in using and participating through social media. For instance, women extension agents were less confident in commenting and active discussion. Further research, therefore, would be interesting to examine whether and what extent social media has brought opportunity for the women extension agents of DAE to foster their voice and to augment contribution to the mainstream of agricultural development in Bangladesh.

Conclusion

Extension agents of DAE used social media to strengthen agricultural innovation in Bangladesh. Social media provided a significant opportunity for them to learn new practices. Although learning occurred mainly on professional and technical areas, they missed the opportunities to use the media for active participation and critical discussion. The ways and outcomes of learning using social media were indicative of the first loop of learning, and the initiation of second loop learning was mostly absent. The use of social media as a means of social interaction and collaboration was also lacking. This interactional pattern of communication can be improved following a strategy of integrating virtual interaction of social media with non-virtual interaction within and beyond the organisation. Although extension agents used social media to fulfil some functions of innovation processes, it did not support innovation as a systemic interaction. Organizational culture of DAE and social media functionalities itself were among other concerns responsible for the ways extension agents used social media for strengthening agricultural innovation.

Acknowledgement

The Anne van den Ban Fund (ABF) is acknowledged to support the graduate study of the first author.

References

- Access to Information Program (AIP) 2009, *Digital Bangladesh concept note*, Access to Information Programme, Prime Minister's Office. Government of the Peoples' Republic of Bangladesh, Available from: <<https://www.apc.org/>> [15 March 2017].
- Aerni P, Nichterlein K, Rudgard S & Sonnino A 2015, 'Making agricultural innovation systems (AIS) work for development in tropical countries', *Sustainability*, vol. 7, no. 1, pp. 831-850. <https://doi.org/10.3390/su7010831>
- Argyris C & Schon DA 1974, *Theory in practice: increasing professional effectiveness*, Jossey-Bass, Oxford, UK.
- Argyris C 1977, 'Double loop learning in organisations: new forms for turbulent environments', *Journal of Marketing*, vol. 55, pp. 77-93.
- Argyris C & Schön DA 1978, *Organisational learning: a theory of action perspective*, Jossey-Bass, San Francisco, California, USA.
- Bagozzi R & Yi Y 1998, 'On the evaluation of structural equation models', *Journal of the Academy of Marketing Science*, vol. 16, no. 1, pp. 74-94.
- Bandura A 1977, *Social learning theory*, General Learning Press, New York, USA.
- Bangladesh Bureau of Statistics (BBS) 2016, *Statistical yearbook of Bangladesh 2016*, Statistics & Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh, Available from: <<http://bbs.portal.gov.bd/>> [30 August 2019].
- Benson D, Lorenzoni I & Cook H 2016, 'Evaluating social learning in England flood risk management: an 'individual-community interaction' perspective', *Environmental Science & Policy*, vol. 55, pp. 326-34, <https://doi.org/10.1016/j.envsci.2015.05.013>.
- Cartwright S 2002, 'Double-loop learning: a concept and process for leadership educators', *Journal of Leadership Education*, vol. 1, No. 1, pp. 68-71.
- Chowdhury A & Hambly Odame H 2013, 'Social media for enhancing innovation in agri-food and rural development: current dynamics in Ontario, Canada', *The Journal of Rural and Community Development*, vol. 8, no. 2, pp. 97-119. <https://journals.brandonu.ca/>
- Chowdhury AH, Hambly Odame H & Leeuwis C 2014, 'Transforming the roles of a public extension agency to strengthen innovation: lessons from the national agricultural extension project in Bangladesh', *The Journal of Agricultural Education and Extension*, vol. 20, no. 1, pp. 7-25, <https://doi.org/10.1080/1389224X.2013.803990>.
- Daniels SE & Walker GB 1996, 'Collaborative learning: improving public deliberation in ecosystem-based management', *Environmental Impact Assessment Review*, vol. 16, no. 2, pp. 71-102. Available from: <<http://www.elkhornsloughctp.org/>>, [28 June 2019].
- Department of Agricultural Extension (DAE) 2016a, *Agricultural extension manual*, Fourth edition, Department of Agricultural Extension (DAE), Ministry of Agriculture (MoA), Government of People's Republic of Bangladesh, Available from: <<http://dae.gov.bd/>> [02 August 2018].
- Department of Agricultural Extension (DAE) 2016b, *To be connected with official Facebook page of DAE*, Office order by Department of Agricultural Extension (DAE), Ministry of Agriculture, Government of the People's Republic of Bangladesh. Available from: <<http://dae.portal.gov.bd/>> [02 February, 2017].
- Department of Agricultural Extension (DAE) 2016c, *To open official Facebook account*, Office order by Department of Agricultural Extension (DAE), Ministry of Agriculture, Government of the People's Republic of Bangladesh, Available from: <<http://dae.portal.gov.bd/>> [02 February, 2017].
- EU SCAR 2013, *Agricultural knowledge and innovation systems towards 2020- an orientation paper on linking innovation and research*, Directorate-General for Research and Innovation, European Commission, Brussels, Belgium. Available from: <<http://www.gppq.fct.pt/>> [28 April, 2019].
- Gilbert E, Karahalios K & Sandvig C 2010, 'The network in the garden: designing social media for rural life', *American Behavioral Scientist*, vol. 53, no. 9, pp. 1367-1388. <https://doi.org/10.1177/0002764210361690>.
- Gill G, Bartlett A, Huda E & Begum TP 2003, 'Rural livelihoods evaluation partnership (RLEP)', Project review report, Hove, UK.

- Government of Bangladesh (GoB) 2016, *Guidelines for using social media in government offices-2016*, Cabinet Division, Bangladesh Secretariat, Government of the People's Republic of Bangladesh, Available from: <<http://cabinet.portal.gov.bd/>> [31 January 2017].
- Greenberg J & MacAulay M 2009, 'NPO 2.0? Exploring the web presence of environmental non-profit organisations in Canada', *Global Media Journal*, vol. 2, no.1, pp. 63.
- Hall JA 2018, 'When is social media use social interaction? Defining mediated social interaction', *New Media & Society*, vol. 20, no. 1, pp 162-179, <https://doi.org/10.1177/1461444816660782>.
- Handayani PW & Lisdianingrum W 2011, 'Impact analysis on free online marketing using social network Facebook: case study SMEs in Indonesia', in *International conference on advanced computer science and information system (ICACSIS)*, Jakarta, Indonesia, pp. 171-176, Available from: <<https://ieeexplore.ieee.org/>> [30 June 2019].
- Hekkert MP, Suurs RA, Negro SO, Kuhlmann S & Smits RE 2007, 'Functions of innovation systems: a new approach for analysing technological change', *Technological Forecasting and Social Change*, vol. 74, no. 4, pp. 413-432, <https://doi.org/10.1016/j.techfore.2006.03.002>.
- Hekkert M, Negro S, Heimeriks G & Harmsen R 2011, *Technological innovation system analysis*, Faculty of Geosciences, Copernicus Institute for Sustainable Development and Innovation, Utrecht University. Available from : <<http://www.innovation-system.net/>> [10 May 2018].
- Hounkonnou D, Kossou D, Kuyper TW, Leeuwis C, Nederlof ES & Roling N 2012, 'An innovation systems approach to institutional change: smallholder development in West Africa', *Agricultural Systems*, vol. 108, pp. 74-83, <https://doi.org/10.1016/j.agsy.2012.01.007>.
- Jacobson W 1996, 'Learning, culture, and learning culture', *Adult Education Quarterly*, vol. 47, no. 1, pp. 15-28. Available from: <<http://journals.sagepub.com/doi/pdf/10.1177/074171369604700102>> [08 October 2018].
- Jacobsson S & Bergek A 2004, 'Transforming the energy sector: the evolution of technological systems in renewable energy technology', *Industrial and Corporate Change*, vol. 13, no. 5, pp. 815-849.
- Kamruzzaman M 2017, How do agricultural extension workers of DAE use social media for strengthening agricultural innovation in Bangladesh? MS Thesis, Wageningen University and Research, Netherlands.
- Kamruzzaman M, Chowdhury A, Van Paassen A & Ganpat W 2018, 'Extension agents' use and acceptance of social media: the case of the department of agricultural extension in Bangladesh', *Journal of International Agricultural and Extension Education*, vol. 25, no. 2, pp. 132-149, <https://doi.org/10.5191/jiaee.2018.25210>.
- Kantamara P & Vathanophas V 2014, 'Single-loop vs. double-loop learning: an obstacle or a success factor for organisational learning', *International Journal of Education and Research*, vol. 2, no. 7, pp. 55-62.
- Kaushik P, Chowdhury A, Hambly Odame H & van Paassen A 2018, 'Social media for enhancing stakeholders' innovation networks in Ontario, Canada', *Journal of Agricultural & Food Information*, vol. 19, no. 4, pp.331-53, <https://doi.org/10.1080/10496505.2018.1430579>.
- Klerkx L, Pant LP, Leeuwis C, Cummings S, le Borgne E, Kulis I, Lamoureux L & Senmartin D 2011, 'Beyond the conventional boundaries of knowledge management: navigating the emergent pathways of learning and innovation for international development', *Knowledge Management for Development Journal*, vol. 7, no. 1, pp. 1-7, <https://doi.org/10.1080/19474199.2011.593880>.
- Klerkx L, Van Mierlo B & Leeuwis C 2012, 'Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions', in *Farming systems research into the 21st century: the new dynamic*, Springer, Netherlands, pp. 457-483.
- Kolb DA 1984, *Experiential learning: experience as the source of learning and development*, Prentice-Hall, Englewood Cliffs, New Jersey, USA.
- Lave J & Wenger E 1991, *Situated learning: legitimate peripheral participation*, Cambridge University Press, Cambridge, UK.
- Leeuwis C 2004. *Communication for rural innovation: rethinking agricultural extension*, 3rd edn, Blackwell Science Ltd, Oxford, UK.
- Leeuwis C & Aarts N 2011, 'Rethinking communication in innovation processes: creating space for change in complex systems', *The Journal of Agricultural Education and Extension*, vol. 17, no. 1, pp. 21-36, <https://doi.org/10.1080/1389224X.2011.536344>.
- Leonardi PM, Huysmanm M & Steinfield C 2013, 'Enterprise social media: definition, history, and prospects for the study of social technologies in organisations', *Journal of Computer-Mediated Communication*, vol. 19, no. 1, pp. 1-19, <https://doi.org/10.1111/jcc4.12029>.
- Materia VC, Giarè F & Klerkx L 2014, 'Increasing knowledge flows between the agricultural research and advisory system in Italy: combining virtual and non-virtual interaction in communities of practice', *The Journal of Agricultural Education and Extension*, vol. 21, no. 3, pp. 203-218, <https://doi.org/10.1080/1389224X.2014.928226>.
- McNamara C 2006, *Field guide to consulting and organisational development: a collaborative and systems approach to performance, change and learning*, Authenticity Consulting, Minneapolis, USA.
- McNamara K, Belden C, Kelly T, Pehu E & Donovan K 2011, 'ICT in agricultural development- overview of ICT in agriculture: opportunities, access, and cross-cutting themes' in *ICT in agriculture: connecting smallholders to knowledge, networks, and institutions*, Agriculture & Rural Development Department, The World Bank, Washington, DC, USA, Available from: <<https://openknowledge.worldbank.org/>> [6 April, 2019].
- Michaelidou N, Siamagka NT & Christodoulides G 2011, 'Usage, barriers and measurement of social media marketing: an exploratory investigation of small and medium B2B brands', *Industrial Marketing Management*, vol. 40, no. 7, pp. 1153-1159.
- Miller NE & Dollard J 1941, *Social learning and imitation*, Yale University Press, New Haven, USA.

- Ministry of Agriculture (MoA) 2012, *National agricultural extension policy (NAEP)*, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Available from: <<http://dae.portal.gov.bd/>> [25 February 2017].
- Pahl-Wostl C, Craps M, Dewulf A, Mostert E, Tabara D & Taillieu T 2007, 'Social learning and water resources management', *Ecology and Society*, vol. 12, no. 2, pp. 5, <http://www.ecologyandsociety.org/vol12/iss2/art5/>.
- Paris C, Thomas P & Wan S 2012, 'Differences in language and style between two social media communities', in *6th International AAAI conference on weblogs and social media (ICWSM)*, Dublin, Ireland, pp. 539–542, Available from: <<https://www.aaai.org/>> [22 July 2019].
- Pedrick C 2014, *Embracing web 2.0 and social media: a life-changing pathway for agricultural development actors*, Technical Center for Agricultural and Rural Cooperation ACP-EU (CTA), Wageningen, Netherlands.
- Rajalahti R 2012, 'Sourcebook overview and user guide' in *Agricultural innovation systems: an investment sourcebook*, Agriculture & Rural Development Department, The World Bank, Washington, DC, USA, <https://doi.org/10.1596/978-0-8213-8684-2>.
- Reed MS, Evelyn AC, Cundill G, Fazey I, Glass J, Laing A, Newig J, Parrish B, Prell C, Raymond C & Stringer LC 2010, 'What is social learning?', *Ecology and Society*, vol. 15, no. 4, pp. rZZ, <https://www.jstor.org/stable/26268235>.
- Rivera WM & Sulaiman VR 2009, 'Extension: object of reform, engine for innovation', *Outlook on Agriculture*, vol. 38, no. 3, pp. 267-273. <https://doi.org/10.5367/00000009789396810>
- Sears RR 1951, 'A theoretical framework for personality and social behavior', *American Psychologist*, vol. 6, no. 9, pp. 476–483.
- Sharma R, Peshin R, Khar S & Ishar AK 2014, 'Agriculture innovation system approach for sustainable agriculture development: a review', *Agro-Economist*, vol. 1, no. 1, pp. 1-7.
- Stanley S 2013, *Harnessing social media in agriculture*, A report for the New Zealand Nuffield Farming Scholarship Trust NZ Nuffield Scholar, Available from: <http://www.nuffield.org.nz/uploads/media/S_Stanley_2013_Final_Report.pdf> [14 November 2017].
- Sulaiman R & Davis K 2012, *The new extensionist: roles, strategies, and capacities to strengthen extension and advisory services*, Global Forum for Rural Advisory Services (GFRAS), Lindau, Switzerland.
- Thompson M 2008, 'ICT and development studies?: towards development 2.0', *Journal of International Development*, vol. 20, no. 6, pp. 821–835, <https://doi.org/10.1002/jid.1498>.
- Treem JW 2015, 'Social media as technologies of accountability: explaining resistance to implementation within organisations', *American Behavioral Scientist*, vol. 59, no. 1, pp. 53-74, <https://doi.org/10.1177/0002764214540506>.
- Wenger E 1998, *Communities of practice: learning, meaning, and identity*, Cambridge University Press, Cambridge, UK.
- World Bank (WB) 2006, *Enhancing agricultural innovation: how to go beyond the strengthening of research systems*, Agriculture & Rural Development Department, The World Bank, Washington, DC, USA, Available from: <<http://siteresources.worldbank.org/>> [28 September 2017].