ABOUT JAERD

The Journal of Agricultural Extension and Rural Development (JAERD) is published monthly (one volume per year) by Academic Journals.

Journal of Agricultural Extension and Rural Development (JAERD) is an open access journal that provides rapid publication (monthly) of articles in all areas of the subject such as Impact monitoring and evaluation system for farmer field schools, Metals in bio solids-amended soils, Nitrogenous fertilizer influence on quantity and quality values of balm, Effect of irrigation on consumptive use, water use efficiency and crop coefficient of sesame etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JAERD are peer-reviewed.

Contact Us

Editorial Office: jaerd@academicjournals.org
Help Desk: helpdesk@academicjournals.org
Website: http://www.academicjournals.org/journal/JAERD
Submit manuscript online http://ms.academicjournals.me/
Editors

Dr. Kursat Demiryurek
Ondokuz Mayis University, Faculty of Agriculture, Department of Agricultural Economics, 55139, Samsun, Turkey.

Prof Theera Rukkwamsuk
Kasetsart University
Thailand.

Dr. Vincent Bado
WARDA, Africa Rice Center
Burkina Faso.

Dr. Tahseen Jafr
Glasgow Caledonian University
Cowcaddens Road, Glasgow Scotland UK, G4 OBA UK.

Dr. Daniel Temesgen Gelay
Welaita Sodo University, Ethiopia

Dr. Ayyanadar Arunachalam,
Department of Forestry, North Eastern Regional Institute of Science & Technology, Nirjuli 791109, Arunachal Pradesh, India.

Dr. V. Basil Hans
St Aloysius Evening College, Mangalore. # 720 Light House Hill, Mangalore – 575 005, Karnataka State. India.

Dr. Farhad Mirzaei
Department of Animal Production Management, Animal Science Research Institute of Iran

Dr. Ijaz Ashraf
Institute of Agri. Extension and Rural Development, University of Agriculture, Faisalabad-Pakistan
Editorial Board

Dr. Vasudeo P. Zamabare  
South Dakota School of Mines and Technology (SDSMT)  
USA.

Dr. Jurislav Babic,  
University of Osijek, Faculty of Food Technology  
F. Kuhaca 20, 31000 Osijek  
Croatia.

Dr. Ghousia Begum  
Indian Institute of Chemical Technology (IICT)  
India.

Dr. Olufemi Martins Adesope  
University of Port Harcourt, Port Harcourt,  
Nigeria.

Dr. A.H.M. Mahbubur Rahman  
Rajshahi University  
Bangladesh.

Dr. Ben Odoemena  
IFAD  
Nigeria.

Dr. D. Puthira Prathap  
Sugarcane Breeding Institute (Indian Council of Agricultural Research)  
India.

Dr. Mohammad Sadegh Allahyari  
Islamic Azad University, Rasht Branch  
Iran.

Dr. Mohamed A. Eltawil  
Kafrelsheikh University  
Egypt.

Dr. Henry de-Graft Acquah  
University of Cape Coast  
Applied Statistics  
Ghana.

Prof. Stanley Marshall Makuza  
Umutara Polytechnic  
Zimbabwe.

Dr. Franklin Peter Simtowe  
International Crops Research Institute for the semi-arid Tropics (ICRISAT)  
Malawi.

Dr. Hossein Azadi  
Centre for Development Studies, Faculty of Spatial Sciences, University of Groningen  
The Netherlands.

Dr Neena Singla  
Punjab Agricultural University  
Department of Zoology College of Basic Sciences and Humanities  
India.

Dr. Emana Getu Degaga  
Addis Ababa University  
Ethiopia.

Dr. Younes Rezaee Danesh  
Department of Plant Protection, Faculty of Agriculture Urmia University, Urmia-Iran.

Dr. Zahra Arjani  
Faculty of Geography, Islamic Azad University Branch of Tehran Central, Tehran  
Iran.

Dr. Hossein Aliabadi Farahani  
Islamic Azad University Shahriar (Shahr-e-Qods) Berach, Agricultural Department  
Iran.

Dr. Shikui Dong  
Environmental School, Beijing Normal University  
China.

Dr. Babar Shahbaz  
University of Agriculture, Faisalabad and Sustainable Development Policy Institute Islamabad  
Pakistan.

Dr. H. M. Chandrashekar  
Institute of Development Studies, University of Mysore, Manasagangotri Mysore 570 006, Karnataka  
State India.

Dr. Kassahun Embaye  
Institution: Institute of Biodiversity Conservation (IBC)  
Ethiopia.

Dr. Hasan Kalyoncu  
University of Süleyman Demirel, Faculty of Science and Art, Department of Biology  
TURKEY.
Review on market re-orientation of extension services for value chain development in Borno State, Nigeria
Mwada Musa GWARY, Alhaji Abba MAKINTA and Rahila Christopher WAKAWA

Enhancing community participation to improve sustainability of irrigation projects in Geita District, Tanzania
January Raphael Bikuba and Kim Abel Kayunze

Causes of losses and the economic loss estimates at post-harvest handling points along the beef value chain in Uganda
Juliet Kyayesimira, Wangalwa Rapheal, Grace Kagoro Rugunda, Lejju Julius Bunny, Joseph W. Matofari and Morgan Andama
Review

Turning challenges into opportunity: Potential for adoption of e-extension in Lesotho

Mojaki R. A. and Keregero K. J. B.

Department of Agricultural Economics and Extension, National University of Lesotho, Roma, Lesotho.

Received 19 February, 2019; Accepted 24 April, 2019

Farmers in Lesotho mostly depend on rain-fed agriculture and are in need of access to agricultural information and knowledge in a timely, complete and quality manner. The traditional practice for delivering agricultural information has mainly relied on agricultural extension staff visiting farmers in order to provide advisory services. Due to the limited number of extension staff and other challenges, the delivery of agricultural extension services through the traditional farm and home visits has been ineffective. This paper presents challenges that the agricultural extension system in Lesotho faces, which necessitate the adoption of information and communication technologies (ICTs) as a basis for improving access of farmers to extension services. The advent of ICTs has given rise to e-extension, which is the delivery of extension services using web tools that allow online sharing, collaboration and networking. A recent study has revealed that agricultural extension professionals in Lesotho recognize the potential and use of e-extension in the country and are well positioned to embrace its introduction. The paper, therefore, recommends that efforts should be made to gradually introduce e-extension in the country, capitalizing on the existing enthusiasm among extension professionals and lessons of best practice from elsewhere.

Key words: Agricultural extension, e-extension, information and communication technology (ICT).

INTRODUCTION

Information is becoming a major input in agriculture, whilst, knowledge and information plays a central role for farmers to respond to opportunities that could improve their agricultural productivity (Nzonzo and Mogambi, 2016). Improved information and knowledge flow to, from and within the agricultural sector constitutes a key component in efforts to improve small-scale agricultural production and link increased production to remunerative markets, leading to improved rural livelihoods, quality and yield, food security and national economies (Dankwah and Hawa, 2014).

Information and communication technologies (ICTs), therefore, represent the best hope for developing countries to accelerate their agricultural development processes and initiatives (Nyambam and Mlozi, 2012). Given that information is essential for facilitating agricultural and rural development and bringing about social and economic change, Oladele (2006) opined that ICTs can enhance the integration and efficiency of agricultural systems by opening new communication pathways and reducing transaction costs. Unfortunately, most African countries have not devoted adequate
attention to providing their citizens with access to information, especially in rural areas, where 70 to 80% of the population lives (Nzonzo and Mogambi, 2016).

The ICTs facilitate exchange of information among stakeholders, allowing rapid access to both technical and business expertise needed (Agu, 2013). Information is regarded as an important factor for increasing agricultural development and improving marketing and distribution strategies (Oladele, 2006). This is because it opens windows for sharing experiences and best practices, as well as information on sources of financial aid and new markets. Nzonzo and Mogambi (2016) stated that the availability of ICTs offers farmers the opportunity to collect, gather, share and disseminate information on emerging production techniques, markets and new varieties which enhance their production levels.

Although agriculture accounts for just 6% of Lesotho’s Gross Domestic Product (GDP), the sector is important for the livelihoods of 80% of the country’s population (CIAT and World Bank, 2018). Agricultural extension plays an important role in agricultural development and can contribute to improving the livelihoods of the farmers and other rural dwellers. According to Richardson (2006), extension is typically seen as a service, public or private, that responds to the needs of farmers and rural people for knowledge they can use to improve their productivity, income and welfare, and to manage the natural resources on which they depend in a sustainable way. Thus, extension brings information and new technologies to farming communities, allowing them to improve their production, income and standard of living. In Lesotho, extension is seen, largely, as a public service, institutionalized and organized by the government through the Department of Field Services (DFS) of the Ministry of Agriculture and Food Security (MAFS).

The problem is that, despite agricultural extension services having been offered in Lesotho for decades, there is little to show about its success. Experience has shown that it continues to be inefficient, ineffective and irrelevant. It has generally failed to build the necessary capacity and ability of farmers to manage their resources effectively and efficiently (Worth and Molomo, 2016). Thus, this paper explores the opportunity for improved information-exchange that ICTs can bring through integration of available technologies and diverse institutional and knowledge landscapes that exist.

**CHALLENGES FACING AGRICULTURAL EXTENSION IN LESOTHO**

There is growing recognition that farmers have needs for agricultural information and appropriate learning methods, which are not yet being met. The public extension services do not seem to have the capacity to reach all smallholder farmers, let alone provide up-to-date and tailored information to meet their needs (Bell, 2015). The difficulty in reaching all farmers arises from lack of extension staff to cover all areas of jurisdiction and physically meet clientele. The ratio of extension staff to farmers, as estimated at 1:750, is a far cry from the recommended 1:200-300 (Ministry of Agriculture, 2002). As a result, extension workers have large areas of jurisdiction, each with a narrow range of activities, which is less effective (Meera et al., 2004). This is exacerbated by the fact that farmers are sparsely populated across large areas and often isolated. Effective public extension services only manage to directly reach about 10% of the farming population, and this is even less if operating funds are limited (Bell, 2015). This situation, which prevails in Lesotho, implies that extension workers cannot be effective in disseminating agricultural information through personal contact that largely relies on the commonly embraced farm and home visits.

The prevailing notion that the delivery of agricultural extension services in Lesotho is the purview of the public sector implies that the government is the single most important player. In this context, as noted by Saravanan (2010), the public sector is expected to assume the responsibility of providing authentic and relevant information and services to farmers. The private sector and non-governmental organisations (NGOs), which are known to have many innovative and participatory approaches, are often left out of extension initiatives despite the recognition of their importance (Daniso et al., 2017). Besides, lack of cooperation leads to duplication of efforts by service providers, low coverage of farmers and obsolete and irrelevant information. While the Agricultural Policy and Capacity Building Project aimed at putting in place, among others, institutional and policy arrangements for sustainable and efficient management and delivery of public and private agricultural services, in the country (World Bank, 2004), no agricultural extension policy was developed as part of this effort. The lack of such a policy in Lesotho implies that there is no mechanism to govern the manner in which the public sector and other providers could come on board in extension service provision.

One of the most striking constraints associated with public sector extension services in Lesotho is poor funding for research and extension services leading to loss of qualified human capital and underperformance (Worth and Molomo, 2016; Canca and Ranthimo, 2017). Due to poor funding, there are few opportunities for continuing professional education and hardly any allowances to support field operations. This is a disincentive to its professionals, who are beginning to perceive themselves as irrelevant even when and where their role is so vital.

Barber et al. (2016) identified another limitation of public extension services as the nonrecurring character of information and knowledge provision to farmers. In situations where extension is well-linked to research and farmers, the information delivered ought to be updated.
and renewed by means of regular exchanges between extension workers and farmers and input from research. However, restrictions of financial resources and personnel mean that there are wide intervals with little or no interaction with farmers and researchers in between.

According to Qamar (2014), the Department of Agricultural Research (DAR) that is responsible for adapting and generating improved agricultural technologies, has been rendered largely dysfunctional by incessant financial constraints and other factors. Besides, the research-extension-farmer linkage in the country has been generally weak (Mojaki et al., 2017; Worth and Molomo, 2016). This limits the flow of information, knowledge, useful new technologies and resources among actors in the technology-delivery-utilization system. Sewnet et al. (2016) identified this state of affairs as a major drawback to the generation, wider testing, dissemination and adoption of improved agricultural technologies. In the same light, Eneyew (2013) indicated that the lack of strong linkage causes disruption in technology flow and low adoption rates, increased time lags between development and adoption of new technology, reduced efficiency in the use of resources, unnecessary competition and duplication of efforts, and increased cost of agricultural research and extension activities.

In summary, the provision of quality agricultural extension services in Lesotho is constrained by an unfavourable extension staff-to-farmer ratio, weak research-extension-farmers linkage, restricted budget, large areas of jurisdiction that are sparsely populated and isolated, and lack of agricultural extension policy. It can be inferred from these challenges that the net effect, over the years, has been the inability of the extension service to reach out effectively to its intended clientele. The situation has been further exaggerated by excessive, if not total, reliance on traditional face-to-face extension methods for communicating and sharing agricultural information and knowledge with clientele. It is clear that the time has come for adoption of more innovative ways of reaching out to clientele in an efficient and cost-effective way.

POTENTIAL FOR UTILIZATION OF E-EXTENSION

The advancements in ICTs provide an opportunity for developing countries, including Lesotho, to harness and utilize information and knowledge to improve agriculture (Anyoha et al., 2018). Aker (2011) stated that the rapid spread of ICT in developing countries offers a unique opportunity to transfer knowledge via private and public information systems. Advances in technology are producing more powerful computing devices to create a dynamic virtual network that allows people all over the world to communicate and share information with each other (Perron et al., 2010).

Given that the challenges associated with poor funding, unfavourable extension staff-to-farmer ratio, lack of transport and having cover large areas will not be wiped away any time soon in Lesotho, the need to explore ways of incorporating ICTs in the conventional agricultural extension services system cannot be overemphasized (Bell, 2015). Indeed, according to Barber et al. (2016), a promising solution for these shortcomings may be found in the increasing prevalence of ICT in extension delivery systems. Daniso et al. (2017) described ICTs as all technologies used for the widespread transfer and sharing of information. The ICTs promote and distribute new and existing farming information and knowledge which is communicated within the agricultural sector since information is essential for facilitating agricultural and rural development and bringing about social and economic changes (Swanson and Rajalahlhti, 2010).

According to Renwick (2012), e-extension is the delivery of extension services using web tools, which allow online sharing, collaboration and networking. The advent of ICTs has given rise to e-extension, which Saravanan (2010) described as a network of institutions that provides a more efficient alternative to the traditional extension system of agriculture, as it focuses on creating an electronic and interactive bridge where farmers and other stakeholders meet and transact to enhance productivity, profitability and global competitiveness. E-extension, as a modern mode of communication, can be used to improve the effectiveness and efficiency of extension services (Ramjattan et al., 2017).

The use of ICTs in extension can lead to a multi-stakeholder, people-centric, cross-sectoral system that brings together all stakeholders, especially farmers, to enable them to access timely and relevant information, and exchange opinions, experiences, good practices and resources related to agriculture (Bore et al., 2015). With the aim of improving communication and learning processes between various actors, an ICT-based extension system can also ensure integration of technology with multimedia, knowledge and culture (Saravanan, 2010).

The use of ICTs has generated new opportunities to address the challenges faced by agriculture. According to Aker (2011), the advancement of mobile technology and the rapid growth of mobile phone coverage moved many of ICT-based initiatives from “traditional” ICTs to mobile telephony, including voice, SMS and internet-based services. FAO (2015) has noted that increasing use of mobile phones for information exchange, such as disease surveillance and pest tracking, is now common practice. Linking knowledge to innovation is also crucial to addressing the information and knowledge gaps in the agriculture sector. This new technology offers several advantages over other alternatives in terms of cost, geographic coverage and ease of use. This is besides offering different advantages, like improved access to market information and coordination among agents’
increased job creation, improved communication among social networks, and the development of new services, such as mobile banking services, among others (Aker, 2011; Aker and Mbiti, 2010).

Mobile phones have become especially pervasive, as evidenced by 78.7% of Lesotho residents owning a mobile phone (Lesotho Communications Authority [LCA] and International Telecommunication Union [ITU], 2017). In addition, among the 14 SADC countries, Lesotho is ranked fifth, having a mobile subscription rate of 100.94 and 45% of mobile phone owners having access to a smart device. Thus, mobile phones provide a unique opportunity for agricultural extension service delivery to farmers without having to rely on the traditional farm and home visits that are, currently, prone to many challenges. This opportunity is favourable to the use of local and context-specific information. According to Elly and Silayo (2013), context-specific information has potential to close the information gap between service providers and farmers, thereby enhancing relevance of extension services.

The existence of web portals also provides unique opportunities for information-sharing and linking with other stakeholders and e-learning is specifically interesting for educational purposes (Barber et al., 2016). Web portals have some combination of online resources, multimedia (usually in the local language), and question and answer services with experts (Parikh et al., 2007).

An important and unique opportunity that has emerged in recent years is communication through social media, the use of websites and applications that enable users to create and share content or to participate in social networking. Through social media, users are able to access services using web-based technologies on desktops and laptops or download services which provide social media functionality to mobile devices, such as smart phones and tablets. These electronic services have led to the creation of highly interactive platforms through which individuals, communities and organizations can share, co-create, discuss and even modify user-generated content. As noted by Gonte (2018), social media has developed significantly in the past few years, creating opportunities for rural farmers to obtain information and knowledge about agriculture. By changing the way groups of people interact, which is different from traditional paper-based media (such as newspapers and posters) and electronic media (such as television broadcasting), social media has enhanced quality, reach, frequency, interactivity, usability, immediacy and performance.

Barber et al. (2016) viewed social media as integrating all functions; from providing advice and sharing knowledge to creating awareness, linking with other actors, and technology transfer. One key feature of the innovation systems perspective is that many actors are involved. It follows that many different sources, types and forms of knowledge and information need to be circulated, communicated and aggregated to support ‘new-style’ agricultural research and innovation for development (Ballantyne, 2010). This conforms very well to the strength of social media whose outlets operate in a dialogic transmission system involving many sources targeting many receivers, as opposed to traditional media that operates under a monologic transmission model involving one source targeting many receivers.

According to Bohloa (2016) and Ministry of Communications, Science and Technology (MCST) (2015), there is convincing evidence that ICTs can revitalize research-extension interactions in ways that respond to farmers’ demands. This is possible by using ICTs as one element in the wider transformation of a traditional, top-down, technology-driven extension system into a more pluralistic, decentralized, farmer-led and market-driven one.

The role of ICTs is also to contribute to urgently needed reforms to empower and support small-scale farmers to respond to food security, market development and climate change challenges (Barakabitez et al., 2015). Throughout the developing world, ICTs are being integrated into classic rural advisory services, through radio, SMS, television, video, internet, libraries, the media and mobile services. In this way, ICTs are opening up new channels for farmers to document and share experiences with each other and with experts. It is clear that ICTs, when thoughtfully and effectively used, can improve the various practice methods of social work, such as delivery of services, education and research (Perron et al., 2010).

According to Bell (2015), ICTs can fill the information gap left by public extension since they have the capacity to dramatically increase both person-to-person connections and their access to information. This is, particularly, useful because most of the farmers are often resource-poor and there are not enough extension workers to reach out to all of them. For instance, ICTs, such as mobile technology, can be harnessed to extend the reach of agricultural extension services by enabling farmers to contact hotlines for technical agricultural advice or to receive market information, such as market locations and prices (Aker and Mbiti, 2010; Bell, 2015). The growth of ICT in developing countries offers a new technology and new opportunities to empower users to communicate and access vital information, especially for remotely located individuals and communities (Aker, 2011).

Social media can offer amazing opportunities to farmers, including helping them to seek information on farm operations and clarify their doubts on plants or livestock disease symptoms. They can provide farmers with immediate access to market-related information. However, Naruka et al. (2017) affirmed that this can be possible only when farmers are socially networked with human resources: agricultural researchers, extension agents, veterinarians, progressive farmers, sellers and
other buyers in virtual space.

EXAMPLES OF SUCCESS STORIES FROM OTHER COUNTRIES

A number of success stories reflecting the potential for adoption of e-extension in the delivery of services to farmers can be identified. Examples include: Grameen Foundation Community Knowledge Worker (GCKW) initiative in Uganda, Indian Kisan Sanchar Limited (IKSL) in India, Farmers Helpline in Kenya, Reuters Market Light in India, Department of Agricultural Extension (DAE) and Department of Agricultural Marketing (DAM) in Bangladesh, “e-Pak Ag” in Pakistan and ‘e-Choupal’ initiative in India.

The Grameen Foundation Community Knowledge Worker (GCKW) initiative in Uganda was aimed at reaching farmers in remote communities through a network of peer advisors by providing free agricultural information and advice to rural farmers via a content database (including crop information, market prices, and inputs) on their smart phones (USAID, 2010). The initiative combines ICT, such as mobile technology and farmer networks, to aid smallholder farmers by improving their access to accurate, timely information which can improve their agricultural activities, businesses and livelihoods. The services provided by GCKW reach the most isolated rural villages by utilising a network of local advisors, who are also farmers chosen by their peers. Through the use of smart phone applications, the GCKWs give other farmers information on weather and marketing prices and advice on treating pests and diseases (Van Campenhout, 2017). The Indian Kisan Sanchar Limited is a mobile information provider to rural farmers through 38,000 Indian Farmers Fertiliser Co-operative (IFFCO) societies throughout the country and provides farmers with real-time agricultural information through a call centre and daily voice messages. In Kenya, the Farmers Helpline operated by KenCall, a for-profit call centre, is a real time call service staffed by agricultural experts that provides agricultural information, advice and support to smallholder farmers over the phone, using voice and voice call-back to farmers, not SMS (USAID, 2010).

The Reuters Market Light provides information on market prices, weather conditions, agricultural policy news and tips on farming cycles via SMS to fee-paying subscribers in India. Information is personalized, based on the type of crop, region of the country and local language. The service employs a staff of 300 full-time content professionals to provide news and data on more than 250 crop types, some 1,000 markets, and weather forecasts for 2,500 locations (USAID, 2010).

In Bangladesh, the Department of Agricultural Extension (DAE) and Department of Agricultural Marketing (DAM) started harnessing ICTs more effectively to deliver information and services to farmers. Government and non-government players introduced interactive programmes, such as phone-in sessions and talk shows to farmers and extension workers for interacting with policy makers and experts. Specifically, the DAM disseminates web-based commodity price information to the regional office, which then displays information on the notice board of a local market. Agriculture-focused tele-centres are planned around farmers’ clubs for more timely and cost-effective dissemination of critical information on inputs, weather and marketing channels. The initiatives have not only created possibility for public-private-partnerships in extension and marketing, but also set the platform for farmer-oriented policy reform. Extension agents (whether, public, private input providers and NGO staff), as intermediaries between farmers and other actors in the agricultural knowledge and information system (AKIS), are placed to make use of ICTs to access expert knowledge or other types of information (Saravanan, 2010).

In Pakistan, the ICT initiative called “e-Pak Ag” was undertaken by the University of California, Davis to look at how ICT could better help farmers, through the support of the Agricultural Innovation Programme for Pakistan (AIP). The initiative aimed to enhance the use of ICT to make credible, relevant information more available to those helping farmers in Pakistan. The e-Pak Ag involves, among other things, stakeholder consultations, reviews and studies and best practice identification and sharing. The initiative engages farmers, private sector, public organizations (extension, research and academia) and civil society. In general, though, farmers get information from a range of sources, including: farmers’ meetings, individual contact with extension or input providers, banners, and advertisements in electronic and print media (Bell and Shabaz, 2016).

In India, the ICT ‘e-Choupal’ initiative makes use of the physical transmission capabilities of current intermediaries - aggregation, logistics, counter-party risk and bridge financing with a judicious blend of click and mortar capabilities, village internet kiosks managed by farmers called sanchalaks. They enable the agricultural community to access ready information in their local language on the weather and market prices, disseminate knowledge on scientific farm practices and risk management, facilitate the sale of farm inputs and purchase farm produce from the farmers’ doorsteps. The aggregation of the demand for farm inputs from individual farmers gives them access to high quality inputs from established and reputed manufacturers at fair prices. As a direct marketing channel, ‘e-Choupal’ eliminates wasteful intermediation and multiple handling, thereby reducing transaction costs significantly. Launched in June 2000, ‘e-Choupal’, has already become the largest initiative among all internet-based interventions in rural India. The ‘e-Choupal’ services today reach out to more than 3.5 million farmers growing a range of crops in more
than 38,000 villages through nearly 6500 kiosks across nine states (Behera et al., 2015).

**IMPLICATIONS FOR LESOTHO**

The examples of success from various countries present useful lessons for Lesotho and demonstrate that DFS can harness the power of social media for the benefit of farming communities (Gonte, 2018). Incorporating ICTs can play a very important role in bridging information gaps, implying that, even with few extension workers, a large number of farmers can be reached. Social media is a new forum that brings people to exchange ideas; connect with, relate to, and mobilize for a cause; seek advice, and offer guidance. Social media has removed communication barriers and created decentralized communication channels and opened the door for all to have a voice and participate in a democratic fashion (Thakur and Chander, 2018).

A recently completed study by Mojaki (2016) has revealed that great potential does exist for the adoption of e-extension in Lesotho. The study established that agricultural extension professionals in the country see the potential for e-extension to transform them from mere agents of extension into knowledge workers, engaged in bottom-up, demand-driven, pluralistic approaches to technology generation, assessment, refinement and transfer. The agricultural extension professionals possess a wide range of competencies in the use of ICT which could become handy in the introduction of e-extension. They are, in fact, already technologically savvy and only require minimal training to enable them to use such expertise in e-extension.

The study also revealed that agricultural extension professionals are aware of the utility of ICT in extension service delivery and are personally ready to integrate ICT applications in extension, if some training is offered. While acknowledging that there is already some basic ICT infrastructure which could support the introduction and integration of e-extension in the country, the extension professionals underscored the need for more investment. They consider the management of agricultural extension services in the country to be generally ready to support the introduction of e-extension; understand the prudent use of ICTs in agricultural extension work; and are receptive to introduction of e-extension in Lesotho (Mojaki, 2016).

It is evident that agricultural extension professionals in Lesotho recognize the potential and use of e-extension in the country and are well positioned to embrace its introduction. A useful starting point, therefore, could be to sensitize them to start using selected ICT applications to deliver extension messages to farmers electronically. In a workshop organized in Leribe by the Food and Agriculture Organization in December 2017, senior extension officers were introduced to aspects of e-extension and they showed great enthusiasm to get further involved.

**CONCLUSIONS AND RECOMMENDATIONS**

The paper concludes that there are numerous, well established challenges to improving information exchange. The low ratio of extension workers to farmers, lack of funds for extension and research operations and weak research-extension-farmers linkage adversely affect equitable distribution of information. In agricultural extension, information is power and ICTs have been increasingly recognized as important elements in promoting connectivity among key players in what has come to be known as e-extension. In light of the prevailing challenges that have constrained effective access of farmers to extension services in the country, the adoption of e-extension could open up new opportunities in service delivery.

Given that agricultural extension practitioners are, by and large, ready and willing to venture into e-extension service delivery, the need to capitalize on existing enthusiasm cannot be overemphasized. This implies stepping up advocacy for the use of ICTs in delivery of e-extension services in the country. The involvement of the Faculty of Agriculture of the National University of Lesotho, in reviewing its undergraduate and postgraduate curricula to include e-extension and in the ongoing pilot project to assess the effectiveness of selected social media platforms in extension service delivery in selected villages in Roma Valley, constitutes a step in the right direction. Experiences from this endeavour will be used as a springboard to wider utilization of e-extension in the country.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

**REFERENCES**


Sewnet Y, Eleno E, Derso D (2016). A review of agricultural research, extension and farmers linkage in Ethiopia”. Agriculture and Biology


Determinants of adoption of improved sorghum package in agro-pastoral households of Somali Region of Ethiopia: A gender perspective

Najib Abdi Hassen

PhD Candidate in Huazhong University of Science and Technology, College of Public Administration, Department of Land resource management, China

Received 27 February, 2019; Accepted 21 August, 2019

The study analysed determinants of adoption of improved sorghum package between male-headed and female-headed households. The specific objectives were to analyse adoption differentials of improved sorghum package, and to identify factors that affect adoption decision of improved sorghum package by male and female-headed households. Purposeful sampling method was employed to select Woreda of sorghum growers with greater number of female-headed households with the aim to involve the required number for the analysis. A multi-stage stratified random sampling technique was used to select four PAs out of 23 PAs in the Woreda and households to be interviewed were derived proportionally to the size of the number of household in each PAs. Cross-sectional research design was applied to collect data from a total of 180 respondents in this study whereby 90 were female-headed and 90 were male-headed households. Pre-tested structured interview questionnaire was used for collecting the essential quantitative data. The Logistic Regression model results revealed that the adoption of improved sorghum package is biased by gender, where Female-Headed Households adopt the package relatively less. Regarding factors affecting adoption decision, non-farm activity had a significant and positive influence on the adoption decision of improved sorghum package, whereas distance to market had a significant and negative influence on the adoption decision for Male-Headed Household. Extension contact, family active labour force, attitude toward sorghum package had a significant and positive influence on adoption decision of Female Headed Household, whereas cosmpoliteness influences negatively. Therefore, policy should address gender disparities in extension services and access to resources that exist because of socio-cultural and institutional factors limiting the adoption of technologies for Female Headed Household. Thus, enhancing efficient delivery of extension with due consideration of the participation of female headed household would improve the livelihood of the households.

Key words: Adoption, gender, agro-pastoral, sorghum package, Somali Region.

INTRODUCTION

Ethiopia is fundamentally an agrarian country and agriculture is Ethiopia’s most important sector, crucial for...
the country’s food security and the livelihoods of its people. The sector is the largest contributor to the overall economy and is fundamental to Ethiopia’s overall development. The agriculture sector continues to be the most dominant aspect of the Ethiopian economy, accounting for nearly 42% of GDP, 80% of employment, and 83.9% of foreign export earnings (Matouš et al., 2013).

Despite of its contribution to the national GDP by large, agriculture in Ethiopia is subsistence. Smallholder farmers are cultivating 95% of their farmland using mostly traditional farming practices and inadequate improved technology can be found in the low productivity Ethiopian agriculture (Zerihun et al., 2014). Productivity in the agricultural sector has been hampered and food insecurity in the rural households of the country aggravated mainly by, among others, low level of technological development or utilization, low adoption rate of modern agricultural technologies, resource degradation, and gender bias.

For past decades, tremendous efforts have been made by the Ethiopian Agricultural Research Systems and Minister of Agriculture and Rural Development (MoARD) to develop and disseminate agricultural technology packages to different regions of the country using on-farm verification, pre-extension demonstration, popularization, training and extension publications. In the Somali region of Ethiopia, package based extension program was started in 1996 in two zones, namely Fafan and Siti. The technologies which were assumed to be appropriate to Jijiga Woreda had been introduced from agricultural research centers of the country. The technologies that had been introduced and distributed to agro-pastorals were different varieties of improved sorghum, namely, Gambella, Birmash, Dinkmash, Kobomash, Seredo and 76 T1 #23 (RBoA, 2002).

Despite most studies on gender division of labour in agricultural sector revealed that up to 40% of farming activities are done by women, especially in food production and processing (FAO, 2011). A closer look at the different extension approaches reveals that technologies have been implemented without the participation of the people for whom they have been designed. Given the poor performance of agriculture, a significant number of people have suffered from food shortage. Obviously, women and their children are the usual victims of such problems. There is ample evidence that the access of rural women to agricultural services is particularly poor, as documented in the Gender in Agriculture Sourcebook, women have unequal access to key agricultural inputs such as land, labor, knowledge, fertilizer, and improved seeds (WomenUN, 2015).

Failure to recognize the roles, differences and inequities between men and women poses a serious threat to the effectiveness of the agricultural development (Worldbank, 2009). Increasing women’s access to land, livestock, education, financial services, extension, technology and rural employment would boost their productivity and generate gains in agricultural output and food security (FAO, 2011). Therefore, the study was conducted with the objective of identifying factors affecting adoption decision of improved sorghum package by male and female headed households.

RESEARCH METHODOLOGY

Description of the study area

Somali Region is one of the largest regions in Ethiopia. The specific survey area, Jijiga Woreda, is one of the ten Woredas of Fafan zone and it is located at the Northeast part of Somali Region. Its altitude ranges from 1,600 to 1,700 m above sea level and it receives an annual rainfall varying from 500 to 600 mm (Figure 1). The area experiences bimodal type of rainfall that occurs from March to late May and from July to mid-October (JZOA, 2001). The mean minimum and maximum temperature ranges from 16 to 20°C. The total population of Jijiga Woreda is 276,816; of this, the rural population constitute 151,232 of which 69,310 is female and 81,922 is male; and there are two farming systems in the Woreda, viz, agro-pastoral and sedentary farming systems (CSA, 2008).

Type and data sources

For this study, both primary and secondary data sources were used. Primary data were collected from sample respondents (both male headed and female headed households in the selected PAs, DAs and key informants) through pre-tested structured interview schedule. Secondary data sources were the various documents (government policy documents) and reports (official and research reports) that are readily available and also those documents written based on the evidences from the study area.

Sampling technique

The study adapted purposive and multi-stage random sampling procedures with the rural households as the ultimate sampling unit for acquiring primary data. Jijiga Woreda was selected purposively as a representative of the agriculturally potential area in the region. Multi-stage sampling techniques were followed to select PAs and households for the study. In the first stage, four peasant associations (PAs) participating in extension activities and with more number of female-headed households were selected purposively. In the second stage, 180 farm household heads were selected with probability proportional to size from the selected PAs with ensuring at least 50% FHH in the sample.

Methods of data collection

For this study, pre-tested interview schedule consisting of different types of questions related to the topic of the research and relevant variables was used for collecting the essential data. Group discussion has been used to crosscheck the data collected through formal survey and also to generate additional contextual data. Prior to the final administration of the interview schedule, six enumerators who have knowledge about the area and those who are well acquainted with culture and language of the society were selected, trained and employed for the data collection. Based on the responses obtained from pre testing adequate non-sample respondents, essential amendments were made on
pertinent issues such as ordering and wording of questions and coverage of the interview schedule. As a result, some questions were deleted; those found important had been incorporated in the final version of the interview schedule. Then using the pre-tested structured interview schedule, primary data were collected.

Data analysis method

Adoption is a decision to make full use of an innovation at best appropriate course of action available (Rogers, 2010). For this study, in order to categorize farmers into adopters and non-adopters of the sorghum package, adoption index of individual farmer was calculated. The adoption index (AI) varies from 0 to 1 depending up on farmer’s degree of adoption of the package components. On the basis of adoption index, respondent farmers were classified into adopter and non-adopter. Farmer who was using seed plus two or more (50%) of the component was considered as adopter otherwise the farmer was considered non-adopter. Once the sampled households are categorized as adopter and non-adopter households following their calculated adoption index, adoption thus became the dummy dependent variable which is affected by different factors. Therefore, adoption in this study takes value of 1 if the sampled household is adopter and takes the value 0 if the sampled household is non-adopter.

AI = Number of practices used by the farmer/Total number of practices in the package

where AI is adoption index of ith farmer.

The households’ data were analyzed using econometric model, so as to draw meaningful inferences about the problem under investigation. The logit and probit modes guarantee that the estimated probabilities will lie between an interval of 0 - 1 (Gujarati and Porter, 1999). Because of this and other advantages, the logit and the probit models are the most frequently used models when the dependent variable happens to be dichotomous (Liao, 1994; Maddala, 1986).

For this study, logit model was used to identify the determinants of gender disparity in adoption of sorghum package. Hereunder, the functional formula of the logit model was specified following (Gujarati and Porter, 1999; Aldrich et al., 1984) the functional form of logit model was specified as follows:

\[ P_i = E(Y_i | X_i) = \frac{1}{1 + e^{-(\beta_0 + \sum_{j=1}^{n} \beta_j X_{ij})}} \]  

where \( P_i \) is a probability of adopting a given sorghum package for the ith farmer and ranges from 0 to 1; \( Z_i \) is a functional form of n explanatory variables (X) which is expressed as:

\[ Z_i = \beta_0 + \sum_{i=1}^{n} \beta_j X_{ij}, i = 1, 2, 3 \ldots \ldots n \]

where \( \beta_0 \) is the intercept and \( \beta_j \) are the slope parameters in the model. The slope tells how the log-odds in favor of sorghum package adoption change as independent variables change by a
unit. If $P_i$ is the probability of adopting a given sorghum package, then $1 - P_i$ indicates the probability of not adopting, which can be given as:

$$1 - P_i = \frac{1}{1 + e^{z_i}} \quad \text{(3)}$$

Dividing Equations 2 by 3 and simplifying gives:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{z_i}}{1} = e^{z_i} \quad \text{(4)}$$

Equation 4 indicates the odds ratio in favour of adopting improved sorghum package. It is the ratio of the probability that a farmer would adopt the package to the probability he/she would not adopt. Lastly, the logit model is obtained by taking the natural logarithm of Equation 4 as follows:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + \beta_1 X_i + \ldots + \beta_n X_n \quad \text{(5)}$$

where $P_i$ = the probability that $Y = 1$ (that the event occurs or probability of adoption); $1 - P_i$ = the probability that $Y = 0$ (that the adoption does not occur); $L_i$ = the natural log of the odds ratio or logit; $\beta_i$ = the slope, measures the change in $L$ (logit) for a unit change in explanatory variables ($X$); $\beta_0$ = the intercept. It is the value of the log odd ratio, $\frac{P_i}{1 + P_i}$, when $X$ or explanatory variable is zero.

Thus, if the stochastic disturbance term $(U_i)$ is taken into consideration the logit model becomes:

$$L_i = \beta_0 + \beta_1 X_i + U_i \quad \text{(6)}$$

**Operational variables**

**Dependent variables**

Sampled households’ adoption decision of improved sorghum package is the dependent variable in this study. This is a dummy variable taking value of 1 or 0 depending on the calculated value of the adoption index that a given sampled household gets. A sampled household who is using seed plus two or more (50%) of the component is considered as adopter and the dependent variable takes the value 1 and otherwise is considered as non-adopter and takes the value 0. Adoption index of individual farmer was calculated using the formula:

$$A_I = \frac{\text{Number of practices used by the farmer}}{\text{Total number of practices in the package}}$$

where $A_I$ is adoption index of ith farmer.

**Explanatory variables in the model**

Farmers’ decision to adopt or reject the sorghum package is expected to be influenced by different factors such as household characteristics, socioeconomic and physical environment in which farmers operate. The model assumes that the dependent variable of this study depends on the age and education level household head, size of farm land owned, the household’s active labour force, livestock holding, off-farm income, non-farm activity, wealth status, extension contact, access to credit, market distance, extent of domestic chores, Cosmo politeness, and attitude towards sorghum package. The codes, definitions, direction of influence, measurements and summary statistics of the hypothesized explanatory variables are presented in Table 1.

**RESULTS**

In order to identify the most important factors which determine household’s sorghum package adoption from the hypothesized potential variables, binary Logit model was estimated by employing SPSS Version 16.0.

As indicated in Tables 2 and 3, the value of the VIF for continuous variables and contingency coefficient for discrete/dummy variables revealed that there was no problem of multicollinearity or association between the continuous and categorical variables, respectively, and thus, all of the explanatory variables were included into logistic analysis. Regarding the fitness of Logit model, the chi-square of 67.99 and 58.014 appeared statistically significant for MHH and FHH, respectively, indicating that selected independent variables reduced the log likelihood ratio of the model. The classification table correctly predicted 83.3 and 95% of MHHs adopters and non-adopters, respectively and 73.1 and 93.8% of female headed household’s adopter and non-adopters, respectively. The model correctly predicted 91.1 and 87.8% of MHHs and female headed household’s observations.

Among the thirteen selected independent variables for the model, four for female headed households and two for MHHs were significant with respect to sorghum package adoption. These variables include market distance (DISMARK) and non-farm (NONFARM) for MHHs and family active labour (FACTLAB), extension contact (EXTCONT), Cosmo politeness (COSMO) and attitude toward sorghum package (ATTITUDE) for female headed households. The remaining explanatory variables were found to have non-significant influence on sorghum package adoption for both female headed households and MHHs.

**DISCUSSION**

Distance to market was found to be negatively and significantly related to the adoption of improved sorghum package for MHH (Table 4) indicating that farmers located nearer to market centres will have a higher probability of getting information and access to inputs and thereby adopting improved sorghum package. More specifically, The odds ratio for market distance indicate that keeping the influence of all other factors constant,
Table 1. Explanatory variables, hypothesized signs and their measurements.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Variable</th>
<th>Expected sign</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>-</td>
<td>Continues variable in years</td>
</tr>
<tr>
<td>2</td>
<td>Education level</td>
<td>+</td>
<td>Dummy: 1 for literate, 0 for illiterate</td>
</tr>
<tr>
<td>3</td>
<td>Family labor force</td>
<td>+</td>
<td>Continuous variable in number of active labor force in the household</td>
</tr>
<tr>
<td>4</td>
<td>Farm size</td>
<td>+</td>
<td>Measured in hectares</td>
</tr>
<tr>
<td>5</td>
<td>Non-farm income</td>
<td>+</td>
<td>Dummy: 1 for participating, 0 for not participating non-farm activity</td>
</tr>
<tr>
<td>6</td>
<td>Off-farm income</td>
<td>+</td>
<td>Dummy: 1 for participating, 0 for not participating off-farm activity</td>
</tr>
<tr>
<td>7</td>
<td>Size of livestock holding (TLU)</td>
<td>+</td>
<td>Continuous number of TLU in the HHs</td>
</tr>
<tr>
<td>8</td>
<td>Wealth status</td>
<td>+</td>
<td>Based on local wealth indicators farmers Labeled as 1:rich, 2:medium, 3:poor</td>
</tr>
<tr>
<td>9</td>
<td>Extension contact</td>
<td>+</td>
<td>Dummy variable in that if the farmer gets extension service it is coded as 1 and 0 otherwise</td>
</tr>
<tr>
<td>10</td>
<td>Access to credit</td>
<td>+</td>
<td>Dummy variable in that, if the farmer gets credit service coded as 1 and 0 otherwise.</td>
</tr>
<tr>
<td>11</td>
<td>Market distance</td>
<td>-</td>
<td>Measured in terms of kilometers</td>
</tr>
<tr>
<td>12</td>
<td>Extent of domestic chores</td>
<td>-</td>
<td>Continues by calculating mean score of household out of 14 domestic chore activities</td>
</tr>
<tr>
<td>13</td>
<td>Cosmopoliteness</td>
<td>-</td>
<td>Dummy variable in that the farmer has access to outside it is coded as 1 and 0 otherwise</td>
</tr>
<tr>
<td>14</td>
<td>Attitude towards sorghum package</td>
<td>+/-</td>
<td>Measured using a summated rating (likert) scale</td>
</tr>
</tbody>
</table>

Source: Own, Hypothesized Relationship of Dependent and Independent Variables.

Table 2. Variance inflation factor (VIF) for continuous explanatory variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>MHH R^2</th>
<th>MHH Tolerance</th>
<th>MHH VIF</th>
<th>FHH R^2</th>
<th>FHH Tolerance</th>
<th>FHH VIF</th>
<th>R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.213</td>
<td>0.787</td>
<td>1.271</td>
<td>0.794</td>
<td>1.260</td>
<td>0.920</td>
<td>0.206</td>
</tr>
<tr>
<td>Family active labor force</td>
<td>0.359</td>
<td>0.641</td>
<td>1.560</td>
<td>0.871</td>
<td>1.148</td>
<td>0.129</td>
<td></td>
</tr>
<tr>
<td>Farm size</td>
<td>0.035</td>
<td>0.965</td>
<td>1.037</td>
<td>0.841</td>
<td>1.188</td>
<td>0.159</td>
<td></td>
</tr>
<tr>
<td>Market distance</td>
<td>0.167</td>
<td>0.833</td>
<td>1.200</td>
<td>0.935</td>
<td>1.070</td>
<td>0.065</td>
<td></td>
</tr>
<tr>
<td>Attitude toward package</td>
<td>0.308</td>
<td>0.692</td>
<td>1.445</td>
<td>0.866</td>
<td>1.155</td>
<td>0.134</td>
<td></td>
</tr>
<tr>
<td>Domestic chores</td>
<td>0.161</td>
<td>0.839</td>
<td>1.192</td>
<td>0.921</td>
<td>1.109</td>
<td>0.079</td>
<td></td>
</tr>
<tr>
<td>TLU</td>
<td>0.096</td>
<td>0.904</td>
<td>1.106</td>
<td>0.927</td>
<td>1.079</td>
<td>0.073</td>
<td></td>
</tr>
</tbody>
</table>

being an adopter of sorghum package will decrease by a factor 0.873 as the distance increases by a single kilometre. The finding is in agreement with the findings of Kassa et al. (2013), who reported similar findings from their respective studies. However, it was found that there is negative but insignificant influence on adoption decision for female headed households, because as the prevailing gender division of labour, going to market is the daily routine activity of women, regardless of market distance.

In line with our expectation, non-farm income of households showed positive and significantly related to adoption for MHHs. This indicates having extra income from non-farm activity...
providing financial benefit to farmers in turn positively influence farmers to invest on sorghum package technology. According to this finding, as the non-farm income level of household heads increases by one unit the likelihood of adopting sorghum package increases by a factor of 0.121. However, FHH non-farm activities were shown non significant. This might be due to that, majority of women in the study area use to expend their income for their household immediate consumption needs rather than for improved package.

The result of the logit estimate in relation to extension contact showed that there is positive and statistically significant influence in the adoption decision of FHH. It was found that, FHH farmers who received visits by extension agents adopt technologies than others. More specifically, as one unit increase of contact to extension, the odds in favour of adopting improved sorghum package increases by a factor of 11.638. This agrees with the finding of Bekele (2015) and Egge et al. (2012) who found the speed of adoption is greatly influenced by the intensity of technical information received from extension agents. However, in the model result, male headed household (MHH) extension contact showed non-significance in relation to adoption because of most male farmers were unwilling and resistant to practice the extension message that they were receiving from Development Agents (DAs).

The other factor found positive and significantly related with adoption of sorghum package for FHH was household’s labour force. This indicates, large active labour force provides sufficient labour for farming operation and those farmers who have access to labour are more likely to adopt improved sorghum package than those who lack labour. The odds ratio indicates that keeping the influence of all other factors constant, being an adopter of sorghum package will increase by a factor of 1.922 as the family labour increases by a single unit. This result is convergent with the findings of Asmelash (2014). However, it is found that there is positive but insignificant influence on adoption decision for MHH. The probable reason for this is that, MHH farmers use their labour for the generating of non-farm income like that of labour for other farm to gain extra income for the household.

Attitude of farmers was hypothesized to influence adoption of sorghum package. The result of logit model shows that attitude towards sorghum package is positively and significantly related with adoption of the technology. The finding implies that those individuals who have favourable attitude towards sorghum technology usually create positive environment to accept new ideas and innovations.

Cosmopolite individuals adopt new practices earlier than other community members. On the basis of such assumption, the exposure of respondents to outside world was expected to positively affect the adoption of sorghum package. However, the logit model result shows that cosmopoliteness in the study area is negatively and significantly related with adoption for FHH. This might be that, the more they go outside the more they tend to focus community activity and pay less attention to their crop. However, this variable’s influence on the adoption decision of MHH is statistically non-significant. The possible reason for this is that, MHH in agro-pastoral spend more time on social and community affairs like conflict resolution and visit to relatives.

**CONCLUSION AND RECOMMENDATIONS**

Agricultural scientists and researchers have developed number of technologies that can increase the productivity

### Table 3. Contingency coefficient for dummy variable.

<table>
<thead>
<tr>
<th></th>
<th>Education level</th>
<th>Contact with extension agent</th>
<th>Cosmopoliteness</th>
<th>Wealth status</th>
<th>Off-farm income</th>
<th>Non-farm income</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MHH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension contact</td>
<td>0.258</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cosmopoliteness</td>
<td>0.250</td>
<td>0.147</td>
<td>0.189</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wealth status</td>
<td>0.710</td>
<td>0.451</td>
<td></td>
<td>0.349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-farm participation</td>
<td>0.270</td>
<td>0.349</td>
<td>0.020</td>
<td>0.349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-farm participation</td>
<td>0.150</td>
<td>0.131</td>
<td>0.1170</td>
<td>0.270</td>
<td>0.471</td>
<td>1</td>
</tr>
<tr>
<td><strong>FHH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension contact</td>
<td>0.020</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cosmopoliteness</td>
<td>0.217</td>
<td>0.050</td>
<td>0.022</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wealth status</td>
<td>0.045</td>
<td>0.388</td>
<td></td>
<td>0.127</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-farm participation</td>
<td>0.087</td>
<td>0.256</td>
<td>0.206</td>
<td>0.127</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-farm participation</td>
<td>0.190</td>
<td>0.165</td>
<td>0.110</td>
<td>0.007</td>
<td>0.373</td>
<td>1</td>
</tr>
</tbody>
</table>
of farmers, but farmers’ especially female farmers often did not use these technologies, because the technologies did not meet their needs. Moreover, needs and priorities of women farmers especially FHH have been rarely considered in the past in the research and development of agricultural technologies. Based on the main findings of the study, the following recommendations are forwarded:

Farmers’ deviation from recommended package practices was found partly due to poor extension service. Moreover, there are rigid cultural taboos that discourage women farmer’s involvement in extension service and limits women participation in extension events that are conducted. Therefore, policy makers and government officials need to assure farmers' accessibility to proper extension services equally for both men and female households. This can be achieved by revisiting extension service so as to improve farmers’ access to information and extension advice and establishing FTC centres which are not far from the household territory.

Distance from market centres is one of the factors influencing adoption of sorghum package. These variables were found to affect the adoption negatively. Farmers were found very far away from market centres not motivated to adopt the package. Therefore, it is important to take some risk minimizing measures. This can be done by organizing the farmers into marketing cooperatives and establishing connections with wholesalers in the towns.

Non-adoption of sorghum package was found to be influenced among other things by income position of male farmers such as availability of non-farm activity in the study area. Therefore, organizing farmers into cooperative unions like saving and credit and creating income generating activities may enhance their income and improve their level of adoption in improved sorghum package.

The result of the study indicates that, women farmer’s attitude toward sorghum package influences sorghum adoption positively and significantly. Therefore, increasing farmer’s awareness on improved sorghum package through awareness creation meeting, using religious and community elders as bridge for transferring and popularizing improved package and using field days for showing the advantage of new sorghum technologies is recommended.

Large active labor force provides sufficient labor for farming operation, the result of the study indicated that, women farmer’s involvement in extension service and ties with community elders positively and significantly. Therefore, increasing farmer’s awareness on improved sorghum package through awareness creation meeting, using religious and community elders as bridge for transferring and popularizing improved package and using field days for showing the advantage of new sorghum technologies is recommended.

Large active labor force provides sufficient labor for farming operation, the result of the study indicated that, active labor force of female-head households influences the adoption of improved sorghum package positively and significantly. Therefore, increasing farmer’s awareness on improved sorghum package through awareness creation meeting, using religious and community elders as bridge for transferring and popularizing improved package and using field days for showing the advantage of new sorghum technologies is recommended.

### Table 4. Logistic regression estimates household’s adoption of sorghum package.

<table>
<thead>
<tr>
<th>Variable</th>
<th>MHH (N=90)</th>
<th>FHH (N=90)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>S.E.</td>
<td>Odds ratio</td>
<td>B</td>
<td>S.E.</td>
</tr>
<tr>
<td>AGE</td>
<td>0.005</td>
<td>0.036</td>
<td>1.005</td>
<td>0.891</td>
<td>-0.039</td>
<td>0.042</td>
<td>0.961</td>
</tr>
<tr>
<td>EDUCA</td>
<td>2.436</td>
<td>1.658</td>
<td>11.431</td>
<td>0.142</td>
<td>1.226</td>
<td>1.068</td>
<td>3.408</td>
</tr>
<tr>
<td>FAMACTLAB</td>
<td>0.240</td>
<td>0.270</td>
<td>1.271</td>
<td>0.733</td>
<td>0.653</td>
<td>0.256</td>
<td>1.922</td>
</tr>
<tr>
<td>FAMACTLAB</td>
<td>0.116</td>
<td>0.121</td>
<td>1.123</td>
<td>0.337</td>
<td>0.164</td>
<td>0.110</td>
<td>1.178</td>
</tr>
<tr>
<td>MARKDIS</td>
<td>-0.136</td>
<td>0.040</td>
<td>0.873</td>
<td>0.001***</td>
<td>-0.084</td>
<td>0.093</td>
<td>0.919</td>
</tr>
<tr>
<td>EXTCONT</td>
<td>0.801</td>
<td>1.375</td>
<td>2.227</td>
<td>0.560</td>
<td>2.454</td>
<td>1.056</td>
<td>11.638</td>
</tr>
<tr>
<td>COSMOPOLITE</td>
<td>-1.492</td>
<td>1.044</td>
<td>0.225</td>
<td>0.153</td>
<td>-2.268</td>
<td>1.291</td>
<td>0.104</td>
</tr>
<tr>
<td>ATTSUM</td>
<td>0.234</td>
<td>0.151</td>
<td>1.264</td>
<td>0.121</td>
<td>0.125</td>
<td>0.075</td>
<td>1.134</td>
</tr>
<tr>
<td>OFFARM</td>
<td>-0.260</td>
<td>1.224</td>
<td>0.771</td>
<td>0.832</td>
<td>0.421</td>
<td>0.915</td>
<td>1.524</td>
</tr>
<tr>
<td>NONFARM</td>
<td>2.113</td>
<td>1.240</td>
<td>0.121</td>
<td>0.088*</td>
<td>0.514</td>
<td>0.992</td>
<td>1.672</td>
</tr>
<tr>
<td>DOMCHOR</td>
<td>-0.009</td>
<td>0.341</td>
<td>0.991</td>
<td>0.978</td>
<td>0.346</td>
<td>0.228</td>
<td>1.413</td>
</tr>
<tr>
<td>WEALTH_STAT</td>
<td>1.508</td>
<td>1.976</td>
<td>4.517</td>
<td>0.445</td>
<td>1.945</td>
<td>1.256</td>
<td>6.997</td>
</tr>
<tr>
<td>TLU</td>
<td>0.049</td>
<td>0.097</td>
<td>1.050</td>
<td>0.615</td>
<td>0.129</td>
<td>0.132</td>
<td>1.138</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.627</td>
<td>5.485</td>
<td>0.197</td>
<td>0.767</td>
<td>-7.900</td>
<td>4.353</td>
<td>0.000</td>
</tr>
</tbody>
</table>

-2 Log likelihood ratio  | 46.576 | 50.193 |
Pearson Chi-square ($\chi^2$) | 67.996 | 58.014 |
Correctly predicted | 91.1  | 87.8  |
Likelihood of adopter | 83.3  | 73.1  |
Likelihood of non-adopter | 95  | 93.8  |

Significant at *P<0.1; **P<0.05; ***P<0.001.
CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

ACKNOWLEDGEMENT

The author is indebted to Jigjiga University and Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) for the modest financial support.

REFERENCES


Factors influencing the adoption of improved cowpea varieties in the Sudan Savannas of Northern Nigeria

Joseph James Mbavai¹*, Muhammad Bello Shitu², Tahirou Abdoulaye³, Oyakhilimen Oyinbo⁴ and Amadu Y. Kamara⁵

¹Department of Teacher Education, Njala University, Sierra Leone
²Department of Adult Education and Community Services, Bayero University Kano (BUK), Nigeria
³International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
⁴Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria
⁵Department of Agricultural Economics, Obafemi Owolowo University Ile-Ife, Nigeria

Received 26 February, 2018; Accepted 26 March, 2018

The study was undertaken to determine the level and factors influencing adoption of improved cowpea varieties introduced by the Sudan Savanna Taskforce project in Musawa Local Government Area of Katsina State. Data were collected from a random sample of 300 households from ten communities in the study area. The analytical tools used for data analysis include descriptive statistics to examine the level of adoption of improved cowpea varieties and Probit and Tobit regression models to identify factors that influence the adoption and intensity of use of the varieties respectively. Results from the analyzed data indicate that more farmers were aware of improved cowpea varieties by a magnitude of 40% and adoption improved by a magnitude of 35.7% adoption. In addition, households with formal education, extension contact, those who participated in the project activities, members of associations and cowpea growing experience are more likely to adopt improved cowpea varieties. Similarly, factors influencing the intensity of adoption were gender of farmers, extension contact, membership of association, participation in project activities and rearing of livestock. Finally, the study recommends that farm expansion and intensification of extension services would be an incentive to adoption decisions by small-scale farmers in the study area and extended to the less educated farmers. Furthermore, there is a need for special training, seminars, field demonstrations and technical support for the cowpea farmers.

Key words: Adoption, factors, improved cowpea varieties, Sudan Savanna Taskforce.

INTRODUCTION

International agricultural research centers are one of the key institutions mandated for the generation and development of innovations for increasing agricultural productivity across the world. Technology development and transfer play a crucial role in attaining the main goal to increase agricultural output, productivity and the welfare of rural households.

Cowpea, (*Vigna unguiculata* L. Walp.), is an important leguminous crop in Musawa Local Government Area (LGA) and Katsina State at large (Ayanwale et al., 2009). As a legume, it is important for nutrient cycling because of its tolerance to drought and soil acidity as well as its...
ability to fix nitrogen from the air for use in the root. It is very well suited to where decline in soil fertility and drought are serious problems (Ibrahim et al., 2016). Cowpea seeds are a major source of plant proteins and vitamins, feed for animals, and a source of cash income (Ibrahim et al., 2016). It is a major staple food and cash crop in the state. The crop has a tremendous potential to contribute to the alleviation of malnutrition among resource-poor farmers and to enhance food security and the productivity and sustainability of the crop-livestock system (IITA, 2009). According to Ibrahim et al., (2016), the low income earners tend to consume more of cowpea food products to get the desired protein than from animal protein. Dugje et al. (2009) reported that in Nigeria, farmers who cut and store cowpea fodder for sale at the peak of dry seasons have been found to increase their annual income by 25%. Cowpea also plays an important role in providing soil nitrogen to cereal crops such as maize, millet, and sorghum, when grown in rotation, especially in areas where poor soil fertility is a problem (Tijjani et al., 2015).

Despite the potential for further yield increases, cowpea production faces numerous problems including insect pest attack, Striga gesneroides parasitism, disease, drought, low and erratic rainfall, and a long dry season (Singh et al., 2002). All of these factors, singly or combined, are responsible for the low grain yield, estimated at approximately 350 kg/ha rather than 1000 to 2000 kg/ha that farmers in Northern Nigeria, including Katsina State, obtain from their cowpea fields (Singh et al., 2002). According to Dugje et al. (2009), cowpea performs well in agroecological zones where the rainfall range is between 500 and 1200 mm/year. However, with the development of extra-early and early maturing cowpea varieties, the crop can thrive in the Sahel where the rainfall is less than 500 mm/year. It is tolerant to drought and well adapted to sandy and poor soils. However, best yields are obtained in well-drained sandy loam to clay loam soils with the pH between 6 and 7 (Dugje et al., 2009). In 2008, the Sudan Savanna Task Force (SSTF) project, funded by the Forum for Agricultural Research in Africa (FARA) and led by the International Institute for Tropical Agriculture (IITA) was set up to operate in four LGAs in Kano and Katsina States in Nigeria. The purpose was to disseminate improved agricultural technologies that include cowpea, soybean, maize and rice among others along their agronomic practices to enhance their increase yields. To achieve this, innovation platforms (IPs) comprising coalition of partners and stakeholders were setup by the Sudan Savanna Taskforce to improve agricultural productivity and farmers’ incomes. In Musawa LGA/Innovation Platform (IP), the collaborating partners include scientists from the Institute for Agricultural Research (IAR)-Samaru, the International Institute of Tropical Agriculture, NGOs, private sector actors, policymakers (especially at the local level) and the Katsina State Agricultural and Rural Development Authority (KTARDA) which provides extension services. This group constitutes the nucleus of the innovation platform. Among the technologies promoted by the project in the Musawa LGA of Katsina State are improved cowpea varieties (IT97K-499-35, IT98K-205-8, IT98K-573-1-1 and IT89KD-288 among others). These varieties are of great importance being that they are early maturing, resistance to Striga, insects and diseases, high yielding in both grains, fodders as well as have the potential to contribute to food security. During its implementation stage, the project used the participatory research and extension approach (PREA) (Ellis-Jones et al., 2005) which involved community mobilization to motivate farmers and create awareness about improved technologies, field demonstrations to show-case the performance of improved varieties, mid and end-of season evaluation to obtain feedback from farmers and farmer groups. The project also trained farmers on the use of the improved varieties (Sudan Savanna Taskforce Report, 2011).

Since the inception of the FARAFunded Sudan Savanna Task Force project between 2008 and 2015, it promoted a number of improved cowpea varieties and management practices among farming households, comprising male and female farmers in Katsina State. Until the time of the study however, there was no published information on the factors influencing the adoption of improved cowpea varieties in the study area. Hence, the necessity to evaluate the project with respect to adoption of improved cowpea varieties among farming households in the project area. This study therefore investigates the factors influencing the probability and intensity of adoption of improved cowpea varieties in Musawa LGA. The study was based on the following specific objectives:

(1) To determine the level of awareness and adoption of improved cowpea varieties in the study area.
(2) To estimate the determinants of adoption of improved cowpea varieties in the study area.

METHODOLOGY

Study area

Agriculture is the most important occupation in Katsina State, Nigeria. Musawa LGA is one of the two Innovation Platforms in Katsina State established by the Sudan Savanna Taskforce project; the other being Safana LGA. Musawa IP is also known as the Maize-Legume-Livestock Innovation Platform by the project and covers the entire Musawa LGA. It is located within the Sudan Savanna Agro Ecological Zone (AEZ). It is found in the southern part of Katsina State. The LGA enjoys tropical wet and dry climate with relatively wind and rapid change in temperature and humidity. The highest amount of rainfall in the area normally falls between June and September with mean annual rainfall ranging between 450 and 650 mm; and duration of not less than 3 months and not more than 5 months (that is, between May and September). The
mean temperature of the area ranges from 14°C as the lowest to 33°C as the highest. The farming household population for the 10 communities (study area) based on census conducted by the project was estimated at 21,800 (Sudan Savanna Taskforce, 2009). The vegetation of Musawa LGA is not different from the rest of other part of Katsina State. However, there is sporadic woodlands across the LGA. Major crops grown in Musawa are sorghum and cowpea (Ayanwale et al., 2009).

Sampling procedure and data collection method

Respondents for the study were selected from 10 communities in Musawa LGA where the Sudan Savanna Taskforce project promoted improved cowpea varieties. The communities were Bakam, Dankado, Farin Dutshe, Garu, Gingin, Kurkujan, Rugar Fari, Tarbboni, Tuge and Yarkanya. Simple random sampling technique was used for the selection of the sample. Using this technique, thirty (30) households were selected from each community to give 300 sampled farmers. Data were collected with a structured questionnaire designed to capture information on households. The questionnaire contained sections on farm and farmer characteristics, market, credit, extension, and awareness/adoption of crop technologies. The questionnaire was pre-tested and administered two months prior to the actual survey by trained enumerators under the direct supervision of the researchers.

Analytical techniques

Data collected were entered using Statistical Package for Social Sciences (SPSS) spreadsheet while descriptive and inferential statistics were used as analytical tools. Descriptive statistics used were frequency counts, percentages and charts, to determine the level of awareness and adoption of improved cowpea varieties as well as the socioeconomic characteristics of the farmers. Inferential statistics used were Probit and Tobit regression models to analyse the factors influencing adoption of improved cowpea varieties.

Probit regression model was used to determine the factors influencing the adoption of improved cowpea varieties in the study area. This model was employed because it accommodates two categories in the dependent variable. According to Bamire et al. (2002), the model has the ability to resolve the problem of heteroscedasticity and it satisfies the assumption of cumulative normal probability distribution. The specification of the Probit model follows:

\[ Y_1 = \alpha \beta_i X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \mu \]  

where \( Y_1 \) is the dependent variable, the probability of technologies dis-adoption (Dummy: 1, discontinued; 0, otherwise). \( \alpha_i \) = Gender of farmer (Dummy: Male=1, Female=0); \( X_2 \) = Age of farmer (years); \( X_3 \) = Educational level of farmer (Years); \( X_4 \) = Cowpea production experience (Years); \( X_5 \) = Extension contact (Dummy: Contact=1, No contact=0); \( X_6 \) = Membership of association (Dummy: Member=1, Non member=0); \( X_7 \) = Participation in project activities (Dummy: Participate =1, Not participate=0); \( X_8 \) = Livestock ownership (Dummy: Own livestock=1, Don’t own livestock=0); \( \alpha \) = constant term; \( \mu \) = disturbance term or error term; \( \beta_i \), …… \( \beta_8 \) are the regression coefficients of the independent variables.

Using the Tobit regression model, therefore it was based on the land area under cultivation of improved cowpea varieties out of the total land area for cowpea production as dependent variable against the independent variables in Equation 1. The functional form of the model following Shiyan et al. (2002) is given as:

\[ Y_i = X_\beta \text{ if } i^* = X_\beta + U_i > T \] 
\[ Y_i = 0 \text{ if } i^* = X_\beta + U_i > T \]  

where \( Y_i \) is the probability of adopting and intensity of use of improved cowpea varieties, \( i^* \) is a non-observable latent variable, \( T \) is a non-observed threshold level, \( X_i \) is the vector of independent explanatory variables determining the adoption decision of \( i \)th farmer, \( \beta \) are the regression coefficients of the independent. \( U_i \) is an independently normally distributed error term with zero mean and constant variance \( \sigma^2 \).

The equation is a simultaneous and stochastic decision model. If the non-observed latent variable \( i^* \) is greater than \( T \), the observed qualitative variables \( Y_i \) that indexes adoption becomes a continuous function of the explanatory variable and zero otherwise; the Tobit Model uses a maximum likelihood method to estimate the coefficient of the equation. The regression coefficients are asymptotically efficient, unbiased and normally distributed.

RESULTS AND DISCUSSION

Adoption of recommended technologies implies that technologies are relevant to the farmers’ circumstances. If farmers become aware of technologies or modifications in the use of resources that are relevant to their circumstances and can improve their farm production and thus their welfare, they will most likely adopt these changes (Bashir et al., 2018; World Bank, 2011).

The results revealed that 66% of the farmers were aware of improved cowpea varieties and 35.7% of the farmers were growing the improved cowpea varieties with male (30.7%) and female (5.0%) (Figure 1 and Table 1). In addition, 56.3% of the farmers belonged to associations with 50% being farmers association and 41.5% being members of community development associations as shown in Figure 2. Again, results presented in Table 2 revealed that high income (94.7%), high yielding (89.7%) and early maturing (72.3%) were among the major reasons given why farmers grow improved cowpea varieties.

Using the probit regression model in Table 3, five variables were found to significantly influence adoption of improved cowpea varieties. The variables include education of the farmers contact of farmers to extension agent, participation in project activities membership of association and experience in growing cowpea. Similarly, the Tobit regression model in Table 4 revealed that three variables, gender, membership of association and participation in project activities, were significant factors found influencing the extent of adoption of improved cowpea varieties. Extension contact aids farmers understanding on modern innovations, which ultimately help farmers to adopt modern technologies.

The result of this study is an update of the baseline study reported by Ayanwale et al. (2009) who found 26% awareness and 0% adoption of improved cowpea varieties prior to the inception of the Sudan Savanna Taskforce project in 2008. This result implies that the project made tremendous progress in creating awareness that led to the increased level in adoption of improved cowpea varieties. This is not surprising as cowpea is an important food and cash crop. It has many attributes that accounts for its adoption. The increase in awareness
Figure 1. Percentage distribution of respondents according to awareness of improved cowpea varieties and sources of awareness.

Table 1. Percentage distribution of respondents according to level of adoption of improved cowpea varieties.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Grow cowpea</th>
<th>Grow improved cowpea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>90.3 (271)</td>
<td>30.7 (92)</td>
</tr>
<tr>
<td>Female</td>
<td>9.0 (27)</td>
<td>5.0 (15)</td>
</tr>
<tr>
<td>Total</td>
<td>99.3 (298)</td>
<td>35.7 (107)</td>
</tr>
</tbody>
</table>

( )=Frequency.

Figure 2. Percentage distribution of respondents according to membership of association and type of association.
Table 2. Percentage distribution of respondents according to technology-related characteristics as reasons of adoption of improved cowpea varieties.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage of n=107</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it high yield</td>
<td>96</td>
<td>89.7</td>
</tr>
<tr>
<td>High income/profit from market sales</td>
<td>101</td>
<td>94.7</td>
</tr>
<tr>
<td>Resistance to drought</td>
<td>60</td>
<td>56.3</td>
</tr>
<tr>
<td>Early maturity</td>
<td>77</td>
<td>72.3</td>
</tr>
<tr>
<td>Household food security</td>
<td>66</td>
<td>61.7</td>
</tr>
<tr>
<td>Diversified food products from cowpea</td>
<td>70</td>
<td>65.3</td>
</tr>
</tbody>
</table>


Table 3. Probit model estimate of determinants of adoption of improved cowpea varieties in the study area.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-3.925</td>
<td>1.114</td>
<td>12.407</td>
<td>0.000</td>
</tr>
<tr>
<td>Gender of farmer</td>
<td>0.207</td>
<td>0.639</td>
<td>0.105</td>
<td>0.746</td>
</tr>
<tr>
<td>Education of farmer</td>
<td>0.743</td>
<td>0.419</td>
<td>3.141</td>
<td>0.076*</td>
</tr>
<tr>
<td>Extension contact</td>
<td>1.158</td>
<td>0.443</td>
<td>6.832</td>
<td>0.009**</td>
</tr>
<tr>
<td>Participation in project activities</td>
<td>2.974</td>
<td>0.416</td>
<td>51.154</td>
<td>0.000***</td>
</tr>
<tr>
<td>Membership of association</td>
<td>0.662</td>
<td>0.379</td>
<td>3.053</td>
<td>0.081*</td>
</tr>
<tr>
<td>Farming experience</td>
<td>0.012</td>
<td>0.016</td>
<td>0.624</td>
<td>0.430</td>
</tr>
<tr>
<td>Age of farmer</td>
<td>0.001</td>
<td>0.016</td>
<td>0.002</td>
<td>0.961</td>
</tr>
<tr>
<td>Experience in growing cowpea</td>
<td>2.995</td>
<td>0.421</td>
<td>50.683</td>
<td>0.000***</td>
</tr>
<tr>
<td>Household size</td>
<td>0.044</td>
<td>0.028</td>
<td>2.424</td>
<td>0.120</td>
</tr>
<tr>
<td>Keeping of livestock (Dummy)</td>
<td>-1.16</td>
<td>0.075</td>
<td>2.410</td>
<td>0.121</td>
</tr>
</tbody>
</table>

-2 Log likelihood: 216.5892802
Cox & Snell R Square (%): 43
Nagelkerke R Square (%): 59

*Significant at 10% probability level; **Significant at 1% probability level.

after three years maybe due to the efforts of the project to create awareness through field days, radio programs, field demonstrations and training of farmers. These findings are consistent with report from Simtowe et al. (2012). They found that improved pigeon pea adoption rates in Kenya could have risen up if the entire population was aware or exposed to the improved pigeon pea varieties. This study revealed that education significantly influenced the probability of adoption of improved cowpea varieties, indicating possible association between education and adoption of improved cowpea varieties. According to Okuthe et al. (2013), education enables one to access information needed to make a decision to use an innovation and practice a new technology. Education increases managerial competence and therefore enhances ability to diagnose, assess, comprehend, and respond to financial and production problems. High level of education enhances the understanding of instructions given and improves the farmers’ level of participation in agricultural activities. This suggests that educated people will tend to adopt and increase area of cowpea under cultivation. In addition, favourable level of formal education of the farmers would make it easier for extension agents to introduce improved cowpea technologies to them. According to Alene and Manyong (2007), farmer education has significant and positive effects on improved cowpea, as opposed to traditional cowpea production. According to them, four years of education raises cowpea production under improved technology by 25.6%, but it has no significant effect on traditional cowpea production. They further concluded that farmer education has a higher payoff for farmers cultivating improved varieties and applying a package of new inputs than for farmers using largely traditional technology. According to Sahin (2006), to create new knowledge, technology education and practice should provide not only a how-to experience but also a know-why experience. In fact, an individual may have all the necessary knowledge, but this does not mean that the individual will adopt the innovation because the individual’s attitudes also shape the adoption or rejection of the innovation. Again, the results revealed cowpea
growing experience as a significant factor influencing adoption of improved cowpea varieties. Here, farmers who have been growing cowpea overtime can easily find it easier to adopt any new variety introduced. Their experience coupled with the new production practices, could boost their uptake of the new varieties introduced.

Tobit regression result showed that gender had significant influence on the intensity of adoption of improved cowpea varieties at 10% level of significance. This means that the male farmers were more likely to adopt modern agricultural production technologies than their female counterparts. The reason for this is that men are the people who make production decisions in the study area and also control productive resources such as land, labour and capital which are critical for the adoption of new technologies. This report therefore agreed with Yanguba (2005), who reported that women are prohibited in Northern Nigeria to be directly involved in farming activities in some communities in Northern Nigeria because of religious and cultural limitations. Bashir et al. (2011) supported that extension contact is very important. They play crucial roles in adoption process as they are major players in creating awareness about the existence of the improved varieties and other improved agricultural practices. There is therefore need to strengthen extension institutions by national and international research institutions. Many studies have supported that extension contact is very important. Chikaire et al. (2011), reported that the goals of extension includes, transferring knowledge from researchers to farmers; advising farmers on their decision making; educating farmers to be able to make similar decision in future and enabling farmers to clarify their own goals and possibilities to enhance desirable agricultural development. This finding is in agreement with findings of Onu (2006) who reported that farmers who had access to extension adopted improved farming technologies had 72% productivity growth rate than those who had no access to extension services. The utilization of new technologies is often influenced by farmers’ contact with extension services, as they provide technical advice for increase in agricultural production. Adoption level increases with the intensity of extension services offered to farmers. The result again agreed with findings of Alene et al. (2010) who said that women have been largely excluded from the development process. With the interventions largely inappropriate to them, it is argued that women have been effectively excluded from the development process.

Table 4. Tobit model estimate of extent of adoption of improved cowpea varieties in the study area.

| Variable                               | B      | S.E     | t-value | P>|t| |
|----------------------------------------|--------|---------|---------|-----|
| Constant                               | -146.6628 | 36.11163 | -4.06  | 0.000 |
| Gender of farmer                       | 45.47679 | 17.74433 | 2.56   | 0.014** |
| Age of farmer                          | -0.3558906 | 0.564711 | -0.63  | 0.532 |
| Household size                         | 0.3890319 | 0.8425112 | 0.46   | 0.645 |
| Education of farmer                    | 11.78681 | 12.1899 | 0.97   | 0.332 |
| Experience in growing cowpea           | -0.1023775 | 0.6354491 | -0.16  | 0.871 |
| Extension contact                      | 24.04992 | 14.62997 | 1.64   | 0.102 |
| Membership of association              | 30.31062 | 12.33824 | 2.46   | 0.024** |
| Participation in project activities    | 91.97951 | 14.20083 | 6.48   | 0.000*** |
| Keeping of livestock (Dummy)           | 0.3954458 | 0.2480392 | 1.59   | 0.107 |
| Number of observations                 | 300     |         |        |     |
| LR chi² (10)                           | 145.76  |         |        |     |
| Prob > chi²                            | 0.0000  |         |        |     |
| Pseudo R²                              | 0.1008  |         |        |     |
| Log likelihood                         | -649.91329 |       |        |     |

***1% probability level of significance; **10% probability level of significance.
and Manyong (2007) who reported that regular contact with extension raises improved cowpea production by an average of 18.5 and 15% but the contact has no significant effect on cowpea production under traditional technology. This confirms the greater role of extension services in raising the yields of improved varieties through the provision of adequate and timely advice on improved technological packages. Unlike this study, Bashir et al. (2018) on adoption of cowpea production technologies among farmers in Taraba State, Nigeria, they found zero extension contact among the respondents. This might have been responsible for the low adoption rate of improved cowpea in Taraba State.

Membership of association had a significant influence on both probability and extent of adoption of improved cowpea. This implies that farmers were able to exchange ideas among themselves. As further revealed by the study, those who were members of associations adopted the technology more than those who were non members. This is in support of study reported by Odoemenem (2007) stating that membership of association enhances access to information on improved technologies, material inputs of the technologies (fertilizers and chemicals) and credit for the purchase of inputs and pay for farm labour. Since a large number (56.3%) of farmers belonged to one organization or the other, the possibility of sharing knowledge among them concerning improved or new farm practices and new agricultural products is inevitable. Baseline study in the project area reported by Ayanwale et al. (2009) revealed membership of the farmer organization was 20% all put together. Tura et al. (2010), reported that membership to cooperative were found to be important in Ethiopia. Studies by Bamire et al. (2010) reported that membership of association positively and significantly influenced adoption of improved technologies.

Another significant factor that had influence on both the probability and extent of adoption of improved cowpea varieties was farmers' participation in the Sudan Savanna Taskforce project’s activities. These activities include among others: on-farm trials, field demonstrations and training relating to cowpea production. Improved cowpea varieties are largely new technologies in the study area. Farmers attach greater risk to new varieties than their traditional or local varieties. Therefore, adoption of new technologies can be enhanced through farmers who have first-hand experience with the new technologies. To increase the rate of adoption among farmers, they have to be encouraged to participate in activities relating to new farm practices like; on-farm trials/demonstrations and training related to such technologies as in the case of improved cowpea introduced in the study area. In similar recent study by Adedipe (2012), she reported that farmers who participated in cowpea related activities benefitted from the activities by using the income they generated from the sales of cowpea to meet certain needs that are associated with improved standard of living such as food, clothing, shelter, education, healthcare and recreation. Unlike the non-participants, she reported that they were more of subsistent farmers. Farmer’s participation has been an important factor in project activities. Farmers’ involvement in the project activities in the study area was a bit low. There is need to increase their involvement.

The result of the study also revealed a positive relationship between livestock keeping and cowpea production and has significant influence on the extent of adoption of improved cowpea. Livestock rearing and cowpea production complements each other. Cowpea fodder is used to feed animals (IITA, 2009). This result therefore agreed with IITA (2009) and Bashir et al. (2018) who reported that the production of cowpea fodder is a significant source of income as well as feed for livestock.

CONCLUSION AND RECOMMENDATIONS

Awareness and adoption level of improved cowpea varieties was the basis for assessing the effectiveness of Sudan Savanna Taskforce project. Compared to the baseline report by Ayanwale et al. (2009), who reported that only 26% of the farmers were aware of improved cowpea varieties with zero percent adoption in Musawa LGA; this study revealed that awareness from that time has increased to 66.0% over a period of three years. Adoption level has grown from 0 to 35.7%. This implies a tremendous achievement in three years. The major source of information came from extension agents. This shows the importance of strengthening extension institutions in the state since they are very vital to training of farmers in the use of improved cowpea production technologies. However, the disparity between awareness level and adoption rate might have been due to some factors that include non-availability of seeds when needed, non-availability and high cost of fertilizer, pests and diseases. This implies that adoption of any technology is not automatic rather a process that needs time and space.

This study recommends that enterprise diversification and intensification of extension visit would be an incentive to adoption decisions by small-scale farmers in the study area and should be intended to the less educated farmers. Furthermore, there is a need for special training, seminars, field demonstrations and technical support for the cowpea farmers.

In conclusion, policy makers should support informal ways of extending new technologies to cowpea farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Adedipe OI (2012), Effect of improved cowpea varieties on farmers income in Sudan Savanna Taskforce’s maize – legume platform of


Full Length Research Paper

Current scenario and challenges of agricultural production to future food security in Bangladesh

Momotaz1, Tanjinul Haque Mollah2, Anannya Mazumder2 and Takaaki Nihei1

1Department of Regional Science, Graduate School of Letters, Hokkaido University, Hokkaido-060-0808, Japan.
2Geography and Environment, Jahangirnagar University, Dhaka-1342, Bangladesh.

Ensuring food security is a global challenge that can be mitigated by improving agricultural production. From the last few decades, many developed nations have introduced modern and sustainable agricultural system to abate this challenge. Now, developing countries also demand the blessings of sustainable agricultural system to face this globally burning issue. The purpose of this study is to examine the current agricultural system of main crops and challenges of food security of Bangladesh. Therefore, on the basis of present scenarios of agricultural productivity, some suggestions have been proposed to combat the food security challenges. Mainly agricultural related secondary data published by the government of Bangladesh were analysed to conduct this research. All over the country, farmers are facing challenges of storage facilities, lack of modern agricultural machineries, unfriendly market policy of agro-products, less empathy of governments and natural disaster. Last few year's potato productions has been increasing noticeably because of soil fertility, due to farmer's well-mannered adaptation strategies to climate change, high yield crop seed, using optimum fertilizer, farmer's dearness etc. On the other hand, Jute, the world second largest product also declining the production which contributes 4.66% to economic growth. However, Government's initiatives can ensure food security and sustainable agricultural system of Bangladesh. In this context, farmer friendly agricultural policies, introducing modern technologies, as well as inventing climate adaptive new crop species can be helpful to achieve food security. This research gears towards realization of present agricultural productivity scenarios and to take proper measures by the decision makers of Bangladesh.

Key words: Crop calendar, cropping pattern, hazards, irrigation.

INTRODUCTION

Bangladesh is the world’s eighth densely populated country which is fifty times higher than that of the US and six times higher than even that of China (Ministry of Land, 2016). Its total land area is 14,570 km² where 60% of the total land area is used as cultivated area (BBS, 2016)*. The population is still increasing by 1.37% every year (BBS, 2017), however, the cultivated land is decreasing simultaneously. The agricultural land is converted by the uncontrolled urbanization, industrialization as well as with the increasing of human activities (Ahmed, 2013). These land to human ratio decreasing phenomenon is the serious encounters of food security in Bangladesh (Roy

*Corresponding author. E-mail: momotaz_ju38@eis.hokudai.ac.jp.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License
et al., 2019). For food security, the country still depends on the import of food grains where crop production is higher than before, implying that demand is more than production. In 2008, Bangladesh imported 11.5% of total availability and it is also predicted that until 2021, the demand of staple food will also exceed supply which indicates that demand will also remain higher than production (Begum and D’Haese, 2010).

Agriculture of Bangladesh is constrained due to climate change induced hazards (drought, flood, salinity, riverbank erosion etc) and by a number of challenges such as in adequate management practise, population growth, unfair crop price, insufficient credit facilities, loss of arable land, lack of investment in agricultural research (Mondal, 2010; Ghose, 2014). In addition, Karim et al. (2017) indicated that availability of quality seed, market access facility, lack of storage facility and slow technology transfer also slow down the agricultural development process. In all, Shelley et al. (2016) added soil fertility, pest: insect, pathogens and weeds, extreme temperature stresses, and multiple stress with those as agricultural challenges. However, there were existing large regional disparities, lacking policy implication, and unequal resources allocation among farmers (Bagchi et al., 2019). Increasing labour cost and water scarcity are not the only factors threatening crop production, but weeds, lodging, blast, debases, poor kernel quality/low-quality seed and low yield rate are also responsible for it. Moreover, natural hazards like flood, drought, riverbank erosion, low price, etc are also accelerating the challenges more severe.

About 1.2 million people needs food security assistance; among this, 80% (884000 refugees are in Cox’s Bazar) of refugees and also about 30% of total population of the country are vulnerable to food insecurity (World Bank, 2017). About 23.2% population live below poverty line in the country (BBS, 2016; SDG, 2018). For food security, the country still depends on the import of food grains where crop production is higher than before, implying that demand is more than production. In 2008, Bangladesh imported 11.5% of total availability and it is also predicted that until 2021, the demand of staple food will also exceed supply which indicates that demand will also remain higher than production (Begum and D’Haese, 2010).

Many developing countries are facing challenges including population growth, low management mechanisms, agricultural resources scarcity, and environmental degradation, however the government has made great effort to solve those challenges (Zhao et al., 2007). In China, agricultural contribution percentage rose to 45% in 2000 from 20% during 1953-1957 because of confirmation of more than 40,000 interventions of agricultural science and technology from 1979 to 2003 (Niu, 2004). On the other hand, India, an agriculture base economic country, has been facing challenges because of dependency on rain for crop yield, declining environmental quality of land, low adaptation of modern technology, practicing too haphazard and unscientific farming (Singh and Parihar, 2015). Singh and Parihar (2015) suggested that human resources, capital, technical resources and optimum use of natural resources are required to achieve sustainable development. Furthermore, agricultural development of Afghanistan is facing challenges with limited access to technology, weak institutional support, organization and management of research, education and extension system (Saleem and Raouf, 2011). Afghanistan is now trying to solve those obstacles through agricultural education and training (Mason et al., 2008; Saleem and Raouf, 2011).

In this paper, firstly, the agricultural condition of Bangladesh and distribution of main crops have been analysed to understand the general concept of agricultural characteristics of the country. Secondly, it emphasized the variety of distributions of main crops across the country followed by the identification of the reasons behind the variability of the production area of the main crops of Bangladesh, and finally, discusses the current challenges towards agricultural crop production and recommendation of those challenges for future food security of the country. To fill out the aim, we took three objectives first, to find out the current crop production and trends of the country; secondly, to study the issues and challenges that impact on sustainable agricultural development; and thirdly, to recommend the pathways of those challenges to achieve sustainably developed agricultural sector for future prospect of the country.

**Study area**

Bangladesh is situated between 88° 01’’ - 91° 41’’ E and 20° 26’’ - 23° 38’’ N, a south-Asian country, surrounded by India (west, north and eastern side), Myanmar (South-eastern side), and Bay of Bengal (Sothern side). Although it is a small country, it has distinct physiographic diversity where 12% land belong to Pleistocene land, tertiary hilly area (8%) and plain land (flood plain and deltaic land) 80% (Figure 1). More than 700 river cuts across the country and drainage system, 79% dominated by three main rivers: Ganges-Brahmaputra-Meghna (GBM) and their tributaries river and overflowed in monsoon. Being a tropical monsoon climatic country, there is fairly marked seasonal variation with frequently high rainfall difference between seasonal temperatures in hot and humid summer (March to June), hot, humid, and heavy rainy monsoon (June to November), dry winter (December to February) with low temperature.

Bangladesh has a monsoon climate with a hot, rainy summer (suitable for Aman rice, Jute) and a dry winter season suitable for Boro rice, wheat, potato, maize (Table 1). In the country, rice is the dominant crop and
and contributes 70% of calories consumed (Majumder et al., 2016), so rice management intervention has been a focus of food security activities. For the causes of climate, suitable rainfall, temperature, and soil type, Bangladesh can grow plenty of rice all over the year. Rice has wide adaptation ability under different agro-ecological niches of the country. For its distinct characteristics, it can be cultivated from slope of the hill to a very deep flooded area where water depth rises around 3 m (Nasim et al., 2017). The study area is also a disaster-prone area that almost all over the year happens in the country meanwhile different regions are affected by different disasters (Table 3).

METHODS
This research was conducted based on secondary information collected from different organizations. Both spatial and non-spatial data were collected for visualizing the distribution pattern of crop production in Bangladesh. Therefore, challenges of food security were scrutinized through related literature. Finally, based on the distribution pattern and constraint of food securities, some pathways were proposed for attaining sustainable agricultural
Table 1. Cropping season.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Kharif-1 (16Mar-15 Jul) or Hot Summer/ pre-kharif (Chaitra- Ashar)</th>
<th>Kharif-2 (16 Jul-15 Oct) or Monsoon or rainy season (Sraben-Asshin)</th>
<th>Rabi (16 Oct to 15 Mar) or dry winter (Kartik-Falgun)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
<td>Mar Apr May Jun</td>
<td>Jul Aug Sep Oct</td>
<td>Nov Dec Jan Feb</td>
</tr>
<tr>
<td>Highest temperature (°C)</td>
<td>31.6 33.2 32.9 31.9</td>
<td>31.1 31.4 31.5 31.5</td>
<td>29.5 26.4 25.2 27.8</td>
</tr>
<tr>
<td>Lowest temperature (°C)</td>
<td>19.6 23.1 24.5 25.6</td>
<td>25.6 25.7 25.4 23.6</td>
<td>19.2 14.2 12.5 15.1</td>
</tr>
<tr>
<td>Average temperature (°C)</td>
<td>25.6 28.15 28.7 28.77</td>
<td>28.35 28.55 28.45 27.55</td>
<td>24.35 20.3 18.85 21.45</td>
</tr>
<tr>
<td>Average Rainfall (mm)</td>
<td>52.4 130.2 277.3 459.4</td>
<td>523.0 420.4 318.2 160.3</td>
<td>42.4 9.6 9.0 25.5</td>
</tr>
<tr>
<td>Relative Humidity (%)</td>
<td>71 75 79 85</td>
<td>86 86 85 83</td>
<td>79 77 76 72</td>
</tr>
<tr>
<td>Prominent crops</td>
<td>Aus, Jute, sorghum, soybean, kachu, oilseed-sesame</td>
<td>Summer vegetables-lady’s finger, amaranth, spinach, snake gourd,</td>
<td>Wheat, maize, Barley, Boro, Potato, Pulses, Winter vegetables, chili, onion, garlic, cumin, watermelon, groundnut, mustard etc.</td>
</tr>
</tbody>
</table>

Development (Figure 2).

Data collection

Data on the distribution area of three main types of rice-Aus, Aman and Boro rice were collected from the Bangladesh Bureau of Statistics (BBS) of 2016. The data of the distribution area of wheat, potato, and maize were collected from the Yearbook of Agricultural Statistics (2015) agricultural production data from FAO’s country profile (Table 2). The collected data were arranged in Excel format before preparing the map of the distribution area of the main crops of Bangladesh in the year 2016 using ArcGIS. It also shows the diversity of crops and crop dominated area by proportion of cultivated area. Finally, the maps show the crop distributed area all over the country of one cropping year.

RESULTS

Four major types of food crops (paddy, wheat, maize and potato) are cultivated all over Bangladesh. The crop calendar of Bangladesh reveals that due to seasonal variety, paddy is cultivated about three times (February to April, May to July and October to November) in year (Table 2). Among them, Aus rice is cultivated from the middle of March and early April to the last of July and early in August. Aman rice is cultivated from the middle of June to the end of November or sometimes early in December to early January. Boro rice is cultivated from mid-November to April or early May. With this, wheat is transplanted in November or early December and harvested in March or early April. Potato is sown in mid-September or early November and harvested in mid-January to early March (Table 2).

Table 4 and Figure 3 explored that the productivity of Boro rice is the highest among all crops which is about 18,938 Mt per year. It also shows that about 74.85% land grows paddy. Among all, Aman rice covers about 49.12%, Boro rice covers 41.94% and Aus rice covers 8.94% land of the country. Based on production, Boro rice is higher than Aman rice. On the other hand, Aus rice productivity is the lowest among all of these crops, that is, about 2,288 Mt per year because of farmers’ interest of high profit in Boro production and less yield rate of Aus rice.

Potato production per year is about 9,474 Mt and maize cultivation is 2,445,578 Mt per year. Crop trend (Figure 3) has also been shown here to realise the productivity change by year after independence to 2016 of the country. Among all food crops, only rice and maize productivity has been increasing but wheat productivity is decreasing; on the other hand, potato productivity is increasing rapidly. In the meantime, the cash crop, Jute has lost the global market after 19th century (Figures 3, 4 and 5).

Southern and southwestern districts are more suitable for Aus rice. Aus rice is mainly cultivated all over the country except some hilly regions and production rate is higher in Barisal region than the other part of the country (Figures 4 and 6a). Aman and Boro rice are cultivated almost in all districts but Aman rice grows well in floodplain region Barisal, Bhola, Dinajpur, Naogaon, Jessore, Sirajganj, Mymensingh, Rangpur Jamalpur districts (Figures 4 and 6b).

On the other hand, Boro rice grows well in the northern region, especially in the irrigated areas such as Dinajpur, Sirajganj, Tangail, Mymensingh, Sunamganj etc (Figures 4 and 6c). In Bangladesh, wheat is grown in the western region, Panchagar, Thakurgaon, Gaibandha, Rajshahi,
1. Understanding the crop production challenges

![Flow chart of methodology](image)

Table 2. Data source and category.

<table>
<thead>
<tr>
<th>Data type</th>
<th>Category</th>
<th>Source</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial data</td>
<td>Kharif-1 (March-July)</td>
<td>BBS, YAS</td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td>Kharif-2 (July-October)</td>
<td>BBS, YAS</td>
<td>2014, 2016</td>
</tr>
<tr>
<td></td>
<td>Robi (October-March)</td>
<td>BBS, YAS</td>
<td>2014, 2016</td>
</tr>
<tr>
<td>Spatial data</td>
<td>Administrative Boundary</td>
<td>Earth explorer</td>
<td>2016</td>
</tr>
</tbody>
</table>

BBS= Bangladesh Bureau of Statistics, YAS=Yearbook of Agricultural Statistics.

Chapai Nabanbgaon, Pabna, Tangail, Rajbari, and Meherpur etc area (Figures 5 and 7). Potato grows in north-western region of the country especially Rangpur, Gaibandha, Rajshahi, Sirajganj, Narayanganj, and Munshiganj district of Bangladesh (Figures 5 and 8). Recently, maize also played a role in mitigating wheat demand. It grows in Faridpur, Gopalganj, Rajbari, Kustia, Manikganj, rajshahi, Meherpur, and Dinajpur districts of the country (Figures 5 and 9).

**DISCUSSION**

This paper examined the major challenges of agricultural production. Although the government of Bangladesh has taken so many steps for the development of the agricultural sector, there are still many present and future challenges in the sector. Due to farmer’s financial problem, natural disaster, lack of promotion of new inventions, lack of proper seed and fertilizer distribution,
Table 3. Main crop calendar of Bangladesh.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aman</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data source: BBS (2016, analysed by authors).

Table 4. Cultivated area, production, and yield rate of main crops of Bangladesh in the year of 2016.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Cultivated area (*1000. acres)</th>
<th>Production *1000 Mt.</th>
<th>Yield rate per ha kg</th>
<th>Percentage of land coverage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aus rice</td>
<td>2516</td>
<td>2288</td>
<td>909</td>
<td>8.94</td>
</tr>
<tr>
<td>Aman rice</td>
<td>13814</td>
<td>13484</td>
<td>976</td>
<td>49.12</td>
</tr>
<tr>
<td>Boro rice</td>
<td>11794</td>
<td>18938</td>
<td>1606</td>
<td>41.94</td>
</tr>
<tr>
<td>Wheat</td>
<td>1099</td>
<td>1348</td>
<td>1226</td>
<td>2.92</td>
</tr>
<tr>
<td>Jute</td>
<td>1675</td>
<td>7559</td>
<td>4512</td>
<td>4.46</td>
</tr>
<tr>
<td>Potato</td>
<td>1175</td>
<td>9474</td>
<td>2160</td>
<td>3.13</td>
</tr>
<tr>
<td>Maize</td>
<td><strong>827387</strong></td>
<td><strong>2445578</strong></td>
<td></td>
<td>1.20</td>
</tr>
</tbody>
</table>

Data source: BBS, analyzed by authors, 2016.

With this, population increase, flooding, and excessive rainfall resulting to weather change make a dramatic impact on agricultural conditions. Flooding and excessive rainfall in 2008 - 2009 damaged Aman rice in Pabna whereas during 2009 - 2010 (April to May), flood and rush of water damaged 46.7% of Boro rice in Sylhet (BBS, 2011). Along with this, Manikganj and Sherpur, regions near Padma River faced severe soil and river bank erosion due to longer and high flood water level that influence change of cropping and homestead areas. From 2003 - 2012, annual rainfall increased by 809 mm in Sylhet, while the value decreased by 364 mm in Dhaka (BBS, 2011). This type of frequent drought, flood, and excessive rainfall occur as a result of changing rainfall patterns which indicates the influences of global climate change (Shapla et al., 2015).

Bangladesh has a monsoon climate with a hot, rainy summer (Aman rice) and a dry winter season (Boro rice). Aman season floods are a severe threat to the farmers in the southern coastal belt and in the northwest region (FAO, 2016). In the last fiscal year, rice was cultivated in 11.7 million hectares whereas production was
Figure 3. Trend of crop production.
Source: FAO (2018, analyzed by authors).

Figure 4. Rice productive area distribution.
Figure 5. Other food productive area distribution for the year 2016.

Figure 6. (a) Regional distribution of Aus, (b) Aman, and (c) Boro rice in Bangladesh in the year of 2016.
Figure 7. Regional distribution of wheat in Bangladesh in the year of 2016.
Figure 8. Distribution of potato all over the country.
Figure 9. Regional distribution of maize cultivated area in Bangladesh in the year of 2016.
34.7 million metric tons (Sindelar et al., 2016). According to Ministry of Food (MOF) in 2018, imported rice amount to 3.06 MMT. About 4% of the total cropped area is occupied by wheat and 11% of the area is cropped in Rabi season (November to February) and contribute 7% in total output of food cereals (Hossain et al., 2013). Driving of climate change to global warming has already produced a radical change in temperature routines in Bangladesh and will impact strongly on wheat production (Hossain et al., 2013). In Bangladesh, wheat is grown in the western region, Panchagar, Thakurgaon, Gaibandha, Rajshahi, Chapai Nababganj, Pabna, Tangail, Rajbari, and Meherpur areas etc (Figure 7). For 2017/2018, wheat planted area is lower at 350 million hectares and production is 1.1 MMT whereas 6.5 MMT wheat has being imported which is more than 80% of Bangladesh’s wheat consumption (Sindelar et al., 2016; MOF, 2018).

Wheat yields were reduced drastically to 0.73 million tons in 2005-2006 by increased temperature, even at higher levels of CO₂ (Karim et al., 2010; BBS, 2008). In 2016, wheat was cultivated in 498,000 ha area (DAE, 2018) which is higher than 2009 but in several southwestern districts, wheat blast was observed in areas as Meherpur, Chuadanga, Jhinaidah, Pabna, Kustia, Jessore, Bhola, Barishal etc. It is estimated that 15% were affected by the wheat blast in this year. In some areas, 100% were also burned (Islam et al., 2016).

Import of wheat is increasing 1.4 million tons every year because of decreasing production to meet increasing domestic demand (Karim et al., 2010). Moreover, consumption of wheat is increasing due to industrialization, rapid urbanization and the consequent increase in the use of numerous bakery products. Cultivated land dropped to its lowest in the last three decades because farmers are switching to rice to get more profit from its high prices. In the last season, wheat cultivated land decreased by 80% (The Daily Star News, February 09, 2018; DAE, 2018). To control blast infection, wheat cultivation was discouraged in southern districts. Rainfall also forces farmers to engage in Boro rice cultivation instead of wheat cultivation.

For the causes of increasing demand and invention of new hybrid species, potato cultivation has been increasing from the last few years. We could substantially reduce pressure on rice by consuming more potatoes that can help partially to meet up the shortage of rice. Every year, million tons of potato damages for lack of proper storage facilities. It needs proper storage for fresh consumption or processing, to prevent post-harvest losses, and to guarantee adequate seed supply for the next cropping season, though off-season planting and cold storage may resolve this problem. Potato can contribute greatly to the food and nutrition security of our country, given the due attention and care.

In the early nineteenth century, Bangladesh was the highest in jute production, now second in respect of fibre production among jute growing countries. Jute alone
contributes about 1.58% to GDP and Bangladesh grow the world’s best quality of jute because of the favourable soil and weather conditions (BBS, 2011). Bangladesh is the largest exporting country of raw jute accounting for 97% of the world’s total and 60% of the products (FAO, 2011). Due to a fall in jute demand worldwide at the end of nineteenth century, 29 jute mills were closed, 25,000 workers were unemployed, and 18 jute mills were privatized. Adamjee Jute Mills (largest jute mill) was closed on 30th June, 2002 based on the claim that it had incurred a loss of USD 35 million (BBC News, 2002). Jute production in Bangladesh is estimated lower despite extensive planting due to crop damage with excessively heavy rainfall; premature harvesting result to shorter fibers, attack of insect, attration towards Ready Made Garments industry of the labors, demand for food security, and farmers choice of paddy production, but the substantial fall of price and world demand was also responsible for the steady decline which had a severe impact on the livelihoods of poor jute growing farmers in the country (FAO, 2011).

Worldwide export and import of jute have declined steadily at rates of 3.5 and 2.5% over the 43 years (1961-2003) according to the FAOSTAT database analysis. Later, import of jute has increased worldwide at a rate of 2.5% p.a. from 2004 to 2013 without improvement of export of jute (Rahman, 2017). Local traders and industries of the country faced fund crisis for jute procurement in the last year which pulled down the prices in the local market as well as export price (FAO Stat, 2016). Among all challenges, two factors are most significant - one being unfavourable market price, because of price volatility, weak bargaining power, multiple intermediary levels, low quality, and government procurement policy whereas another is production inefficiency, because of limited technical knowledge, lack of irrigation facilities and low-quality seed.

Nevertheless, besides other sectors, jute sector in Bangladesh also has to recover these major pressures by determining the competitiveness of jute in the global market, examining the financial profitability at the farm level and identifying the diver of productivity and efficiency at the farm level. Figure 6 shows a diagram for agricultural development to fill out increased demand of food, to ensure nutrition for everyone, and to play an important role in the economy of the country.

Finally, while production of Aus ice is decreasing, Boro rice production is increasing, wheat and potato production is also increasing but potato production is much higher than others. Although jute production was downward before the last decade, if market management through implementation of Minimum Support Price (MSP) for the growers of jute fibre at the jute market season (September to December) can be improved, and the agricultural as well as product diversification technologies can be transferred properly, the jute sector will regain its glory and contribute to accelerating the economy of the country.

**CHALLENGES OF AGRICULTURAL DEVELOPMENT**

Bangladesh currently has some challenges or barriers in the agricultural sector in terms of development, e.g. climate change induced hazards like uneven rainfall pattern, long dry period, heat wave; increased soil and water salinity for sea level rise; natural hazards like flood, cyclone, hailstorm etc.; riverbank erosion; political instability etc.

**Organizational structure**

A meaningful and strong organizational structure is the prerequisite for sustainable agricultural development. The current agricultural policy and organizational structure cannot fully support the farmers. Bangladesh Rice Research Institute (BARI), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Agricultural Development Corporation (BADC) who is the main quality seed producer of the country, contributes only 25% seeds planted (Hossain, 2012). Department of Agricultural Extension (DAE) etc. and some NGOs (PROSHIKA, CARITAS, and UBINIG etc.) are involved in extent of sustainable agricultural practices but their activities are satisfactory.

**Water stress**

The retardation in crop growth caused by water stress at the seedling stage can be overcome, but at the reproductive stage, water stress can cause substantial reduction in rice yield (Shelley et al., 2016). Drought is one of the major abiotic constraints for rice and jute grown under rainfed conditions in Bangladesh. Aman rice usually suffers from water stress at the reproductive stage and reducing crop yield (Mahmood et al., 2004; Shelley et al., 2016).

**Salinity**

Soil and water salinity increase in the dry winter season and decrease in monsoon season in the coastal area. About 20% of the country cover coastal area, in which about 30% comprised the net cultivable area (Haque, 2006). The coastal area remains fallow during winter due to salinity. Aman is the main crop in the coastal area, and farmers mostly use traditional rice varieties, which can withstand salinity having a poor yield (Shelley et al., 2016).

**Climate changes**

Climate change affects agriculture most, such as irregular
pattern of temperature and rainfall. Sea level rise due to climate change is increasing soil and water salinity in the southern region and shrinking arable land (Rahman, 2017). Climate projections suggest that Bangladesh will experience significant increases in average temperature and extreme weather events (e.g., heat wave), which will threaten crop and livestock production (Mondal, 2010; IPCC, 2007). It also contributes to food insecurity and poverty of the country and represents a severe and urgent issue with the potential to reduce total agricultural crop production over the coming decades (Hoque, 2001).

**Natural hazards**

Every year, crops are damaged due to flood, cyclone, drought, and heat wave. Irregular and off-season heavy rainfall creates flash flood that damages Aus rice in summer, pre-monsoon and post monsoon period. Cyclone damages Jute and Aman rice with about 24% of rainfed lowland; while long dry summer damages wheat, and drought burns jute leaves (Mondal, 2010; IPCC, 2007).

From 2009 to 2014, 56% of households are affected one time, 27% of households are affected two times and the rest of them are affected three or more times by disaster (Islam, 2016). Out of 155,175 acres of land, 80.2% were croplands damaged due to disaster, 68.3% were land damaged due to river or coastal erosion, 14% of land were due to flood, 10.4% by salinity, 0.8% by drought, 3.5% by storm and 3.5% by water logging (Islam, 2016).

Not all the natural hazards happen every year all over the country; while in one year flood may not be so much destructive, next year it would be. With this, every hazard effect in some specific region of the country like flood happen in floodplain area, and waterlogging in low land area. Tidal surge happens in coastal area, land slide in hilly area etc. Among all damage of crops, 12% were damaged by flood, 5.3% by the hailstorm, 5% by drought, and 4.7% by waterlogging. From the fiscal year 2009 to 2015, if there was no damage and loss in that period, GDP could increase on average by 0.30% per year (Islam, 2016).

**Riverbank erosion**

Every year, agricultural land keeps decreasing due to riverbank erosion in the Ganges, Brahmaputra and Meghna floodplain. Thousands of people become landless and homeless. It also damages cattle and livestock production (Mondal, 2010).

**Soil fertility**

For the causes of hot and humid climate, the rate of organic matter depletion is high. Due to imbalanced use of chemical fertilizers, intensive agriculture, limited addition of crop residues, and limited practice of green-manure cropping, soil fertility is also declining in the country (Shelley et al., 2016). Soils of the area are deficient in some essential elements such as n, P, K, and S, which are limiting factors and N is the most limiting factor among which Mg, Zn, and B are also reported to be limiting in many areas (Jahiruddin and Satter, 2010).

**Government policy**

Political instability is one of the main barriers of agricultural development in the country. Farmers are facing an electricity crisis, fertilizer, and seed crisis, lack of irrigation facilities, unstable market price, lack of cold storage etc. where some people get the facilities and most of the farmers are deprived because of proper distribution and lack of honesty of local government officers. Farmer’s right by undertaking policy reforms and strong affirmative actions can prevent farmer’s rights and can remove these barriers to the improvement of the agricultural sector in rural areas of Bangladesh. Low investment in agricultural research (Karim, 1997; Bhattacharya et al., 2015).

**Multiple stress**

Urbanization, excessive use of chemical, dependency on nature, land fragmentation, same crop cultivation consecutively, unskilled farmer, lack of agricultural education, lack of qualitative seed (Mondal, 2005; Huda, 2004), lack of advance technologies, lack of adequate machineries, imbalanced market price, improper pest management, imbalanced use of fertilizers, uncontrolled population growth, declining of arable land and awareness are also equally responsible (Bhattacharya et al., 2015; IPCC, 2007).

**Conclusion**

Last but not least, the purpose of the current study was to determine the trend and challenges of crop production of Bangladesh and to give some recommendation to overcome those challenges. These findings suggested that plan should be made from community levels to international levels by bottom-up process. The following conclusions can be drawn from the present study- in community-level, government should take steps such as, making embankment, dam, river and canal drilling for removing excessive sediment, irrigation plant, sufficient supply of good quality seed, fertilizer etc.; make people aware of climate change and disaster preparedness; train the farmer about cultivation; to give financial support to farmers; to ensure stable and balanced market price everywhere; to give farmer storage facilities that they can
store their extra crops. At the national level, invent new technology, new crop species, ensure hundred percent food and nutrition to everyone, and finally, security and political commitment must be ensured to mitigate the problems.

The study has gone some way towards enhancing our understanding of challenges of increasing agricultural production and implications of those challenges and also the first study reporting an advantage in those who want to develop food security. Although the current study is based on a small data of production, the findings suggest that the most inevitable factors of food production need to be resolved for future food security of the country. The generalizability of the results is subject to certain limitations. First, lack of information of annual consumption, demand and production of all food crops. Second, the limitation of cross-sectional design. This research has thrown up many questions in need of further investigation and the challenges are investigated in future studies. The findings have a number of important implications for future practice.

**Recommendations**

1. Coordination with Government Organization (GOs), Non-Government Organization (NGOs), public sectors, strong network, research organizations, and private and multidiscipline organizations to extend sustainable agriculture. Construction of modern multipurpose cold storage and descent within a flexible distance from crop land. Investment should be increased in agricultural research to at least 2% of GDP as recommended by World Bank and FAO (FAO, 1996) and increased understanding institutional links between farmers and research.
2. Go and NGOs can excavate derelict ponds, canals etc. for conserving rain water for dry season. Re-excauation of canals, making dam, embankment alongside the river area that is severely flooded every year and causes massive crop damage. Uninterrupted power supply during peak irrigation time and reduction in irrigation cost or subsidy on diesel and fuel can also lessen irrigation water strain.
3. Invention of saline tolerant varieties. Tile drainage system can remove salinity, low-volumente irrigation, and different salts management techniques that can minimise salts effects on crops.
4. Climate change adaptable new species of crops like saline, drought tolerant species should be invented such as salt tolerant varieties BRRI Dhan-47, 67 (Boro), BRRI Dhan-40,41 (Aman) and drought tolerant high yield varieties- BRRI Dhan-42 (Aus). Scientists and researchers should be encouraged to develop advanced technologies and inventions for coping with climate change induced hazards, simultaneously imply and disseminate as same at community level.
5. Comprehensive disaster management involves identifying disaster prone region according to climate change modelling and vulnerability and then establishing community-based adaptation programme. To develop climate change resilient cropping system by increasing applied agricultural research to invent new high yield crop varieties which will be able to survive flooding salty water for log periods, as well as keep indigenous and other varieties suited to the needs of poor farmers. Construct embankment, cyclone centre, and rehabilitate and re-reconstruct the existing infrastructures along with, planning for drainage system and water management system.

1. Constructing dam and embankment, regular river drilling, monitoring river channel, constructing permanent residence in char land for those that have lost their land and home. Government and NGOs should emphasize on this and provide working opportunities.
2. “Healthy soil” is a key component in sustainability that is a very common thinking of sustainable agriculture practitioners. Encouraging farmers to choose high yield species, testing soil and following the recommended fertilizer, and use of balanced fertilizer integrating with chemical and organic manures. GOs and NGOs should motivate farmers to reduce dependency on chemical fertilizers to maintain soil fertility as well as sustainable agriculture practices. Farmers should incorporate crop residues with soil and grow short duration green manure crops to decrease depletion of organic matter (Figure 10).
3. Government should make land zoning based on current uses and potentialities, arrange sufficient credit facilities, and remove farmers- governmental communication gap, increase information access right and flexibility, train up farmers, and also protect and conserve indigenous genetic resources.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

**ACKNOWLEDGEMENTS**

The authors are thankful to the Bangladesh Bureau of Statistics (BBS) and Yearbook of Agricultural Statistics, Bangladesh Disaster-related Statistics, Department of Disaster Management, and Bangladesh Meteorological Department for their valuable data. Authors also appreciate Mustafizur Rahman, who always helped with arranging of data and making of maps. Finally, authors are grateful to Sharmin Shishir, the post-doctoral student of Faculty of Environmental Science of Hokkaido University for encouraging the writing of this paper.

**REFERENCES**


Hossain MA (2016). Emergence of wheat blast in Bangladesh was caused by a South American lineage of Magnaporthe oryzae. BMC Ecology 14(1):84.


Ministry of Food (MOF) (2018). Peoples Republic of Bangladesh. http://www.bangladesh.gov.bd/index.php?site=voir/job%0E%A6%96%E0%A6%AE%0E%A6%80D%0E%A6%AF%20%0E%A6%AE%0E%A6%80D%0E%A6%44%0E%A7%8D%0E%A6%80D%0E%A6%43%0E%A6%0E%A6%0E%B2%0E%A7%9F


Shelley IU, Takahashi NM, Kano NM, Haque MS, Inukai Y (2016). Rice


