



Ex-Ante Analysis of Adoption of Introduced Chicken Strains Among Smallholder Farmers in Selected Areas of Tanzania

Rogers Andrew, Jeremia Makindara, Said H. Mbaga, Roselyne Alphonse

► To cite this version:

Rogers Andrew, Jeremia Makindara, Said H. Mbaga, Roselyne Alphonse. Ex-Ante Analysis of Adoption of Introduced Chicken Strains Among Smallholder Farmers in Selected Areas of Tanzania. 15th International Conference on Social Implications of Computers in Developing Countries (ICT4D), May 2019, Dar es Salaam, Tanzania. pp.436-447, 10.1007/978-3-030-18400-1_36 . hal-02285245

HAL Id: hal-02285245

<https://inria.hal.science/hal-02285245>

Submitted on 12 Sep 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

***Ex -Ante* analysis of adoption of introduced chicken strains among smallholder farmers in selected areas of Tanzania**

Rogers Andrew^{1[0000-0003-2103-6806]}, Jeremia Makindara², Said H. Mbaga³ and Roselyne Alphonce⁴

¹ Department of Policy, Planning and Management, Sokoine University of Agriculture, Morogoro, Tanzania
randrew@sua.ac.tz

² Jeremia Makindara, Department of Business Management, Sokoine University of Agriculture, Morogoro, Tanzania
makj@sua.ac.tz

³ Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture, Morogoro, Tanzania
mbagash@sua.ac.tz

⁴ Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture, Morogoro, Tanzania
alphonce@sua.ac.tz

Abstract. Keeping local chickens is an integral part of Tanzania's rural economy although it suffers low genetic potential. To address the problem, the Africa Chicken Genetic Gains (ACGG) project introduced and tested improved strains of chicken viz. Sasso and Kuroiler in Tanzania. The paper aimed to predict the rate of adoption of Sasso and Kuroiler chicken strains by using the Adoption and Diffusion Outcome Prediction Tool (ADOPT). Developmental research design involving provision of 25 six weeks old chicks to farmers was adopted. Data were obtained from a questionnaire survey and Focus Group Discussion in three regions of Tanzania. The results indicate that the peak for adoption is likely to be 34, 29 and 38% after 8, 7 and 9 years in Bahi, Ifakara and Wanging'ombe sites respectively. The sensitivity report indicates that the adoption rate may increase to reach 59, 49 and 57% and may decline to about 17, 16 and 21% in Bahi, Ifakara and Wanging'ombe respectively. Extension efforts to facilitate availability of the strains, feeds, treatment and reducing upfront and operating costs are main factors affecting change in the adoption rate to optimize the inherent genetic potential. It is recommended to facilitate extension efforts for adoption rate improvement by upgrading local chicken value chain to enable farmers to access the strains, feeds, medication and market.

Keywords: Ex –ante, Prediction Adoption, ADOPT, Introduced Chicken strains, Tanzania

Introduction

Keeping local chickens is an integral part of Tanzania's rural economy whereby about 3782000 households keep chickens. According to [1], it is estimated that there are about 35.5 million local chickens and 24.5 million commercial chickens raised by individual households and small to medium commercial companies. The sector contributes about 1% of the national Gross Domestic Product (GDP). In 2013, the estimated monetary value of meat and eggs was TZS 874 billion and 364 billion respectively [2]. However, local chicken rearing suffers high mortality (over 50%) due to diseases, poor management, low input uses and inherent low genetic potential [1]. The low genetic potential of local chicken in Tanzania has multifaceted effects to increased contribution of the sector to the country's GDP and protein intake among rural dwellers. According to [3], the weight of chicken ranges between 1.6 and 2.0kg, while annual eggs produced per hen per year is 36 eggs on average.

In response to the low genetic potential of local chicken in Tanzania, the Africa Chicken Genetic Gains (ACGG) project introduced and tested tropically adapted and improved strains of chicken viz. Sasso and Kuroiler at village level in Tanzania. Kuroiler and Sasso are said to be fast growing and can produce about 150 eggs per year under moderate management [4, 5]. The concept of the on farm testing adopted by ACGG, is expected to provide empirical information for a better understanding of the diffusion, adoption, and impact of improved technologies to guide producer groups, researchers and policy makers in making prudent and informed decisions about allocating resources [6-8].

Adoption of new agricultural technologies leads not only, to increasing productivity and food security, but also enhances agricultural development while reducing poverty. However, adoption of the introduced chicken strains may not be straightforward since farmers are economic agents who can only decide to adopt a new technology only if they are exposed to it [9], expected benefit exceeds the benefit of available related technology, and the technology is affordable [10, 11]. Generally, farmers look at some or all of factors and choose to adopt a technology based on their utility and profit maximization behaviour [12]. The assumption is that farmers engage in adoption of new technology only if the benefits or perceived utility of using the new technology outweighs the benefits of the current or old technology.

Adoption Theories

Adoption is a process that involves series of stages one undergoes from first hearing about a product to finally accepting or using it. In addition, it includes the moment at which the decision maker acts to make the spread of the technology happen [13]. Diffusion and adoption theories and frameworks seek to describe the dynamic process of the implementation and adoption of innovations [14]. There are several diffusion and adoption theories and frameworks [15]. Nevertheless, [13] contends that, the Diffusion of Innovations theory by Rogers [16] and Bass Diffusion Model by Bass [17] are classical theories popularly that describe how, why, and at what rate new ideas and technology are spread. Roger's model is applicable after adoption is complete while Bass' model estimates the probability that adoption will occur in re-

sponse to exposure to the innovation (external influence) and the social interaction effect (internal influence), which is then applied to the total adoption by some point in time [18]. In case of this study, a combination of these models was used to explain the likelihoods of farmers to adopt the introduced strains since the strains were already on farm and farmers have had an opportunity to make comparison on their merits and demerits relative to available local chicken strains.

Factors affecting adoption of new technologies

[11] assert that farmers' decisions about whether and how to adopt new technology are conditioned by dynamic interaction between characteristics of the technology itself and the array of conditions and circumstances. Generally, the literature on adoption of new technologies generalizes that complexity of economic, social, environmental and psychological boundaries of farmers [13, 19-23] highly affect the decision of adopting the innovations. Moreover, [16], a renowned father of adoption theories, classifies factors into major five attributes of an innovation causing variance in the rate of adoption of a technology. These are: relative advantage, compatibility, complexity, trialability and observability. This paper uses the tool that is built based on the scholarly accumulated 22 variables affecting adoption of agricultural technology to predict the adoption rate and time to peak.

Empirical Review

There is extensive literature on technology adoption in developing countries across a variety of topics [24]. In Tanzania, several studies on adoption of agricultural technologies have been conducted [25-28]. All these studies used ex-post analyses mainly using Tobit or Probit regressions. These analyses have been useful for increasing our understanding on why some individuals adopted and others did not technologies. These studies nevertheless used either probit or logit regression models both of which, according to [10], fall short of proper methodological approaches to the exploration of the drivers of technology adoption in agriculture as they overlook non-exposure and selection biases. Further, the ex-post regression studies have contributed little to the problem of designing innovation adoption and scaling up pathways. The paper uses ex-ante approach to evaluate likelihood of innovation uptake at large scale to guide producers, research institutions and policy makers in making prudent and informed decision with regard to the introduced strains.

Methodology

Description of study areas

The present study used data collected at three sites in three regions in Tanzania. The Regions are Dodoma, Morogoro and Njombe, specifically in Bahi, Ifakara and Wanging'ombe Districts respectively. Dodoma is a semi-arid region, located at 6°48'S 39°17'E and an altitude of 1 125M above sea level. Annual rainfall is about 500 to 700mm and annual average temperature of about 22.6°C. Between the driest and wettest months, the difference in precipitation is 129 mm and the average temperatures vary by 5.1°C [29]. The area is mainly characterized by drought tolerant crops like sorghum, groundnuts, finger millet and sunflower. ACGG project sites in Bahi district were in four villages namely; Mayamaya, Bahisokoni, Mudemu and Mpa-matwa.

Morogoro Region is located between latitude 5°58' 10°0'S 35°30'E and an altitude of about 525M above sea level. The annual rainfall ranges from 600 to 1200mm with an average annual temperature of about 25°C. Morogoro Region is characterized with an average annual rainfall is 1160 mm with average temperature of 16°C. There are typically two distinct long and short rainy seasons of March–May and November–January/February, respectively, but the rain sometimes falls uninterrupted from October to March [29]. The production system in Ifakara district is dominated by rice and maize production, horticultural produces and bananas. The on farm test sites were located in four villages namely; Kibaoni, Kikwalila, Lipangalala and Lumemo.

Njombe Region is located between 8°51'0"S, 34°50'0"E and an altitude of about 2 000M above sea level. Its climate is classified as warm and temperate. In winter, there is much less rainfall than in summer. The average annual rainfall is 1160 mm with an average temperature of 18.6°C [29]. On farm testing sites were located in four villages namely; Ujindile, Uhambule, Msimbazi and Ufwala. Farming system of the sites is dominated by tea, maize, sunflower, pulses and horticultural production.

Research design

The study adopted developmental research design whereby farmers were selected and provided with introduced chicken based on their farming practices, typically low input production system. Developmental research design assumes a traditional model of skill in which the unit of analysis is taken to be the individual. It is maintained that as if expertise "resides under the individual's skin" in the form of explicit or tacit knowledge, skills and cognitive properties [30, 31]. In this context, the design included process and context of chicken keeping. Process refers to the technical requirement of chicken keeping while context stressed on the socio-economic characteristics and biophysical conditions that might affect growth and productivity. [32] argues that developmental approach can assist in determining the most effective agents of influence. Households recruited to receive the chickens were selected based on the following criteria:

1. Experience of chicken keeping for at least two years;
2. Keeping at least 15 adult chickens, but no more than 50;
3. Willingness to accept 25 birds of randomly selected strains;
4. Commitment to provide night shelter, and a minimum supplemental feeding;
5. Willingness to participate in the project for a minimum of 72 weeks.

Implementation of the design involved provision of 25 six weeks pre-brooded chicks to selected farmers. The chicks were vaccinated against Mareks and Newcastle diseases at the hatchery, followed by Infectious Bronchitis (IB) at 0, 7, 10, 16 and 21 days. Newcastle vaccine was repeated at 10 and 21 days using Lasota vaccine. At 6th week, the chicks were again vaccinated for fowl pox before being distributed to farmers. Farmers continued keeping these strains based on their practices with additional supplementation and were encouraged to keep records for evaluation purposes.

Data collection

Data were collected through household survey involving face-to-face and focus group discussion (FGD). 202 out of 264 targeted beneficiary households in the twelve villages participated in data collection. The households, which were involved, represent about 76.5% of the total intervened household in the study zones. Out of total farmers, 111 farmers were Sasso chicken keepers while, 91 farmers were Kuroiler chicken keepers. The data collected were streamlined to 22 variables (Fig. 1) that are fundamental to adoption prediction. These include: profit orientation, risk orientation, enterprise scale, interested nonparticipant farmers,, production constraints, practice complexity, observability, advisory support, the relative upfront cost of the practice, time for profit and benefit to be realized in the future and ease and convenience of managing the introduced strains.

The Estimation Procedure

Adoption and Diffusion Outcome Prediction Tool (ADOPT) (Figure 1) was applied to predict the likely peak level and proportional of the household that might adopt the introduced chicken strains and the probable time taken to reach that peak under prevailing environment. ADOPT is an MS Excel-based tool that evaluates and predicts the likely level of adoption and diffusion of specific agricultural innovations with a particular target population in mind [13, 33, 35]. As indicated (Fig. 1), ADOPT uses 22 parameters covering four areas that influence the rate and peak level of adoption: i) population specific influence, ii) relative advantage of the population, iii) actual advantage of using the technology/relative advantage of the practice and iv) learning of the actual advantage of the technology. According to [33], the tool operationalizes a framework that is based on well-established adoption theory and literature [16]. Given that, technology uptake is a complex and nonlinear process, influenced by multiple factors; it requires theories/ tool useful to provide a full picture of the adoption process [34]. ADOPT provides a comprehensive framework which takes into account the interaction of various factors that influence decision-making among the farmers with regard to innovation uptake [13, 33, 35,36]. The output of the tool is a

value in years of time to peak adoption and a percentage value for peak adoption level.

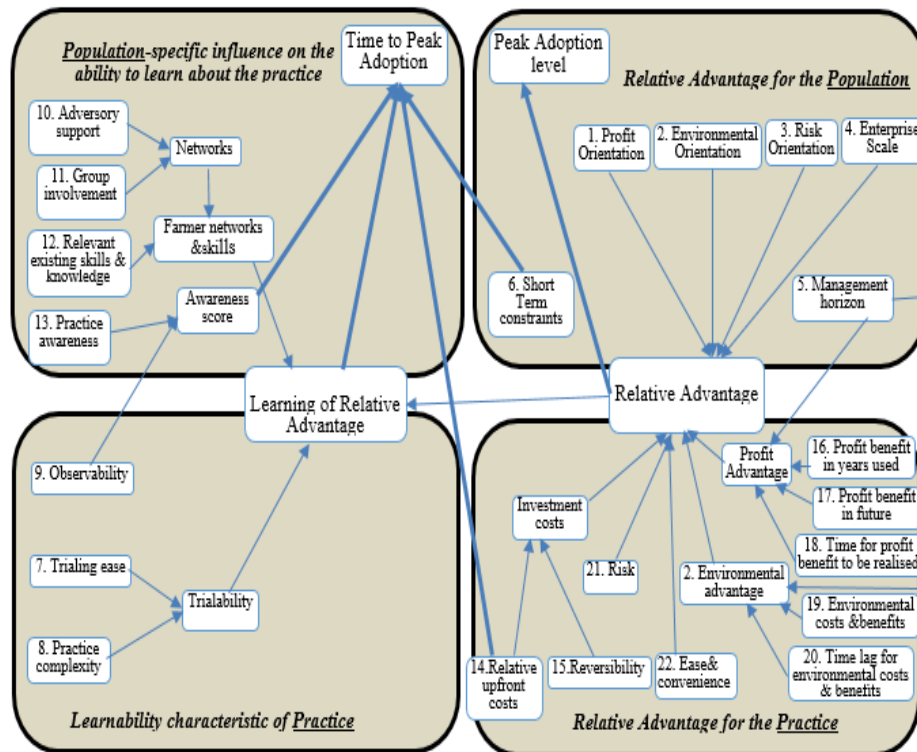


Fig. 1. Adoption and Diffusion Outcome Prediction Tool (ADOPT) Framework

Results and Discussions

Prediction of adoption of introduced chicken strains

The general assessment of the introduced chicken strains indicates that farmers in selected sites consider the introduced strains useful and beneficial to them. The results indicate that the peak for adoption of the introduced chicken strains in Wang'ing'ombe, Bahi and Ifakara sites will be 38, 34 and 29% after 9, 8 and 7 years respectively (Fig. 2). The predicted adoption peak level in Wang'ing'ombe is the highest because of market access for both inputs and poultry products. The district is located nearby Makambako Town center, which is so potential for business activities. In Ifakara, it is noted that the predicted level of adoption is low in comparison with other sites. Contrary to expectation, Ifakara has the highest scavenging areas around home-steads and good environment that support production of crops to support chicken feeding. Bahi District is rather dry with limited food production, culminating in less

feed available for chickens. The lower level of predicted adoptions is largely contributed by fact that either farmers in the area have many other options of income generating activities, or probably the strains are still new and it may take time to evaluate and make commitments to invest. Moreover, the predicted adoption rates and the expected peaks presents an impressive result given that in Sub Saharan Africa (SSA) new agricultural technology uptake has been reported to be rather low especially if the technology requires the use of a combination of inputs [37]. For example, uptake of tissue banana in Kenya was only about 10% after 12 years [8]. The findings are also consistent with other ex post adoption studies of agricultural technologies in Africa. For example, in Tanzania, [27] reported that in Arusha region, 23.7% of farmers adopted minimum tillage practices (such as zero tillage, ripping and minimum tillage) while in the Dodoma region, 29.1% adopted pit as planting technique. On the contrary, [38] observed that if all farmers had been exposed to improved varieties, potential adoption rate of improved pigeon pea in Northern Tanzania would be 62%. These findings imply that there is potential for adoption of introduced chicken strains once all farmers become aware of at least one strain.

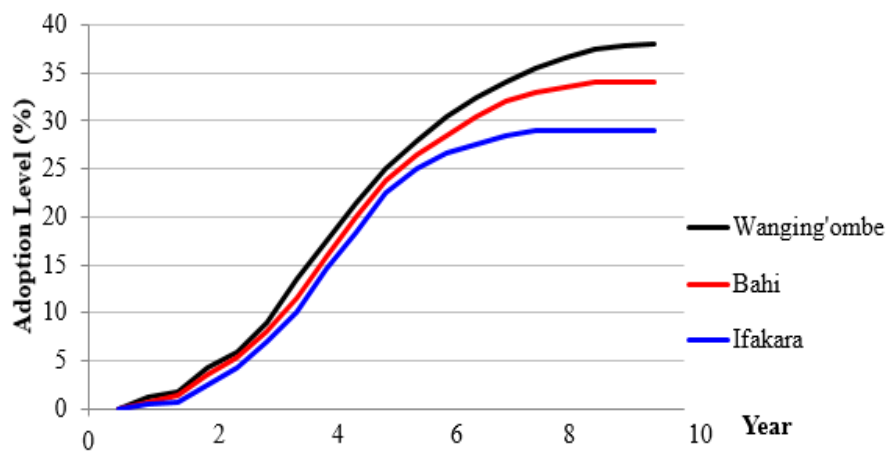


Fig. 1. Predicted adoption level of introduced chicken strains

Sensitivity analysis and factors affecting changes in adoption rate

Sensitivity analysis (Fig. 3) indicates that the adoption peak level may change because of changes in prediction parameters. There is likelihood of adoption peak to reach about 59, 49 and 57% in Bahi, Ifakara and Wanging'ombe respectively. However, the step down procedure indicates that the peak level may also decline to about 17, 16 and 21% in Bahi, Ifakara and Wanging'ombe respectively.

Factors affecting the adoption include the scale of chicken keeping, relative upfront costs, profit accrued in the year of introduction, projected profit/benefit, risks and ease and convenience of keeping introduced strains (Fig. 4). An increase in the scale of operation may contribute to change in the adoption rate by 17% up and by 14% down. These results are consistent with the literature on the correlation between farm size and adoption of the innovation [39, 40].

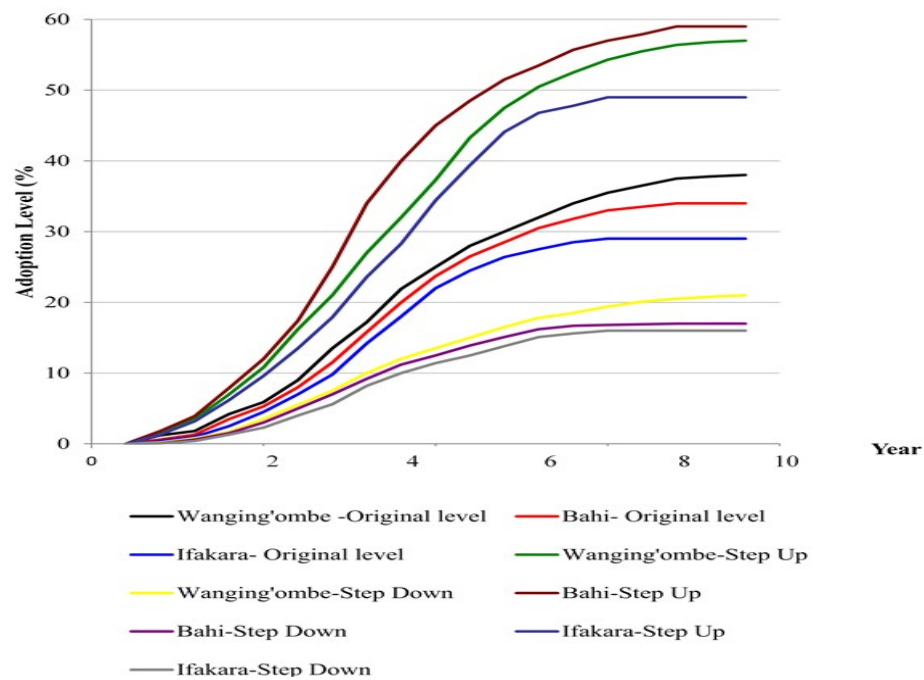


Fig. 1. Sensitivity Curve for changes in adoption level of the introduced chicken strains

Likewise, a low upfront cost is critical to improved innovation uptake among smallholder chicken keepers. Farmers observe that reduced upfront costs would contribute to increase adoption of the introduced strains by 18.5% (Fig. 4). The findings are consistent with rich literature that explains negative relationship between the upfront costs of adoption of the innovation [41-43].

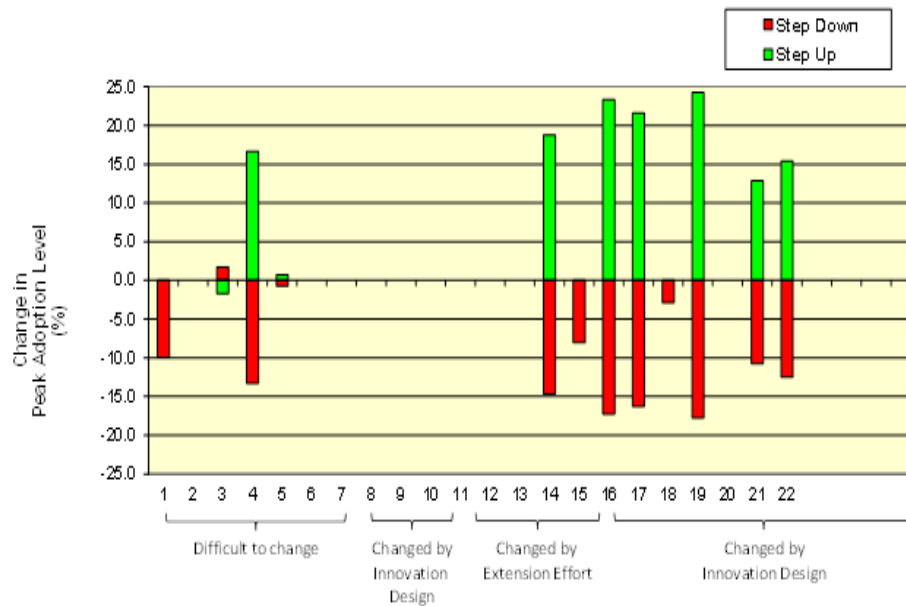


Fig. 1. Factors affecting change in the peak level of adoption rate in Bahi sites

Farmers considered profit and future benefit in general to be critical in supporting increased adoption. Raised awareness that the introduced strains are beneficial may contribute to the increase in adoption as depicted in Fig.3. However, farmers revealed that if profit and future benefit relative to available local chickens is not realized, it may contribute to decrease in the adoption rate by 16%. According to [44], exposure to information about the profit of the new technologies as such significantly affects farmers' choices about it.

Furthermore, sensitivity analysis indicates that risks (mortality, higher consumption and failure to brood) associated with keeping introduced strains play greater role in affecting farmers' decisions in adopting the technology. Taking into account on the risk associated with keeping introduced strains, adoption will be reduced by 11% (Fig. 3). However, if the observed risks are reduced, adoption rate may be increased by 13%. The effect of risk revealed by this study is in line with the result by [45] who observed that the risk-averse farmers may not adopt modern technology if it raises production risk by increasing yield variability too much. In contrast, if the new technology has the potential to attenuate variability in economic outcomes, then it would be more rapidly adopted among risk-averse farmers.

Lastly, the results indicate that ease and convenience are other potentially important contributing factors to the adoption decision among farmers. Other things being equal, ease and convenience of managing introduced chicken strains were found to contribute to increase in the adoption rate by 15. Difficulties in keeping these strains especially the requirement for additional inputs was found to affect the increase in adoption of introduced strains by 13%.

Conclusions and Recommendations

Using the ADOPT tool to quantitatively predict the adoption, it is concluded that there is high possibility of adoption and diffusion of the introduced chicken strains, albeit at a different pace between selected districts where the on farm test was conducted. The difference in reaching the peak adoption is associated with the extent to which the farmers were motivated and the presence of alternative income portfolios. The sensitivity analysis pinpoints scale of chicken keeping, relative upfront costs, and profit accrued in the year of introduction, projected profit/benefit, risks and ease and convenience of keeping introduced strains as the main determinant of peak adoption. It is recommended that to enhance adoption and diffusion rates more efforts should be directed at ensuring readily availability of the introduced test strains and promotion of innovative ways of reducing of upfront costs.

Acknowledgements: The authors acknowledge Bill and Melinda Gates Foundation (BMGF) for financial support to the Africa Chicken Genetic Gains (ACGG) Project and Sokoine University of Agriculture (SUA) for their support in accomplishing this study. Secondly, sincerest thanks are extended to the Commonwealth Scientific and Industrial Research Organization (CSIRO) for granting authors the Adoption and Diffusion Outcome Prediction Tool (ADOPT) for analysis. Lastly, particular gratitude goes to the smallholder chicken keepers who agreed to participate in the on farm test of the introduced chicken strains and provided data for this study.

References

1. URT.: Tanzania Climate Smart Agriculture Programme: 2015-2025. <http://www.kilimo.go.tz> (2015) (accessed 19 October 2016)
2. Komwihangilo, D.M.: The Role of Chicken in the Tanzanian Economy and Opportunities for Development: An Overview: First National Innovation Platform July 13th- 15th 2015 Blue Pearl Hotel, Dar es Salaam, Tanzania
3. United Republic of Tanzania (URT): National Sample Census of Agriculture Small Holder Agriculture. Volume III: Livestock Sector National Report (2012). <http://www.kilimo.go.tz> (accessed 09 May 2016)
4. WSPA.: Enhancing rural livelihoods and nutrition through higher welfare poultry production in India. Case study(2011). <http://www.Wspa-international.org> (accessed 19 October 2016)
5. Rodelio, B. C., Silvino, Q. T.: Sustainable Organic Farming in the Philippines: History and Success Stories (2013). <http://www.wafaci.org> (accessed 12 August 2016).
6. Peshin, R.: Farmers' adoptability of integrated pest management of cotton revealed by a new methodology. *Journal of Agronomy for Sustainable Development* 33 (3): 563-572(2013). doi:10.1007/s13593-012-0127-4
7. Milkias, D., Abdulahi, A.: Determinants of Agricultural Technology Adoption: The Case of Improved Highland Maize Varieties in Toke Kutaye District, Oromia Regional State, Ethiopia. *Journal of Investment and Management*. 7(4), 125-132 (2018). doi: 10.11648/jjim.2018.0704.13
8. Langat, B. K., Ngéno, V. K., Nyangweso, P. M., Mutwol, M. J., Kipsat, M. J., Gohole, L., Yaninek, S.: Drivers of Technology Adoption in a Subsistence Economy: The Case of Tissue Culture Bananas in Western Kenya. An Article Presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013: Hammamet,

- Tunisia (2013). <http://ageconsearch.umn.edu/bitstream/161444/2> (accessed 11 November 2017)
9. Foster, A. D., Rosenzweig, M. R.: Microeconomics of technology Adoption. Economic Growth Centre Discussion Article No. 984. Yale University: New York (2010). doi. org/ 10. 1146/annurev.economics.102308.124433
 10. Pindiriri, C.: Breaking the Tradition Trap: Assessing Drivers of Modern Technology Adoption by Smallholder Farmers in Hurungwe District, Zimbabwe. African Economic Conference held in Abuja, Nigeria. 5-7 December 2016. <https://www.afdb.org/uploads/tx> (accessed 12 January 2018)
 11. Loevinsohn, M., Sumberg, J., Diagne, A.: Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? Protocol. London: EPPI Centre, Social Science Research Unit, Institute of Education, University of London (2012). <https://eppi.ioe.ac.uk> (accessed 01 May 2017)
 12. Qasim, M.: Determinants of Farm Income and Agricultural Risk Management Strategies: The Case of Rain-Fed Farm Households in Pakistan's Punjab. Kassel. University Press GmbH (2012)
 13. USAID.: Scaling Agricultural Technologies and Innovation Diffusion. pp 57(2015). http://pdf.usaid.gov/pdf_docs/PA00KFQG.pdf (accessed 19 October 2016)
 14. Miranda, Q. M., Farias, S.J., Schwartz, A., de Almeida, P.L.J.: Technology adoption in diffusion of innovations perspective: introduction of an enterprise resource planning system in a non-profit organization. *Revista de Administração e Inovação (Journal of Technology Management and Innovation)*, 13 (1), 48-57(2016). <https://doi.org/10.1016/j.rai.2016.02.002>
 15. Wisdom, J.P., Chor, B.H.K., Hoagwood, E.K., Horwitz, M.S.: Innovation Adoption: A Review of Theories and Constructs. *Journal of Administration Policy Ment Health*. 41(4), 480–502 (2014). doi:10.1007/s10488-013-0486-4
 16. Roger, E.M.: Diffusion of innovations (5th ed.). The Free Press, New York, USA(2003)
 17. Bass, F. M.: A New-Product Growth Model for Consumer Durables. *Management Science*, 15, 215-227(1969).
 18. Wright, V.: Rates of Adoption: The Diffusion of Agricultural Innovations. Service Design Research Working Article 06-11. Published by the Victorian Government Department of Primary Industries East Melbourne (2011). <http://geoffkainerresearch.Com> (accessed 15 October 2018)
 19. Holden, T.S.: Risky Choices of Poor People: Comparing Risk Preference Elicitation Approaches in Field Experiments. Centre for Land Tenure Studies Working Article 10/14. pp 46 (2014). doi: 10.13140/2.1.4482.7200
 20. Francis, C., Mundy, V., Janke, R., King, J.: Alternative Approaches to On-Farm Research and Technology Exchange (1995). <http://digitalcommons.unl.edu> (accessed 11 November 2016)
 21. Yesuf, M.; Kassie, M and Köhlin, G.: Risk Implications of Farm Technology Adoption in the Ethiopian Highlands. Discussion Article Series on Environment for Development. pp18 (2009). <http://www.efdinitiative.org> (accessed 17 October 2016)
 22. Emerick, K., De Janvry, A., Sadoulet, E., Dar, M. H., 2015. Technological innovations, downside risk, and the modernization of agriculture. <http://are.berkeley.edu/~esadoulet> (accessed 20 September 2018)
 23. Hill, R.V.: Investment and abandonment behaviour of rural households: An empirical investigation. *American Journal of Agricultural Economics*. 92(4), 1065–1086(2010). doi. org/ 10.1093/ajae/aaq055
 24. Shaw, C.S., 2014. Agricultural Technology Adoption in West Africa. A Thesis Submitted to the Office of Graduate and Professional Studies of Texas A&M University in partial fulfilment of the requirements for the degree of Master of Science.
 25. Pedersen, K.E.: Factors affecting the adoption of improved banana technologies in Northern Tanzania. Published by Rockwool Foundation Research Unit (2012). <https://www.rockwool-fonden.dk>
 26. Kaliba, A.R.M., Verkuijl, W., Mwangi, A.J.T., Mwilawa, P., Anandajayasekeram, H., Moshi, A.J.: Adoption of Maize Production Technologies in Central Tanzania. *International Maize*

- and Wheat Improvement Center (CIMMYT), the United Republic of Tanzania, and the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR) (1998). <http://www.tanzaniagateway.org> (accessed 21 September 2018)
27. Kahimba, F.C., Mutabazi, K.D., Tumbo, S.D., Masuki, K.F., Mbungu, W.B.: Adoption and scaling-up of conservation agriculture in Tanzania: Case of Arusha and Dodoma regions. *Journal of Natural Resources*. 5: 161-1765 (2014). <http://dx.doi.org/10.4236/nr.2014.54016>
 28. Namwata, B.M.L., Lwelamira, J., Mzirai, O.B.: Adoption of improved agricultural technologies for Irish potatoes (*Solanum tuberosum*) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences*. 8 (1): 927- 935(2010). <http://www.m.elewa.org/JAPS/2010/8.1/4.pdf> (accessed 19 August 2018)
 29. Climatic Data Org.: Tanzania Climatic Data (2016). <https://en.climate-data.org> (accessed 12 March 2018)
 30. AFNETA.: Alley Farming Training Manual Volume 1 pg 196(1992). <http://biblio.iita.org/documents> (accessed 21 November 2016).
 31. Richey, R.C.: Developmental Research: The Definition and Scope in Proceedings of Selected Research and Development Presentations at the National Convention of the Association for Educational Communications and Technology Sponsored by the Research and Theory Division (16th, Nashville, TN, February 16-20, 1994(1994). <http://files.eric.ed.gov> (accessed 15 August 2016)
 32. Paikoff, R.L.: Adapting Developmental Research to Intervention Design: Applying Developmental Psychology to an AIDS Prevention Model for Urban African American Youth. *Journal of Negro Education*. 65, 44–59(1996). www.jstor.org/stable/2967367 (accessed 12 August 2016).
 33. Kuehne, G., Llewellyna, R., Pannell B., Wilkinsonc, R., Dollingd, P. J., Ouzmana, J., Ewing, M.: Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Journal of Elsevier: Agricultural Systems*. 156,115–125(2017). doi.org/10.1016/j.agsy.2017.06.007
 34. Meijer, S.S., Catacutan, D., Ajayi, O. C., Sileshi, G.W., Nieuwenhuis, M.: The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in Sub-Saharan Africa. *International Journal of Agricultural Sustainability*. 13 (1), 40-54(2015). doi.org/10.1080/14735903.2014.912493.
 35. Dhehibi, B., Nejatian, A., Wahaibi, H., Atroosh, K., Yafei, M.S., Otaibi, A., Hendi, M., Belgacem, A. O.: Adoption and Factors Affecting Farmer's Adoption of Technologies in Farming System: A Case Study of Improved Technologies in ICARDA's Arabian Peninsula Regional Program. *Journal of Sustainable Development*. 10 (6), 1-13(2017). <https://doi.org/10.5539/jsd.v10.n6p1>
 36. Akroush, S., Dhehibi, B., 2015. Predicted Willingness of Farmers to Adopt Water Harvesting Technologies: A Case Study from the Jordanian Badia (Jordan). *American-Eurasian Journal of Agricultural and Environmental Sciences*. 15 (8): 1502-1513. [http:// dx.doi. org/10.5539/sar.v6n1p80](http://dx.doi.org/10.5539/sar.v6n1p80)
 37. Mukasa, A.N., 2016. Technology Adoption and Risk Exposure among Smallholder Farmers: Panel Data Evidence from Tanzania and Uganda. African Development Bank Group Working Article No. 233 April 2016. Conference held on December 4-5, 2015 in Addis Ababa, Ethiopia. Retrieved from <https://www.afdb.org/fileadmin/uploads/afdb> (accessed 9 August 2018)
 38. Simtowe, F., Kassie, M., Diagne, A., Silim, S., Muange, E., Asfaw, S., Shiferaw, B., 2011. Determinants of Agricultural Technology Adoption: The Case of Improved Pigeon Pea Varieties in Tanzania. *Quarterly Journal of International Agriculture*, 50(4): 325–345. <https://www.researchgate.net/publication/225274683> (accessed 10 August 2018)
 39. Mignouna, B., Manyong, M., Rusike, J., Mutabazi, S., Senkondo, M., 2011. Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya. *The Journal of Agrobiotechnology Management and Economics*. 14(3), 158-163. <https://mospace.umsystem.edu/xmlui/handle/10355/12458> (accessed 6 July 2018).

40. Lavisson, R., 2013. Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, Msc Thesis, Accra Ghana. Retrieved from [http:// 197.255. 68.203/ handle/1 23456789 /5410](http://197.255.68.203/handle/123456789/5410) (accessed 21 April 2018)
41. Muzari, W., Gatsi, W., Muvhunzi, S.: The Impacts of Technology Adoption on Smallholder Agricultural Productivity in Sub-Saharan Africa: A Review, *Journal of Sustainable Development*. 5 (8): 69-77(2012). <http://dx.doi.org/10.5539/jsd.v5n8p69>
42. Wekesa, E., Mwangi, W., Verkuijl, H., Danda, K and De Groote, H., 2003. Adoption of Maize Technologies in the Coastal Lowlands of Kenya. CIMMYT, Mexico, D.F. <https://ageconsearch.umn.edu/bitstream/56109/2/coastalKenya.pdf> (accessed 13 October 2018)
43. Makokha, S., Kimani, S., Mwangi, W., Verkuijl, H., Musembi, F., 2001. Determinants of Fertilizer and Manure Use for Maize Production in Kiambu District, Kenya. CIMMYT, Mexico. Retrieved from <https://repository.cimmyt.org/xmlui> (accessed 7 June 2017)
44. Caswell, M., Fuglie, K., Ingram, C., Kascak, S., 2001. Adoption of Agricultural production practices: Lessons learned from the US. Department of Agriculture area studies project. Washington, DC. US Department of Agriculture. Resource Economics Division, Economic Research service, Agriculture Economic Report No. 792
45. Salazar, C., Rand, J.: Production risk and adoption of irrigation technology: evidence from small-scale farmers in Chile. *Latin America Economic Review*, 25(2): 2-37(2016). <https://doi.org/10.1007/s40503-016-0032-3>