Research Application Summary

Drivers of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties, Kenya

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Abstract

Agriculture has the potential to improve dietary diversity through farm enterprise diversity if farming households consume what they produce. This paper evaluated the drivers of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties, Kenya. Data from 320 small-scale farmers' households was collected using semi-structured questionnaires. Simpson's Index and crop and livestock count were used to measure farm enterprise diversity. The results showed that farm enterprise diversity was positively influenced by age and education of the household head, land tenure, land size, slope of the land, access to irrigation, number of trainings attended and number of groups household members were engaged in. The study recommends formulation of policies that favour access to land and capital to young farmers and enhanced knowledge on education which will likely improve the use of technology and information which can go a long way in helping the farmers diversify their farm enterprises.

Key words: Drivers, Farm diversity, Kenya, Makueni, Nyando, small-scale farmers

Résumé

L'agriculture a le potentiel d'améliorer la diversité alimentaire par la diversité des entreprises agricoles si les ménages agricoles consomment ce qu'ils produisent. Cet article a évalué les moteurs de la diversité des entreprises agricoles parmi les petits agriculteurs des sous-comtés de Makueni et Nyando, au Kenya. Les données de 320 ménages de petits agriculteurs ont été collectées à l'aide de questionnaires semi-structurés. L'indice de Simpson et le nombre de cultures et de têtes de bétail ont été utilisés pour mesurer la diversité des entreprises agricoles. Les résultats ont montré que la diversité des entreprises agricoles était influencée positivement par l'âge et l'éducation du chef de ménage, le régime foncier, la taille des terres, la pente des terres, l'accès à l'irrigation, le nombre de formations suivies et le nombre de groupes dans lesquels les membres du ménage étaient engagés. L'étude recommande la formulation de politiques qui favorisent l'accès à la terre et au capital pour les jeunes agriculteurs et l'amélioration des connaissances sur l'éducation, ce qui améliorera probablement l'utilisation de la technologie et de l'information, ce qui peut aider considérablement les agriculteurs à diversifier leurs entreprises agricoles.

Mots clés : Facteurs déterminants, diversité des exploitations agricoles, Kenya, Makueni, Nyando, petits exploitants agricoles

Introduction

Agriculture is an important sector in majority of developing countries. Agriculture is the main source of food and employment for more than 70% of poor people in SSA and a main source of income for around 2.5 billion people in the developing world (Dobermann *et al.,* 2013; Muyanga and Jayne, 2014; Mwangi and Kariuki, 2015; Sibhatu *et al.*, 2015). Despite the potential contribution of agriculture as a source of food, diets consumed by households generally from low income countries are less diverse since they are mainly starchy staples and lack nutrient dense foods like animal-source foods, fruits and vegetables (Jones *et al.,* 2014). Furthermore, about 12% of Kenyan households consume unacceptable diets (WFP, 2016). Therefore, this contributes to the burden of malnutrition and morbidity.

Agriculture and nutrition are interconnected through provision of vital micronutrients to smallholder households (Bagnall-Oakeley *et al.,* 2014; Yosef *et al.,* 2015). Farm enterprise diversity which is the number of different plant and livestock species in a farm, is seen as one of the interventions in agriculture that can help small-scale farmers' households to access diverse foods for good health and nutrition. Farm diversity has the capability to influence a household's dietary diversity hence nutritional status of individuals through income from sale of crops and food purchases and through subsistence farming (Jones *et al.,* 2014). Furthermore, greater diversity of an agricultural system in terms of variety, balance and disparity increases adaptive capacity and reduces vulnerability of the system to adverse trends and events like weather variability (Martin and Magne, 2014). Crop diversity helps in boosting crop production in cases of very low rainfall (Donfouet *et al.,* 2017). Households may also diversify as a strategy to overcome market failure and manage risk or could be an individual in a household specializing due to individual attributes or comparative advantage (Sibhatu and Qaim, 2016; Davis *et al.,* 2017). Imperfect markets have driven farmers to switch to other crops based on improved high-yielding varieties due to financial incentives created by increasing intensification of the agricultural production system (Pallante *et al.,* 2016). In addition, production systems influence the diversity of crops produced and sold (Smale *et al.,* 2015). Thus, farm diversification could help in solving the problem of food insecurity due to rainfall uncertainty, pest and disease infestation and high cost of agricultural inputs (Mburu *et al.,* 2016).

Agriculture interventions that promote farm enterprise diversity could go a long way in contributing to consumption of quality diets among small scale farmers' households. Farm enterprise diversity could help farmers to access a variety of crops and animal source foods that if well utilized could lead to consumption of quality diets. In addition, farm enterprise diversity could help in achieving food and nutrition security which is one of the big 4 agendas by the Government of Kenya that seeks to increase large scale production of staple foods by the small-scale farmers. However, drivers of farm enterprise diversity is not clear in empirical literature. This study aimed at filling this gap among small-scale farmers in Makueni and Nyando Sub-Counties.

Materials and Methods

Study area: The study was undertaken in Makueni (latitude 1° 35´ and 3° 00 South and longitude 37° 10´ and 38° 30´ East) and Nyando (longitudes 33° 20 E and 35° 20 E and latitudes 0° 20 South and 0° 50 South) Sub-Counties in Makueni and Kisumu Counties, respectively (GoK, 2018a; 2018b). The study sites were purposively selected based on susceptibility to climate change,

levels of poverty, agro-ecological conditions and agricultural production systems (Silvestri *et al.,* 2015). The two regions are semi-arid and rainfall pattern is bimodal but the rainfall amounts differ and practice mixed production systems of crops and livestock. Further, Makueni and Nyando Sub-Counties are Climate Change, Agriculture and Food Security Research Program (CCAFS) project sites aimed at improving farmer's access to climate information to improve their farm production decisions (Kiptoo *et al.,* 2021).

Sampling and methods of data collection: This study used simple random sampling technique. A 10 km by 10 km research grid was picked on each site and the study was done through resampling small-scale farmers that were previously surveyed by CCAFS in 2012. Data was collected using Rural Household Multi-Indicator Survey (RHoMIS) tool in the months of October, November and December, 2016. RHoMIS is a tool used for household survey and is designed to depict standardized indicators related to food security, agricultural production and market integration, nutrition, poverty and greenhouse gas emissions (Hammond *et al.,* 2017). Questions in the RHoMIS tool were semi-structured and data was collected using Open Data Kit (ODK) installed on android tablets.

Data Analysis: Crop and livestock count and Simpson's Index were used to measure farm enterprise diversity following the methodology by (Jones *et al.,* 2014). To come up with a crop and livestock count variable, the different crop species a household planted during the last main season were summed up and added to the number of different livestock species the household kept. Secondly, Simpson's diversity Index which is used in ecology and sometimes in crop diversity to measure species richness and species abundance was calculated. Following, Jones *et al.* (2014) methodology, the Simpson's Index can be written as;

$$\text{Simpson's Index}_i = 1 - \sum s_j^2 \quad \text{......................................} \quad (Eq.1)$$

Where, S_j is the part where household i used to plant crop j out of the total land size that was used to plant all crops. As the Simpson's Index approaches 0, specialization in a crop increases and as it approaches 1 crop diversification increases (Mbulukwa, 2014).

Results and Discussion

Ordered Logit and Poisson models were used to determine factors influencing farm enterprise diversity and the results are presented in Table 3. Both Ordered Logit and Poisson models results revealed that age of the household head had a positive influence on farm enterprise diversity at 1% and 10% significance levels, respectively. The results implied that older household heads were more likely to have diversified farm enterprises. This could be attributed to factors related to old age like being more risk averse, farming experience gained over the years and access to more resources leading to age having a positive effect on farm enterprise diversity. Similar findings were reported by Mburu *et al.* (2016) and Asante *et al.* (2017) who found out that farm diversity increased with age and the number of years the farm had been cultivated since older farmers are more risk averse due to their farming experiences. Contrary, Mishra *et al.* (2004) and Mesfin *et al.* (2011) alluded that the negative association between age and farm diversity could be due to older farmers being less risk-averse and therefore having less diversified farms compared to younger farmers since they have more wealth.

Education of the household head had a positive significant effect on farm enterprise diversity at 5% significance level. Higher education level of the household head was associated with more farm enterprise diversity. With education, a farmer is able to look for new information and technologies to help in diversifying their farm enterprises. In addition, an educated household head could probably be working and may use income they earn to purchase and maintain more crop and livestock species. The results are similar to those of Rahman and Chima (2016) and Boncinelli *et al.* (2018) who found out that education of the household head had a significant positive effect on the decision to adopt a diversified cropping system since the ability to process information increases with education. In addition, education which contributes to household head's human capital, boosts the ability to hold new production technologies quickly, seek new information on technology and to meet more complex requirements for crop diversification (Rehima *et al.,* 2013).

Table 3. Ordered Logistic and Poisson table on factors influencing farm enterprise diversity

Variables	Simpson's Index		Crop and livestock count	
	Coeff.	Robust Standard Errors	Coeff.	Robust Standard Errors
Socioeconomic factors				
Gender	0.1309	0.2972	-0.0166	0.0389
Age of the household head	0.0233***	0.0086	0.0018*	0.0010
Education of the household head	-0.0680	0.1435	0.0371**	0.0160
Off-farm income	0.4167	0.4264	0.04320	0.0507
Land tenure				
Own land rent in land	-0.4923	0.3921	0.0861**	0.0363
Own land rent out land	-0.7497	1.5369	0.2678***	0.0450
Land size	-0.0342	0.0517	0.0141***	0.0045
Slope	-0.1484	0.1108	0.0261*	0.0144
Irrigation	0.5567*	0.3227	0.2052***	0.0304
Aid	-0.4917*	0.2916	0.04134	0.0329
Institutional characteristics				
Distance to the market	-0.0404	0.0493	-0.0080	0.0050
Number of trainings attended	0.2789***	0.0900	0.0353***	0.0076
Number of groups	0.0193	0.0472	0.0150**	0.0075
Location dummy	0.5243*	0.2746	-0.0568*	0.0335
-Constant		1.7716***		0.1077
Wald chi^2 (14)	34.66		190.05	
Prob> chi^2	0.0016		0.0000	
Pseudo R^2	0.5640		0.3721	
Log likelihood	-293.8035		-723.75029	
Number of observations	319		319	

Land tenure in form of owning land and renting in some more had a significant positive effect on farm enterprise diversity at 5% significance level. Land tenure gives a farmer a sense of security and control over the land and this could encourage them to grow more crops and keep more livestock species. In addition, small-scale farmers who rent in more land maybe those who have scarcity of land. Therefore, this enables them to increase their operations thus having more diversified farm enterprises. On the other hand, land tenure in form of owning land and renting out

part of it had a positive significant effect on farm enterprise diversity at 1% level of significance. By renting out part of their land, the small-scale farmers could have received an income which they may have used to develop their farm enterprises. The results contrast the findings by Mekuria and Mekonnen (2018) who found out that land rent out had a negative significant effect on crop-livestock diversity since a household that rented-out its land was unlikely to diversify its farming activities since the same piece of land could have been used to produce more crops and forages and keep animals on it.

Land size in acres was found to have a significant positive effect on farm enterprise diversity at 1% level of significance. Farmers who have bigger land sizes are more likely to diversify their farm enterprises since they face high production risk. This result is similar to those of Rehima *et al.* (2013), Amine and Fatima (2016), and Mekuria and Mekonnen (2018) who found out that farm size had a significant positive effect on crop-livestock diversification since more landholding enabled farmers to allocate their farming activities in multiple productions compared to small farms thereby minimizing income, production and price risks.

Slope of the land had a positive significant effect on farm enterprise diversity at 10% significance level. The result implied that farms lying on flat land encouraged the small-scale farmers to diversify their crops and livestock species. Flat lands are suitable for growing more crop species and keeping more livestock compared to steep land since they are prone to erosion and landslides. The results are in line with the findings of Dube and Guveya, (2016) and Boncinelli *et al.* (2017) who found out that slope of the land influences diversity of cropping enterprises since farmers having farms in flat terrains have more chances of diversifying their cropping patterns as compared to farmers with farms in slopy terrains.

Access to irrigation had positive significant effect on farm enterprise diversity in both Ordered Logit and Poisson models at 10% and 1% significance levels, respectively. Both Makueni and Nyando Sub-Counties are semi-arid lands. Therefore, having access to irrigation by the small-scale farmers helped them solve the problem of uncertainty in production associated with water scarcity. Thus, this encouraged the farmers to grow more crop species under irrigation even during the dry season. The results are in line with those of Dube and Guveya (2016), Ciaian *et al.* (2018), and Mekuria and Mekonnen (2018) who found irrigation having a positive effect on crop-livestock diversification since irrigation increases crop-livestock diversity by supplementing water during times when it is scanty and also households that can irrigate their fields can grow a wide spectrum of crops.

Access to aid had a negative but significant effect on farm enterprise diversity at 10% level. Farmers who received an aid reduced their probability of diversifying their farm enterprises by 4.9%. Reliance on aid can make farmers not have incentive of diversifying their farm enterprises since they get contented by depending on what they are given. In addition, aid through cash can make farmers channel the money to other uses they had already planned for. The findings are in line with those of Turner *et al.* (2006) who found that majority of farmers who had diversified their farm enterprises were farmers who did not receive grant aid. The reason could be due to pressures on farm incomes and copying from farmers who were less risk averse and had diversified their farm enterprises.

The number of trainings attended by a farmer had a significant positive effect on farm enterprise diversity in both models at 1% significance level. Farmers who have access to more trainings on crop commercialization and risk mitigation diversify their farm enterprises to mitigate risk in times of crop failure and to market their produce to earn an income. The results corroborate the findings of Kasem and Thapa (2011) who found out that farmers who had diversified farms had attended more training sessions conducted by both public and private agencies which enabled them gain more knowledge on technical know-how, economic benefits and marketing opportunities related to new crops.

Number of groups household members were engaged in had a positive significant effect on farm enterprise diversity at 5% significance level. Groups act as information channels where members are able to exchange ideas, are taught collectively by extension agents and members offer support to each other for example through providing labour in the farms. Group members also act as guarantors for other members enabling them to access loans to buy farm inputs which promote farm enterprise diversity. The findings are consistent with those from Kasem and Thapa (2011) who found out that crop diversification was adopted by farmers who had better interactions with farmer's groups responsible for the dissemination of information on crop diversification and organizing training programs for their members. These results are in contrast to those of Rehima *et al.* (2013) who found that social organizations had a negative significant effect on crop diversification since cooperatives may have their own objective and specialize in particular crops thereby narrowing the probability of farmers diversifying their farm enterprises.

Location dummy had a significant positive effect on farm enterprise diversity at 10% significance level in Ordered Logit model and a negative significant effect on farm enterprise diversity at 10% level of significance in Poisson model. These results implied that small-scale farmers in Makueni had more diverse crop species compared to farmers in Nyando and on the other hand less diverse livestock species compared to farmers in Nyando as shown in Tables 5 and 6. The reason for the higher number of crop species in Makueni could be attributed to the fact that small-scale farmers in the Sub-County have bigger sizes of land, being closer to the market and extension services, having attended more trainings on crop commercialization and risk mitigation in the past year and household members' engagement in more social groups than small-scale farmers in Nyando. On the other hand, the higher number of livestock species in Nyando Sub-County compared to Makueni could be a strategy by the small-scale farmers to overcome risk associated with crop failure. In addition, the results could be attributed to the difference in agroecological conditions of the two Sub-Counties and the types of production systems. Dube and Guveya (2016) found out that farmers with farms in drier agroecological zones had higher probability of adopting crop diversification compared to farms in better agroecological zones since there is high risk of crop failure due to erratic rainfall patterns.

Conclusion and Recommendations

Farm enterprise diversity varied with location. This may be attributed to factors like small-scale farmers in Makueni having bigger land sizes, shorter distances to the market and to extension services, a higher number of social groups household members were engaged in and attending more trainings on crop commercialization and risk mitigation compared to small-scale farmers in Nyando. This implies that location matters when it comes to farm enterprise diversity. The likelihood of small-scale farmers diversifying their farm enterprises was influenced by both

socioeconomic and institutional factors. Generally, households with older and educated household heads had high farm enterprise diversity due to factors like being more risk averse due to their past experiences, endowment with more resources and being able to look for new information and technologies. Farm enterprise diversity was negatively influenced by slope of the land since flat land is suitable for cultivating more crop and livestock species compared to steep lands due to being prone to erosion and landslides.

There is need for policies and programs by the government and development partners that promote access to education, productive resources and good infrastructure to the small-scale farmers. For instance, policies that favour access to land and capital to young and starting farmers can go a long way in helping them diversify their farm enterprises. Enhanced knowledge on education will improve the use of technology and information by the farmers. In addition, good infrastructure makes transportation easier and as such farmers are able to get their produce to the market within a short time and at low cost and access extension agents with ease.

Acknowledgement

References

Agyeman, B. A. S., Asuming-Brempong, S. and Onumah, E. E. 2014. Determinants of Income Diversification of Farm Fouseholds in the Western Region of Ghana. *Quarterly Journal of International Agriculture* 53 (1): 55–72. http://ugspace.ug.edu.gh/handle/123456789/25055

Asante, B. O., Villano, R. A., Patrick, I. W. and Battese, G. E. 2017. Determinants of farm diversification in integrated crop–livestock farming systems in Ghana. *Journal of Renewable Agriculture and Food Systems* 1: 1–19. https://doi.org/10.1017/S1742170516000545

Bagnall-Oakeley, H., Rumsby, M., McNair, D., Crosby, L. and Hoover, S. 2014. Nutrition sensitivity: How agriculture can improve child nutrition. United Kingdom: Save the Children.

Boncinelli, F., Bartolini, F. and Casini, L. 2018. Structural factors of labour allocation for farm diversification activities. *Land Use Policy* 71: 204–212. https://doi.org/10.1016/j.landusepol.2017.11.058

Boncinelli, F., Bartolini, F., Casini, L. and Brunori, G. 2017. On-Farm Non-Agricultural Activities: Geographical Determinants of Diversification and Intensification Strategy. *Letters in Spatial and Resource Sciences* 10 (1): 17–29. https://doi.org/10.1007/s12076-016-0168-4

Ciaian, P., Guri, F., Rajcaniova, M., Drabik, D. and Paloma, S. G. 2018. Land Fragmentation and Production Diversification: A Case Study from Rural Albania. *Land Use Policy* 76: 589–599. https://doi.org/10.1016/j.landusepol.2018.02.039

Davis, B., Di Giuseppe, S. and Zezza, A. 2017. Are African households (Not) leaving Agriculture? Patterns of households' income sources in Rural Sub-Saharan Africa. *Food Policy* 67: 153-174 https://doi.org/10.1016/j.foodpol.2016.09.018

Dobermann, A., Nelson, R., Beever, D., Bergvinson, D., Crowley, E., Denning, G. and Barredo, L. 2013. Solutions for Sustainable Agriculture and Food Systems. Sustainable Development Solutions Network.

Donfouet, P. P. H., Barczak, A., Détang-dessendre, C. and Maigné, E. 2017. Crop production and crop diversity in France: A Spatial Analysis. *Ecological Economics* 134: 29–39. https://doi.org/10.1016/j.ecolecon.2016.11.016

Dube, L. and Guveya, E. 2016. Factors influencing smallholder crop diversification: A case study of Manicaland and Masvingo Provinces in Zimbabwe. *International Journal of Regional Development* 3 (2): 1–25. https://doi.org/10.5296/ijrd.v3i2.9194

Government of Kenya. 2018a. Makueni County Integrated Development Plan (Cidp) 2018-22. Nairobi: Government of Kenya Printing Press.

Government of Kenya. 2018b. Kisumu County Intergrated Development Plan II. Nairobi: Government of Kenya Printing Press.

Greene, W. H. 2007. Econometric Analysis (6th Edition). New York University: Prentice Hall.

Gujarati, D. N. 2003. Basic Econometrics (4th Edition). New York: McGraw-Hill/Irwin.

Hair, J. F., Ringle, C. M. and Sarstedt, M. 2011. PLS-SEM: Indeed a Silver Bullet. *Journal of Marketing Theory and Practice* 19 (2): 139–152. https://doi.org/10.2753/MTP1069-6679190202

Hammond, J., Fraval, S., van Etten, J., Suchini, J. G., Mercado, L., Pagella, T., van Wijk, M. T. 2017. The Rural Household Multi-Indicator Survey (RHoMIS) for rapid characterisation of households to inform Climate Smart Agriculture interventions: Description and applications in East Africa and Central America. Agricultural Systems 151: 225–233.

Jones, A. D., Shrinivas, A. and Bezner-kerr, R. 2014. Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Jounal of Food Policy 46: 1–12.

Kamara, L. I., Dorward, P., Lalani, B. and Wauters, E. 2019. Unpacking the drivers behind the use of the agricultural innovation systems (AIS) Approach: The case of Rice research and extension professionals in Sierra Leone. *Agricultural Systems* 176 (102673): 1–15.

Kamau, J. W., Stellmacher, T., Biber-Freudenberger, L. and Borgemeister, C. 2018. Organic and conventional agriculture in Kenya: A typology of smallholder farms in Kajiado and Murang'a Counties. *Journal of Rural Studies* 57: 171–185.

Kasem, S., and Thapa, G. B. 2011. Crop diversification in Thailand: Status, determinants, and effects on income and use of inputs. *Land Use Policy* 28: 618–628.

Kenya National Bureau of Statistics and International Classification for Functioning Disability and Health Macro. 2015. Kenya Demographic and Health Survey 2014. Nairobi: Government of Kenya Printing Press.

Kenya National Bureau of Statistics. 2019. Economic Survey. Nairobi: Government of Kenya Printing Press.

Kiptoo, E., Waswa, L. M. and Ayuya, O. I. 2021. Linking farm production to household diets: Evidence from two low potential areas in Kenya. *Cogent Food and Agriculture* 7 (1): 1913842. https://doi.org/10.1080/23311932.2021.1913842

Kock, N. and Lynn, G. S. 2012. Lateral collinearity and misleading results in variance-based SEM: An Illustration and Recommendations. *Journal of the Association for Information Systems* 13 (7): 546–580.

Lande, R., De Vries, P. J. and Walla, T. R. 2000. When species accumulation curves intersect: Implications for ranking diversity using small samples. *Oikos* 89 (3): 601–605. https://doi.

org/10.1034/j.1600-0706.2000.890320.x

Martin, G. and Magne, M. A. 2014. Agricultural diversity to increase adaptive capacity and reduce vulnerability of livestock systems against weather variability-a farm-scale simulation study. *Agriculture, Ecosystems and Environment* 199: 301–311. https://doi.org/10.1016/j.agee.2014.10.006

Mbulukwa, M. C. 2014. Analyzing the importance of diversifying beyond tobacco for small-scale farmers in Malawi (Unpublished Master's Thesis). Purdue University, West Lafayette, Indiana.

Mburu, S. W., Koskey, G., Kimiti, J. M., Ombori, O., Maingi, J. M. and Njeru, E. M. 2016. Agrobiodiversity conservation enhances food security in subsistence based farming systems of Eastern Kenya. *Agriculture and Food Security* 5 (19): 1–10. https://doi.org/10.1186/s40066-016-0068-2

Mekuria, W. and Mekonnen, K. 2018. Determinants of crop–livestock diversification in the mixed farming systems: Evidence from central highlands of Ethiopia. *Agriculture and Food Security* 7 (60): 1–15. https://doi.org/10.1186/s40066-018-0212-2

Mesfin, W., Fufa, B. and Haji, J. 2011. Pattern, trend and determinants of crop diversification: Empirical evidence from smallholders in Eastern Ethiopia. *Economics and Sustainable Development* 2 (8): 78–90.

Min, H. 2013. Ordered Logit Regression Modeling of the self-rated health in Hawai'i, with comparisons to the OLS Model. *Journal of Modern Applied Statistical Methods* 12 (2): 371–380.

Mishra, A. and El-Osta, H. 2002. Risk Management through enterprise diversification: A farm-level analysis. Paper presented at AAEA Meetings, Long Beach, CA.

Mishra, A. K., El-Osta, H. S. and Sandretto, C. L. 2004. Factors Affecting farm enterprise diversification. *Agricultural Finance Review* 64 (2): 151–166.

Muyanga, M. and Jayne, T. S. 2014. Effects of rising rural population density on smallholder agriculture in Kenya. *Journal of Food Policy* 48: 98-113. https://doi.org/10.1016/j.foodpol.2014.03.001

Mwangi, M. and Kariuki, S. 2015. Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development* 6 (5): 208–217.

Nagendra, H. 2002. Opposite trends in response for the shannon and simpson indices of landscape diversity. *Apllied Geography* 22: 175–186. https://doi.org/10.1016/S0143-6228(02)00002-4

Pallante, G., Drucker, A. G. and Sthapit, S. 2016. Assessing the potential for niche market development to contribute to farmers' livelihoods and agrobiodiversity conservation: insights from the finger millet case study in Nepal. *Ecological Economics* 130: 92–105. https://doi.org/10.1016/j.ecolecon.2016.06.017

Rahman, S. 2016. Impacts of climate change, agroecology and socio-economic factors on agricultural land use diversity in Bangladesh (1948–2008). *Land Use Policy* 50: 169–178. https://doi.org/10.1016/j.landusepol.2015.09.010

Rahman, S. and Chima, C. D. 2016. Determinants of food crop diversity and profitability in southeastern Nigeria: A Multivariate Tobit approach. *Agriculture* 6 (14): 1–14. https://doi.org/10.3390/agriculture6020014

Rehima, M., Belay, K., Dawit, A. and Rashid, S. 2013. Factors affecting farmers' crops diversification: Evidence from SNNPR, Ethiopia. *International Journal of Agricultural Sciences* 3 (6): 558–565.

Rufino, M. C., Quiros, C., Teufel, N., Douxchamps, S., Silvestri, S., Mango, J., Moussa, A. S.

and Herrero, M. 2012. Household characterization survey – IMPACTlite Training Manual. Working Document, CGIAR Research Program on Cimate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Sibhatu, K. T., Krishna, V. V. and Qaim, M. 2015. Production diversity and dietary diversity in smallholder farm households. *Proceedings of the National Academy of Sciences* 112 (34): 10657–10662. https://doi.org/10.1073/pnas.1510982112

Sibhatu, K. T. and Qaim, M. 2016. Farm production diversity and dietary quality: linkages and measurement issues (Global Food Dicussion Papers No. 80). Germany. https://doi.org/10.1007/s12571-017-0762-3

Silvestri, S., Douxchamps, S., Kristjanson, P., Förch, W., Radeny, M., Mutie, I. an Rufino, C. M. 2015. Households and Food Security: Lessons from Food Secure Households in East Africa. *Agriculture and Food Security* 4 (23): 1–15. https://doi.org/10.1186/s40066-015-0042-4

Simpson, E. H. 1949. Measurement of Diversity. *Nature* 163 (4148): 688-688.

Smale, M., Moursi, M. and Birol, E. 2015. How does adopting hybrid maize affect dietary diversity on family farms? Micro-evidence from Zambia. *Food Policy* 52: 44–53. https://doi.org/10.1016/j.foodpol.2015.03.001

Turner, M., Whitehead, I., Millard, N., Barr, D. and Howe, K. 2006. The effects of public funding on farmer's attitudes to farm diversification. London: Centre for Rural Research.Wooldridge, J. M. 2016. Introductory econometrics: A modern approach. Nelson Education.

World Food Program. 2016. Comprehensive food security and vulnerability survey. Rome, Italy: WFP.

Yosef, S., Jones, A. D., Chakraborty, B. and Gillespie, S. 2015. Agriculture and nutrition in Bangladesh: Mapping evidence to Pathways. *Food and Nutrition Bulletin* 36 (4): 387–404. https://doi.org/10.1177/0379572115609195

Zamasiya, B., Nyikahadzoi, K. and Mukamuri, B. B. 2017. Factors influencing smallholder farmers' behavioural intention towards adaptation to climate change in transitional climatic zones: A case study of Hwedza District in Zimbabwe. *Journal of Environmental Management* 198: 233–239. https://doi.org/10.1016/j.jenvman.2017.04.073