

**Variety for security: A case study of agricultural, nutritional and dietary diversity  
among smallholder farmers in Western Kenya**

**Mary Ng'endo Kanui**

Linacre College and School of Geography and the Environment



*A thesis submitted to the University of Oxford in partial fulfilment of the requirements  
for the degree of Doctor of Philosophy*

Supervisors: Dr Patricia Daley and Dr Shonil Bhagwat

**Trinity Term 2015**

## **Thesis abstract**

Variety for security: A case study of agricultural, nutritional and dietary diversity  
among smallholder farmers in Western Kenya

Thesis for Doctor of Philosophy in Geography and the Environment

Mary Ng'endo Kanui, Linacre College

September 2015

Agricultural biodiversity, commonly referred to as agrobiodiversity, is that part of biodiversity that is geared towards agriculture and food production. Agrobiodiversity is said to contribute much to food and nutrition, but there is lack of data confirming this, particularly from Eastern Africa. To assess the extent of agrobiodiversity on smallholder farms and in local markets and to connect these to food intake and perceptions of food security among smallholder farmers in Western Kenya, the thesis asks four main research questions: (i) What is the extent of food plant diversity in smallholder farms, the bio-physical and socio-economic factors influencing it and the contribution of this diversity to the household's food needs? (ii) What is the relationship between agricultural and dietary diversity? (iii) What linkages are there between agricultural and nutritional diversity? (iv) How does access to agrobiodiversity in local markets contribute to meeting household food needs and what is the extent of smallholder farmers' integration into these markets? Through a combination of focus group discussions, farm and market surveys conducted across three time points, results indicate that: (i) higher food plant species richness is found on farms managed by wealthier and older households. However, these households are not more food secure

than the rest, (ii) while there is a lack of a strong relationship between agricultural and dietary diversity, dietary diversity is instead significantly influenced by socio-economic factors including a household's wealth status, ethnicity and education level, (iii) despite a diversity of locally available on-farm and market food species meeting existing macro-and micro-nutrient needs, there is a general lack of understanding of this diversity as food shortage months coincide with a lack of maize despite high availability of a diversity of other foods not only to replace the maize but also to contribute to a diverse diet, (iv) smallholder farmers rely on multiple food sources, with markets mainly for sourcing cereals, fruits and animal source foods. There is also low integration of smallholder farmers as sellers in local markets. Together, the four case studies show interlinkages across food availability, accessibility and utilisation, which when addressed with equal weight, could unlock local agrobiodiversity's potential as a path to food and nutrition security of smallholder farming households.

## **Acknowledgements**

This thesis has seen the light of day thanks to the amazing support of the many people I would like to acknowledge. Sincere gratitude goes to Dr Patricia Daley and Dr Shonil Bhagwat, my University supervisors, as well as Dr Gudrun Keding, my external supervisor, who put time and effort into reading draft thesis manuscripts, for their academic assistance, expert guidance, invaluable insights and encouragement through all stages of this research work. Many thanks to Dr Gudrun Keding for introducing me to her Bioversity International colleagues at the Nairobi and Rome offices, whose inspiring work on improving human lives through agrobiodiversity has fuelled my research passion. She also facilitated connections with other great minds in this interdisciplinary field, especially Dr Katja Kehlenbeck (World Agroforestry Centre, Kenya), Dr Johannes Herrmann (Giessen University, Germany) and Dr Roseline Remans (Bioversity International, Ethiopia), whose big and small footprints can be seen in the thesis articles 1,2 and 3, respectively. This entire research would not have been possible without the unreserved co-operation and kindness of the Western Kenyan farmers and market traders who took time away from their engagements to participate in the interviews. Many thanks also to the local administration and contact persons who facilitated the connections with all the participants in the research sites, and to the field research assistants and data entry clerks for their fantastic help.

I am blessed to have received fantastic financial support to enable me complete my studies. While the numerous fieldwork grant applications I had initially applied for proved unfruitful, the best opportunities were waiting to open up. Many thanks to Bioversity International, Regional Office for sub-Saharan Africa, Nairobi, Kenya, for

## Acknowledgements

the fieldwork funding that enabled this research undertaking to be a reality, financially supported by the Federal Ministry for Economic Cooperation and Development (BMZ) in Germany and the CGIAR Research Program on Agriculture for Nutrition and Health, during the 2012 and 2014 surveys, respectively. Sincere gratitude also goes to the Rhodes Trust for funding my tuition, living and private medical cover expenses at Oxford, which has enabled me to pursue two degrees in the last four years - Master of Philosophy and Doctor of Philosophy, transformational opportunities at a world-renowned institution that have turned my childhood dream into a reality.

The journey to Oxford commenced way back, thanks to the unwavering support and encouragement of my mum, Tabitha Kanui, who always believed I would get there. Single-handedly raising my brother and I with unmatched devotion, she is the one who first taught me the power of God-sized prayers, positivity and conscientiousness, among so many other cherished values, which have enabled me to rise and thrive through the ebbs and flows of the seemingly short but intense 2-year DPhil journey. The stability she continues to provide amidst the many geographical changes in my life so far is a firm launching pad that I am eternally grateful for. Among her other amazing attributes, her excellent financial management skills have shaped my positive Oxford experience, especially in the last year at Oxford when I had run out of stipend. Combined with an ingenious financial savings plan from one of my amazing supervisors to see me through this financially lean year at Oxford, the financial discipline I first learnt from mum enabled me to implement this foresighted plan with ease. Thanks to this, I have managed to give undivided attention to my thesis work, without the need to take up a part-time job to cater for my fourth year living expenses.

## Acknowledgements

Special thanks go to the many people who have enriched my life in countless ways: the passionate INULA research team, friendly Linacre college mates, warm-hearted Kenyan Oxford community, like-minded SoGE DPhil colleagues, inspiring Rhodes scholars, charming Rhodes House porters, encouraging chats with the Rhodes House registrar, Mary Eaton, and motivating one-to-one meetings with the three Rhodes House wardens during my time – who have, in their unique ways, modeled diverse dimensions of ‘fighting the world’s fight’. For all these amazing people, I am so grateful for the reflective exchanges that have enabled me to not only learn to be a researcher but also, if not more importantly, to learn more about myself – or as one of my friends likes to put it – unearth the gem that I am. Among these is the realisation of the incredible attributes of my dominant introverted personality, skills that I have honed through the support of my empowered introverted friends, especially Natasha Phiri, Triza Muthoni, Tomomi Matsumoto and Yenny Djuardi, who get me when I sometimes don’t, and their awesomeness inspires me to live, glow and connect from an empowered zone. A big thank you to numerous other friends as well as mentors, those back in Kenya who have been with me in spirit, the friendships I have blessed with at Oxford and in other parts of the world, for tirelessly checking in on me and encouraging me throughout this journey.

My last writing up year at Oxford could not have been as enjoyable without the friendship of my 11 Norham Gardens housemates. Thanks to them, writing up has been anything but a lonely or isolating experience, with the unique communal spaces that provided avenues to talk, laugh or cry with other DPhils, depending on how the day had

## Acknowledgements

gone. It's also been a great pleasure writing up some of my work from the SoGE DPhil office – it has been such an encouraging environment and through the friendship of my colleagues, I have learnt to cultivate compassion and be grateful for each writing up stage. Many thanks to Balqis Mohamed Rehan, Julia Wagemann and Takeshi Inagawa for the fantastic help with analysing the functional diversity data using the unfamiliar R software and an even more alien R Script. Heart-felt gratitude also goes to Hannah Dawson, Jonathan Balls and Vimal Balasubramaniam for voluntarily proof-reading some of my near-final thesis chapters, helping to detect glaring blips that my tired eyes could not spot and helping me to improve my mechanisms of expression. A big thank you also goes to the OUCE IT support staff, especially Tim Churchouse, who went beyond his call of duty to offer incredible support when my laptop started to crash two weeks prior to handing in my thesis – I doubt I would have submitted this thesis by the set deadline were it not for the extra support, including a backup laptop, that helped me to manage the extra pressure during this final hurdle. A special thank you to my GP and nutritionist, who went out of their way to equip me with 'extreme self-care' tools whenever the intense academic pressure knocked me down. Their bounce-back strategies have proved especially critical during this final leg – many thanks for teaching me these life-long habits!

Finally, but by no means the least, I am grateful to my creator and closest friend, for the gift of sound health and mind, the incredible potential imparted in me and enabling me to finish strong – it has been a truly remarkable Past having Doubt (PhD) journey.

## **Table of contents**

<b>Thesis abstract .....</b>	<b>ii</b>
<b>Acknowledgements .....</b>	<b>iv</b>
<b>Table of contents.....</b>	<b>viii</b>
<b>List of figures .....</b>	<b>xv</b>
<b>List of tables .....</b>	<b>xx</b>
<b>Definition of terms and key concepts.....</b>	<b>xxii</b>
<b>1 Introduction .....</b>	<b>1</b>
1.1 Weaknesses of the global food system .....	1
1.2 Alternatives to the present global food system .....	7
1.3 Agrobiodiversity challenges and opportunities for smallholder farmers.....	11
1.4 Kenyan policy context and linkages to agrobiodiversity .....	16
1.5 Impacts of underutilisation of agrobiodiversity .....	22
1.6 Thesis aims, objectives and structure .....	23
<b>2 Literature review and conceptual framework .....</b>	<b>29</b>
2.1 Food security at the global, regional and local levels.....	30
2.2 Drivers of agrobiodiversity at the farm level .....	34
2.3 Gender roles in smallholder farming systems.....	39
2.4 Agriculture-nutrition linkages in smallholder farming systems .....	41
2.5 Markets and their role in regional food security.....	43
2.6 Recent Kenyan policies shaping the agricultural sector .....	49
2.6.1 <i>Incentives and disincentives in the context of agrobiodiversity management and marketing .....</i>	<i>51</i>

## Table of contents

2.7	Conceptual framework guiding the study .....	54
2.7.1	<i>The multiple dimensions of food security</i> .....	54
2.7.2	<i>Food security in the context of global environment change: the food system concept</i> .....	56
2.7.3	<i>Application of the food system concept at the household level</i> .....	57
2.7.4	<i>Extent of local agrobiodiversity utilisation for household food security</i> .	65
2.8	Summary and knowledge gaps .....	68
<b>3</b>	<b>Methodology overview .....</b>	<b>71</b>
3.1	Overview of the study area and research boundaries.....	71
3.2	Overview of the data collection methods.....	76
3.2.1	<i>Quantitative data</i> .....	78
3.2.2	<i>Qualitative data</i> .....	79
3.3	Research Ethics.....	79
3.4	Methodological approaches and possible success factors .....	79
3.4.1	<i>Farm surveys</i> .....	79
3.4.2	<i>Focus group discussions</i> .....	83
3.4.3	<i>Market surveys</i> .....	89
3.4.4	<i>General reflections</i> .....	90
3.5	Study limitations and data manipulation .....	98
<b>4</b>	<b>Paper 1: Variability of on-farm food plant diversity and its contribution to food security: A case study of smallholder farming households in Western Kenya</b>	<b>102</b>
4.1	Abstract.....	102
4.2	Introduction.....	103

## Table of contents

4.3	Methodology .....	108
4.3.1	<i>Study area and data collection</i> .....	108
4.3.2	<i>Data analysis</i> .....	111
4.4	Results.....	114
4.4.1	<i>Plant species richness and diversity variation</i> .....	116
4.4.2	<i>Biophysical and socio-economic factors affecting food plant species richness and diversity parameters</i> .....	119
4.4.3	<i>Household food security and on-farm agrobiodiversity</i> .....	126
4.5	Discussion.....	128
4.5.1	<i>Patterns of food plant species richness and diversity</i> .....	128
4.5.2	<i>Biophysical and socio-economic factors influencing food plant richness and diversity</i> .....	130
4.5.3	<i>Contribution of agrobiodiversity of the surveyed farms to family food and nutrition security</i> .....	133
4.6	Conclusions.....	139
4.7	Acknowledgments .....	141
<b>5</b>	<b>Paper 2: Influence of seasonal on-farm diversity on dietary diversity: A case study of smallholder farming households in Western Kenya</b> .....	<b>142</b>
5.1	Abstract.....	143
5.2	Introduction.....	144
5.3	Methodology .....	147
5.3.1	<i>Study area and data collection</i> .....	147
5.3.2	<i>Data analysis</i> .....	150
5.4	Results.....	153

## Table of contents

5.4.1	<i>Household and on-farm agrobiodiversity characteristics.....</i>	153
5.4.2	<i>Seasonal comparison of food scores at household and individual level</i>	158
5.4.3	<i>Associations across indicators of dietary and farm diversity in the two seasons</i>	161
5.5	Discussion.....	165
5.5.1	<i>Seasonal food consumption and sources.....</i>	166
5.5.2	<i>Relationship between on-farm and dietary diversity.....</i>	169
5.5.3	<i>Non-farm production factors influencing dietary diversity.....</i>	170
5.6	Conclusions.....	174
5.7	Acknowledgments .....	175
<b>6</b>	<b>Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security: A case study of smallholder farming households in Western Kenya.....</b>	<b>177</b>
6.1	Abstract.....	178
6.2	Introduction.....	179
6.3	Methodology.....	183
6.3.1	<i>Study area and data collection.....</i>	183
6.3.2	<i>Data analysis.....</i>	188
6.4	Results.....	191
6.4.1	<i>Characteristics of surveyed smallholder farming households .....</i>	191
6.4.2	<i>Species and nutrient diversity through on-farm and market food species</i>	193
6.4.3	<i>On-farm food shortage months and cultural perceptions of foods.....</i>	197
6.4.4	<i>Preferences for different farming systems.....</i>	201

## Table of contents

6.5	Discussion.....	202
6.5.1	<i>Availability and accessibility of nutrients in different seasons .....</i>	<i>202</i>
6.5.2	<i>Food shortage months coincide with low preference for a diversity of local foods .....</i>	<i>204</i>
6.6	Conclusions.....	209
6.7	Acknowledgments .....	210
<b>7</b>	<b>Paper 4: Challenges and opportunities for market integration to improve food security: A case study of smallholder farming households in Western Kenya.....</b>	<b>211</b>
7.1	Abstract.....	212
7.2	Introduction.....	213
7.3	Methodology.....	216
7.3.1	<i>Study area and data collection .....</i>	<i>216</i>
7.3.2	<i>Data analysis .....</i>	<i>219</i>
7.4	Results.....	220
7.4.1	<i>Profile of the local markets and market traders.....</i>	<i>220</i>
7.4.2	<i>Main foods available in markets and for household food consumption. ....</i>	<i>224</i>
7.4.3	<i>Pre- and post-harvest losses.....</i>	<i>227</i>
7.4.4	<i>Participation in local market trading system .....</i>	<i>228</i>
7.5	Discussion.....	230
7.5.1	<i>Smallholder farming households rely on multiple food sources .....</i>	<i>230</i>
7.5.2	<i>On-farm production as a food source.....</i>	<i>230</i>
7.5.3	<i>Markets and social networks as a food source.....</i>	<i>232</i>
7.5.4	<i>Smallholder farming households rarely sell their surplus on-farm produce in the formal markets.....</i>	<i>233</i>

## Table of contents

7.5.5	<i>Market traders mainly source produce from distant areas</i> .....	236
7.5.6	<i>Organised smallholder farmers stand to benefit by filling in market gaps</i> 238	
7.6	Conclusions.....	241
7.7	Acknowledgments .....	241
<b>8</b>	<b>Overall conclusions.....</b>	<b>243</b>
8.1	Summary of research questions addressed .....	243
8.2	Individual study findings .....	246
8.3	Combined study findings .....	252
8.4	Study recommendations.....	257
8.5	Study limitations and areas of future research .....	263
<b>9</b>	<b>Appendices .....</b>	<b>267</b>
9.1	Appendix I: Species Lists .....	267
9.1.1	<i>Species List 4.1</i> .....	267
9.1.2	<i>Species List 6.1</i> .....	273
9.1.3	<i>Species List 7.1</i> .....	282
9.2	Appendix II: Co-author declarations .....	286
9.3	Appendix III: Additional thesis output - policy brief .....	289
9.4	Appendix IV: Questionnaires .....	291
9.4.1	<i>Farm survey September/October 2012</i> .....	291
9.4.2	<i>Farm survey November/December 2012</i> .....	295
9.4.3	<i>Farm survey July/August 2014</i> .....	304
9.4.4	<i>Focus group discussion guidelines (facilitator's version): September/October 2012</i> .....	315

## Table of contents

9.4.5	<i>Focus group discussion guidelines (note taker's version):</i>	
	<i>September/October 2012</i> .....	328
9.4.6	<i>Market survey September/October 2012</i> .....	334
9.4.7	<i>Market survey July/August 2014</i> .....	336
9.5	Appendix V: Food plant and livestock standardised measurements .....	338
	<b>References</b> .....	<b>341</b>

## List of figures

- Figure 2.1:** Conceptual framework investigating the economic and nutrition contribution of local agrobiodiversity among smallholder farmers (through market, on-farm, dietary and nutritional diversity) using four empirical chapters (Papers 1 to 4) with nine research questions (RQ 1.1 to 1.9) in leading to household food system activities and ultimately household food security outcomes (food system activities and food security outcomes adapted from Ericksen *et al.* (2010)). Local agrobiodiversity, as a set of food system activities, contributes to household food security outcomes, and the four papers (Papers 1 to 4) depict the inter-linkages across the three household food security outcomes – food availability (a), accessibility (b) and utilisation (c). Thus, these four papers map onto the conceptual framework in a cyclical manner, finally closing the ‘local agrobiodiversity circle’..... 58
- Figure 3.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kilingili, E=Mudete , F= Chavakali, G= Majengo ..... 73
- Figure 3.2:** farm walk with farmers (far left and far right) identifying their plant and livestock species ..... 80
- Figure 3.3:** Pictorial scale indicating the different levels of on-farm agrobiodiversity in one men-only (left side) and one women-only (right side) group..... 86

## List of figures

- Figure 3.4:** Women-only (left-side) and men-only (right side) group members participating in matrix and group ranking exercises, respectively ..... 89
- Figure 3.5:** Interview with a market trader selling grains and pulses ..... 90
- Figure 4.1:** Map of the study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga districts mainly categorised as humid Lower Midland (LM 1) and humid Upper Midland (UM 1) agro-ecological zones, respectively. The sampling sites indicating the six villages (triangular symbols) are coded as: 1=Khushipari A, 2= Emahanga, 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo ..... 110
- Figure 4.2:** Summed Dominance Ratio (SDR) of food plant species grouped into seven food groups, cultivated on 15 farms surveyed each in Mumias and Vihiga districts, Western Kenya, in 2012 ..... 118
- Figure 4.3:** Classification dendrogram as a result of hierarchical cluster analysis (minimum variance method, squared Euclidean distances) on the basis of natural log (log e) transformed densities of 59 plant species cultivated in 26 farms in 6 villages of Mumias and Vihiga districts, Western Kenya. The thick dotted line marks the cut-off point to define the correct number of clusters according to the ‘elbow’ criterion. The alphanumeric codes in the clusters refer to the 26 farm codes (with V for Vihiga and M for Mumias farms). Out of the 30 farms in this study, four farms (M-143, M-146, V-014 and V-129) were identified as outliers and excluded from this analysis ..... 122
- Figure 4.4:** Summed Dominance Ratio (SDR) of food plant species grouped into seven food groups, cultivated on 26 farms grouped into three clusters and surveyed in Mumias and Vihiga districts, Western Kenya, in 2012 ..... 126
- Figure 4.5:** Proportion of food consumed during the last five times and produced on the farm, sorted by the different food groups for the three cluster types in Mumias and

## List of figures

Vihiga districts, Western Kenya. Remaining percentages of food were procured through local markets or social networks. Please note that for the food groups ‘spices/condiments’, ‘animal source foods’, ‘sugarcane’ and ‘starchy roots/tubers/green bananas’, respondents could not remember the last five times they consumed it and only provided information on the last one to four times of consumption. .... 127

**Figure 5.1:** Map of the study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga districts mainly categorised as humid Lower Midland (LM 1) and humid Upper Midland (UM 1) agro-ecological zones, respectively. The sampling sites indicating the six villages (triangular symbols) are coded as: 1=Khushipari A, 2=Emahanga, 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo (Source: Ng’endo *et al.* (2015))..... 148

**Figure 5.2:** Proportion of main uses of on-farm produce, sorted by the different food groups, during September/October 2012 planting season (PS) and July/August 2014 harvesting season (HS) among smallholder farming households in Mumias and Vihiga districts, Western Kenya..... 157

**Figure 5.3:** Proportion of different household members (%) consuming each food group according to the dietary diversity score (DDS) categories, interviewed during two seasons in Mumias and Vihiga districts (n=30). Twelve food groups (fg) are selected for the household DDS according to FAO (2011) ..... 159

**Figure 5.4:** Proportion of women (%) consuming each food group according to the dietary diversity score (DDS) categories, interviewed during two seasons in Mumias and Vihiga districts (n=30). Nine food groups (fg) are selected for the women DDS according to FAO (2011)..... 160

List of figures

**Figure 5.5:** Proportion of overall household members and women (%) consuming each food group in Mumias and Vihiga districts interviewed during July/August 2014 harvesting season in Mumias and Vihiga districts (n=30). Eight food groups are selected according to WFP (2008) ..... 161

**Figure 6.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kilingili, E=Mudete , F= Chavakali, G= Majengo ..... 184

**Figure 6.2:** Functional diversity dendrograms comparing on-farm food species richness and average functional diversity (FD) during the 2012 and 2014 seasons in 30 smallholder farms of Mumias and Vihiga districts, Western Kenya. The dendrogram species are clustered based on their content of seven nutrients under investigation, coded as: 1=Carbohydrates, 2= Proteins, 3= Vitamin A , 4= Vitamin C, 5= Folic acid, 6= Iron, 7=Zinc. Missing species in either dendrogram indicate those unavailable in that particular season, but present in the other season. Species in bold indicate those that are unique to that season ..... 195

**Figure 6.3:** Functional diversity dendrograms comparing highly accessible food species during the 2012 and 2014 seasons in seven markets of Mumias and Vihiga districts, Western Kenya. With the exception of zinc, these market species are rich in the remaining six nutrients under investigation, coded as: 1=Carbohydrates, 2= Proteins, 3= Vitamin A , 4= Vitamin C, 5= Folic acid, 6= Iron. Missing species in each dendrogram

## List of figures

indicate those that are not highly accessible in that particular season, though in most cases they may still be available but accessible at low or medium levels..... 196

**Figure 6.4:** On-farm seasonal availability of major food groups as perceived by focus group discussion participants (n=97) with corresponding hunger months as perceived by smallholder farming households in Mumias and Vihiga districts in 2012 (n=30) ..... 198

**Figure 7.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kilingili, E=Mudete , F= Chavakali, G= Majengo ..... 218

**Figure 7.2:** Food sources for the different food groups given as the last five consumptions among households in Mumias (M) and Vihiga (V) districts between November and December 2012, N=30 (15 per district) ..... 225

**Figure 7.3:** Main food uses of on-farm products among households in Mumias (M) and Vihiga (V) districts between September and October 2012, N=30 (15 per district).... 226

## List of tables

<b>Table 4.1:</b> Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold <i>et al.</i> (2005)) .....	108
<b>Table 4.2:</b> Socio-economic and demographic characteristics (means, medians or percentages; ranges given in brackets) of 30 smallholder farmer households and their farms surveyed in six villages of Mumias and Vihiga districts, Western Kenya, n=5 per village .....	115
<b>Table 4.3:</b> Results of stepwise multiple linear regression analyses using food plant species richness and diversity parameters as well as fruit tree richness and diversity surveyed on 30 farms in Mumias and Vihiga districts, Western Kenya, as dependent variables and selected farm and socio-economic household characteristics as independent variables .....	120
<b>Table 4.4:</b> Farm, socio-economic and food plant species diversity characteristics (ranges in brackets) of 30 farms grouped into three clusters and two outlier farm types, surveyed in Mumias and Vihiga districts, Western Kenya .....	124
<b>Table 5.1:</b> Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold <i>et al.</i> (2005)) .....	149
<b>Table 5.2:</b> General characteristics of 30 smallholder farmer households in Mumias and Vihiga districts, Western Kenya during July/August 2014 season .....	153
<b>Table 5.3:</b> Scores (hunger and food), main food sources and uses among 30 smallholder farming households during two seasons in Mumias and Vihiga districts, Western Kenya .....	156
<b>Table 5.4:</b> Correlations between socio-economic factors and food scores among 30 smallholder farming households during two seasons (September/October 2012 planting	

## List of tables

season (PS) and July/August 2014 harvesting season (HS)) in Mumias and Vihiga districts, Western Kenya.....	164
<b>Table 6.1:</b> Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold et al. (2005)).....	185
<b>Table 6.2:</b> General characteristics of 30 smallholder farming households in Mumias and Vihiga districts, Western Kenya.....	192
<b>Table 7.1:</b> Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold et al. (2005)).....	216
<b>Table 7.2:</b> Frequency of products in seven markets in Mumias and Vihiga districts, Western Kenya, in September/ October 2012 .....	221
<b>Table 7.3:</b> Overlaps and gaps in products available in seven markets and on 30 farms in Western Kenya, between September and October 2012 .....	223
<b>Table 7.4:</b> Types of market traders and origin of products in the seven markets in Mumias and Vihiga districts, in September/October 2012 .....	229

## Definition of terms and key concepts

**Traditional foods** Refers to indigenous (those whose primary or secondary centre of origin is known to be in a specific place) or introduced foods, which due to long use have become a part of the culture of a people (Abukutsa-Onyango, 2010).

**Orientation of smallholder farming production systems** The thesis distinguishes two main smallholder farming production systems, by grouping surveyed farms in different clusters:

- pure subsistence-oriented production systems: farms focusing on subsistence-only food crops (for example, the ‘cereal farm’ cluster )
- market-oriented production systems: farms integrating some commercial crops, which can result in different levels of commercial orientation of farm production (for example, the ‘long-standing cereal-sweet potato farm’ and ‘large sugarcane farm’ clusters)

See **Figure 4.3** and Paper 1 Section 4.5.3 for more discussion on this issue.

**Wealth indicator measurements** The thesis makes use of two different but correlated wealth indicator measures to differentiate the smallholder farming households’ socio-economic status (for example, poor/rich; low/middle/high-resourced). The two wealth indicators are:

## Definition of terms and key concepts

- Tropical Livestock Units (TLUs): as a wealth indicator proxy, the TLU per household member was calculated using livestock units coefficients for the sub-Saharan Africa region (Chilonda and Otte, 2006) to represent a common unit for the different types and numbers of livestock present. See Paper 1 Section 4.3.2 for more details on its use.
- Wealth index: to calculate this index using the standardised Principal Component Analysis (PCA) method (Filmer and Pritchett, 2001), the thesis makes use of 13 variables on living conditions and household assets. See Paper 2 Section 5.3.2 for more details.

## **1 Introduction**

Maintaining agricultural biodiversity (agrobiodiversity) is an approach that entails greater use of biodiversity to ensure dietary diversity. This thesis assesses the extent of agrobiodiversity on smallholder farms and in local markets and relates these to food intake and perceptions of food security among smallholder farming households in Western Kenya. In subsequent chapters, different elements of the study are elaborated. This chapter discusses the research in relation to the literature and trends around land use change, climate change, urbanisation and nutrition transition. The aims and objectives of this study are also addressed.

### **1.1 Weaknesses of the global food system**

For the past 50 years, there has been a consistent increase in global supply (Khoury *et al.*, 2014) and consumption of food from plant and animal sources (Kearney, 2010). Despite the global agricultural surpluses, more than one billion people still remain hungry (Ponisio *et al.*, 2015), with rising numbers contending with micronutrient deficiencies (von Grebmer *et al.*, 2014). This paradox is in part explained by agricultural growth that is increasingly accompanied by a narrowing of the existing diversity, which is likely to jeopardise food and nutrition security efforts (Khoury *et al.*, 2014; Puma *et al.*, 2015), with many people still lacking access to diverse healthy foods (Kremen *et al.*, 2012). Globally, around 94 plant species account for 90 per cent of the world's food crops (Khoury *et al.*, 2014) and just three crops (maize, rice and wheat) account for close to 60 per cent of the calories obtained from plants (Tilman *et al.*, 2011). With the total livestock diversity of about 40 species also getting eroded

## Chapter 1: Introduction

(Pattison *et al.*, 2007), the over-reliance on only a handful of crops and even fewer animals for a large proportion of people's calorific intake makes the global food system highly unsustainable in numerous ways, four that resonate with this thesis.

Firstly, the limited variety of the crops and animals used for food is increasingly resulting in land use change from polyculture into simplified monoculture systems. As these monocultures lack diversity, which is vital for the provision of ecosystem services and reduced dependence on off-farm agricultural inputs (Kremen and Miles, 2012), this transition is accompanied by intensive management practices, such as the application of agricultural inputs to guarantee yields (Gonthier *et al.*, 2014). The need for additional inputs (fertilisers, pesticides and improved seeds) renders intensified monocultures a high-cost but short-term approach. This is already unaffordable, especially for low-capital endowed farmers (FAO, 2010a), and is having deleterious effects on the environment in the long run (Kremen and Miles, 2012). Even with increased economic access to agricultural inputs, there is a declining trend in yields from these 'global' crops (Grassini *et al.*, 2013; Ray *et al.*, 2013) as compared to those from diverse farming systems (Waha *et al.*, 2012).

Secondly, the changing climate is affecting agricultural systems all over the world (Luedeling *et al.*, 2014), especially in its variability and extremities (Thornton *et al.*, 2014). The impacts on food security in countries with high hunger rates are worse than others (Wheeler and von Braun, 2013; Thornton and Lipper, 2014). So far, the majority of studies that have attempted to link climate change and food security have emphasised food production and availability as opposed to the multi-dimensional nature of food

security (Ziervogel and Ericksen, 2010; Thornton *et al.*, 2014). Even so, comparing the well-studied monoculture (Luedeling *et al.*, 2014) to the less-studied diverse agricultural production types (Thornton and Lipper, 2014) suggests that diverse systems offer a clear advantage in the face of the changing climate. This is especially the case when shifts in suitable environmental conditions for species occur (Gallagher *et al.*, 2013; Barbet-Massin and Jetz, 2015), which could in turn result in species loss (Gallagher *et al.*, 2013). The functional traits of diverse systems provide a buffer for the maintenance of ecosystem functioning of animal (Bihn *et al.*, 2010) and crop (DeClerck *et al.*, 2011; Remans *et al.*, 2011) species through redundancy offered by multiple species with similar functions (Gallagher *et al.*, 2013), and functionally unique species that add distinct traits to the functional diversity (Bihn *et al.*, 2010). However, diverse systems are complex ecosystems, where besides climate change variability, other multiple non-environmental factors interact simultaneously, particularly socio-economic and political circumstances (Vermeulen *et al.*, 2012b; Thornton *et al.*, 2014), further making it difficult to predict climate change impacts in these food systems (Gregory *et al.*, 2005; Morton, 2007; Thornton *et al.*, 2014). Furthermore, the link between climate change and food security remains complicated as it is not just because food production and availability are affected by multiple factors, but so are the other food security components that make up the food system, such as access and utilisation of food (Ziervogel and Ericksen, 2010; Ingram, 2011; Thornton *et al.*, 2014). Despite the uncertainty on how climate change will affect different food systems in the future, agricultural systems still need to take action (Vermeulen *et al.*, 2012a) by increasing peoples' adaptive capacity (Thornton *et al.*, 2014), particularly their ability to either

## Chapter 1: Introduction

move up or out of agriculture by diversifying agricultural or livelihood sources (Maass *et al.*, 2014; Thornton and Lipper, 2014).

Besides changes in land use and climate, population increase and urbanisation are other challenges affecting food systems (Misselhorn *et al.*, 2012). Higher population growth results in not only greater migration to urban areas but it is also likely to result in increased income growth and food demand, which in turn shapes food consumption and composition patterns (Regmi and Meade, 2013; Herforth and Ahmed, 2015). With increased incomes, decreased consumption of basic staples (such as cereals) is replaced by greater demand for higher-value foods such as animal source foods, fruits and vegetables (Regmi and Meade, 2013). In addition, increased awareness of the health benefits of micronutrient-rich traditional foods sustains their great demand in urban areas (Ngugi *et al.*, 2007), for example, African leafy vegetables (Gotor and Irungu, 2010; Muhanji *et al.*, 2011; Chege *et al.*, 2015). The concomitant expansion of high-value markets such as green groceries, open markets, supermarkets and established institutions (for example hospitals, schools and hotels) in both big and small towns in developing countries (Ngugi *et al.*, 2007), provides opportunities for farmers to participate as sellers in these new supply channels (Rao and Qaim, 2010). Transition from the sporadic farm gate sales to supplying farm produce to these retail or wholesale markets that are associated with more secure prices (Rao and Qaim, 2010) improves the livelihood of farmers. For example, by providing farmers with higher incomes which in turn increases their economic access to food and spurs higher farm productivity (Chege *et al.*, 2015).

## Chapter 1: Introduction

The proliferation of supply chain actors comes with the demand for consistently high-quality supplies and thus capital-endowed farmers (such as large scale farmers or those who engage in off-farm activities) are more likely to benefit the most from supplying these niche markets (Rao and Qaim, 2010). However, it remains difficult for smallholder farmers to meet this growing demand for high-value produce (Lie *et al.*, 2012; Andersson *et al.*, 2015) as most of them lack the necessary technical, entrepreneurial and organisational skills, among other constraints (Ngugi *et al.*, 2007; Lie *et al.*, 2012). These challenges in turn trigger the majority of risk-averse smallholder farmers to shift back to the safer but lower valued and demanded crops (such as cereals), trapping them in the vicious subsistence production poverty cycle (Fanjul and Guerena, 2009). A few market-oriented smallholder farmers have been able to tap into these niche markets through producer organisations, such as co-operative societies, that are gaining renewed interest in many developing countries (Fanjul and Guerena, 2009; Nyang *et al.*, 2010). However, these rural producer organisations do not necessarily reach the poorest of smallholder farmers (Bernard and Spielman, 2009), for example those with low education levels, which has spurred a new wave of institutional support ranging from short-term public-private partnerships (Lie *et al.*, 2012) to long-standing market development agencies utilising innovative business approaches. While the impacts on smallholder farmers' growing participation in these modern supply chains are manifold (Pellegrini and Tasciotti, 2014; Qaim *et al.*, 2014; Chege *et al.*, 2015), there is still limited understanding on how the different market opportunities support the availability and accessibility of a diversity of foods besides those currently in high demand in the niche markets (McDermott *et al.*, 2015). In addition, impacts of market

## Chapter 1: Introduction

participation on household nutrition and health are not well understood (Qaim *et al.*, 2014; Chege *et al.*, 2015).

Finally, agriculture is not just about food production and income generation but also nutrition (Haddad, 2013). Agriculture for food production mainly applies where food markets are weak (Haddad, 2013; Hoddinott *et al.*, 2014; Sibhatu *et al.*, 2015), but adequate access to markets is likely to substitute for farm production diversification (Hoddinott *et al.*, 2014). This suggests that the linkage between farm production diversity and dietary diversity doesn't universally exist (Sibhatu *et al.*, 2015), calling for the need to change the current agricultural research focus from food production to that of the multi-dimensional nature of food systems if dietary diversity is to be improved (McDermott *et al.*, 2015). While pathways that link agriculture and nutrition are well known (Gillespie *et al.*, 2012; Haddad, 2013), evidence-based correlations on how agricultural interventions can improve nutrition remain weak (Haddad, 2013), with various challenges on explicitly bringing the nutrition agenda into focus, especially in developing countries (van Royen *et al.*, 2013; Lachat *et al.*, 2014). This has led to renewed interest by various international development stakeholders to change agriculture and food systems to enhance the nutrition impacts (Fanzo, 2014; Khoury and Jarvis, 2014; Lachat *et al.*, 2015; McDermott *et al.*, 2015). Diverse agricultural systems go a long way in providing the up to 51 different nutrients required by the human body in consistently adequate amounts (Graham *et al.*, 2007), for which a single crop or livestock species is unable to meet these diverse essential nutritional needs (DeClerck *et al.*, 2011). However, the nutritional value of food is not the only determinant on food use (Kayode *et al.*, 2005). Food consumption is influenced not only by its availability

and affordability but also by its convenience and desirability (Herforth and Ahmed, 2015), thus bringing into focus the much needed broader emphasis on what people value (Noack and Pouw, 2014). This in turn necessitates the nutrition-sensitive agriculture agenda to start from a focus on understanding factors limiting the consumption of nutritious diets, in particular, and to broaden from food availability to the wider food system agenda (McDermott *et al.*, 2015).

### **1.2 Alternatives to the present global food system**

The high vulnerability of the global food system makes it imperative to explore agricultural production alternatives to ensure food and nutrition security without causing further environmental degradation (Tscharntke *et al.*, 2012). Among the existing alternatives to conventional agriculture is ecological intensification whose core priority is increased efficient use of natural resources such as water, light and nutrients (Baudron *et al.*, 2012). However, this focus is likely to take precedence over a balance between nature and consumer needs (Zimmerer *et al.*, 2015), where it could even lower yields in regions still lagging behind in food production in the face of climate change, such as sub-Saharan Africa (Folberth *et al.*, 2014). More applicable models of eco-intensification have been implemented in the developing world, such as conservation agriculture, that not only ensures efficient natural resource use (Baudron *et al.*, 2012) but also holds the potential to improve crop yields especially during dry seasons (Thierfelder and Wall, 2010). However, its high labour and economic demands make this approach impractical for the majority of resource-constrained smallholder farmers in the developing world (Giller *et al.*, 2009; Marongwe *et al.*, 2011). While additional elements have been incorporated to increase its uptake, such as agroforestry (Bayala *et*

## Chapter 1: Introduction

*al.*, 2011) and positioning it as a nutrition-sensitive approach (Mayer, 2015), its adoption rates remain low in many places (Kassam *et al.*, 2009), including Eastern and Southern Africa (Baudron *et al.*, 2012). In addition, the knowledge intensiveness of this technical approach has been critiqued as overlooking the existing diversity in local farming knowledge and practices (Baudron *et al.*, 2012).

Agricultural biodiversity, commonly referred to as agrobiodiversity, refers to biological diversity components of relevance to food and agriculture (Frison *et al.*, 2006; Baidu-Forson *et al.*, 2012) from both cultivated and wild plant and livestock species (Powell *et al.*, 2015). Agrobiodiversity is a phenomenon that harnesses the available biological resources managed in agricultural landscapes (Kawa *et al.*, 2015). It's been recognised specifically for its importance to smallholder farming communities in rural areas not only to conserve important ecosystem services but also to increase productivity (Baidu-Forson *et al.*, 2012). However, agrobiodiversity is increasingly being replaced by monocultures resulting in the loss of biological and cultural diversity (Bisht *et al.*, 2014). While agrobiodiversity is likely to be a direct contributor to dietary diversity for subsistence-oriented rural households (Hoddinott *et al.*, 2014), many of these households in developing countries predominantly grow staple crops (Baiphethi and Jacobs, 2009; Hoddinott *et al.*, 2014). Staple foods are those that constitute a significant portion of a regular diet, for example rice, wheat and maize, supplying a large share of the daily calories of a population (Smale *et al.*, 2009). The lack of dietary diversity in these areas is still a problem as their diets are predominantly based on these staples (Ma *et al.*, 2008) and they also lack purchasing power to buy diversified foods (Meenakshi *et al.*, 2010).

Staple crops cultivated by the majority of poor farmers (such as maize, rice and cassava) can be bio-fortified with micronutrients (White and Broadley, 2009). This approach has been deemed a cost-efficient measure to tackle micronutrient deficiencies (Stein *et al.*, 2007; White and Broadley, 2009) in the absence of the difficult to implement dietary behaviour changes that are required to achieve dietary diversity (Ma *et al.*, 2008). While bio-fortification of many other crop varieties with adequate micronutrient levels are yet to be developed (Ma *et al.*, 2008), it is likely that when bio-fortification moves away from staple crops and single-nutrient focus, it can optimise its targeted approaches in supporting other nutrition interventions (Johns and Eyzaguirre, 2007). With the multiple challenges facing food systems, no single intervention can solve food and nutrition insecurity challenges (Johns and Eyzaguirre, 2007; Ma *et al.*, 2008), but will rather require a synergy among different approaches to achieve more.

Among the aforementioned approaches, this thesis focuses on the vastly underutilised local agrobiodiversity because it not only taps into the deep knowledge of traditional farming systems managed by rural farmers (Bisht *et al.*, 2014; Powell *et al.*, 2015) and the cultural diversity brought about by social interactions with other farmers (Cavechia *et al.*, 2014), but also takes into account the contribution of non-traditional livelihood diversification processes such as migration in enhancing agrobiodiversity (Zimmerer, 2014). Migrants may have higher on-farm agrobiodiversity due to their increased mobility and contact with outside communities (Shrestha *et al.*, 2002; Bernholt *et al.*, 2009). Agrobiodiversity's value has been recognised by some global players in agricultural research and development such as the Consultative Group for International

## Chapter 1: Introduction

Agricultural Research (Khoury and Jarvis, 2014), the World Bank (2011) and FAO (2014). There is in fact high agrobiodiversity, more so in some geographical regions than in others, which remains largely untapped. For example, it is suggested that compared to Europe and other developed countries, biodiversity is a main feature of African agriculture (Reyniers *et al.*, 2002) and the continent is a centre of diversity for crops such as millet and sorghum (Baidu-Forson *et al.*, 2012). Furthermore, in many developing countries, there is an abundance of less well-known agricultural species, commonly referred to as underutilised plant species (Gruere *et al.*, 2006). Yet these are the places that experience recurrent hunger, a loss of agrobiodiversity and an urgent need to improve agricultural systems (DeClerck *et al.*, 2011). The erosion of agrobiodiversity could be partly explained by the general trend towards contemporary monocultures that is likely to replace diverse land use systems (Netondo *et al.*, 2010; DeClerck *et al.*, 2011), resulting in underutilisation of readily available and accessible nutritious local foods. Yet with the changing climatic conditions, traditional agrobiodiversity could be better adapted to local conditions, and tapping into rural and urban markets to sell a diversity of nutritious produce to the burgeoning populations, such as indigenous vegetables (Gotor and Irungu, 2010; Muhanji *et al.*, 2011; Chege *et al.*, 2015), is likely to provide additional income to the food producers. The increased incomes are likely to enable access to diversified foods, especially during out-of-season periods, with an overall impact on bolstering household food and nutrition security. However, agrobiodiversity may not apply in all contexts, for example in low rainfall areas (Kandulu *et al.*, 2012). Even in conditions where it may work better, diversification also depends on many non-production factors, including consumer demand, marketing facilities and economic conditions (Graham *et al.*, 2007).

It is important to note that the aforesaid food security views, in addition to others, have their own narratives connected to them, with contrasting values, interests and power dynamics (Brunori *et al.*, 2015). Agrobiodiversity is just one of the many strategies, with inherent economic and political dimensions, beyond the diverse on-farm production by farmers (Coolsaet, 2015). While the agrobiodiversity discourse presents an opportunity for farmers to be involved in contributing to environmental solutions, their role and position in relation to consumers, for example in marketing their on-farm produce, requires access to financial resources, which may not be equally accessible to all farmers. Another element limiting their equal participation is that there might be misrepresentation of particular groups of farmers (such as the under-represented farmers) and the level of decision-making processes may not be all-inclusive, especially when it comes to who is authorised to deliberate and negotiate on their behalf (Coolsaet, 2015). Hence, while advocating for greater attention for agrobiodiversity, there exists a contestation of forces over its governance (for suggestions on addressing some of these issues, see Chapter 8 Section 8.4 recommendation 4).

### **1.3 Agrobiodiversity challenges and opportunities for smallholder farmers**

Africa has approximately 33 million smallholder farms (Altieri, 2008), representing 80 per cent of all farms in the region (World Bank, 2009; Garrity *et al.*, 2010). As the main food producers, the tendency of smallholder farmers in Africa losing out to large agribusinesses controlled by multinational corporations is making it difficult for them to compete in these global markets (Kremen and Miles, 2012). Food companies aiming to increase supply of particular crops while reducing labour costs offer smallholder

## Chapter 1: Introduction

farmers immense incentives, such as technical assistance at the production stage, credit and processing facilities and market access for monocultures (Kremen and Miles, 2012). For example, sugarcane smallholder farmers, contracted by sugar companies in Western Kenya, are mainly responsible for planting and weeding, while the sugar companies supply them with the necessary inputs and provide farm preparation, harvesting and transport services at a cost that is recovered after sugarcane processing by these sugar factories (Govere *et al.*, 1999). However, sugarcane growing in this sugar producing region has led to a decline in local agrobiodiversity (Netondo *et al.*, 2010), suggesting that provision of subsidies to a narrow range of crops jeopardises food and nutrition security in the long run (Khoury *et al.*, 2014), and is also likely to bring about other challenges. For example, provision of fertiliser and seed subsidies by national governments in other parts of East and Central Africa such as Malawi (Dorward and Chirwa, 2011) and Zambia (Mason *et al.*, 2013) has led to increased maize production in the short-term (Dorward and Chirwa, 2011). However, the high costs (Jayne and Rashid, 2013) and multiple implementation challenges (Ricker-Gilbert *et al.*, 2013) of these input subsidy programmes may outweigh its benefits (Jayne and Rashid, 2013).

On the one hand, the large number of smallholder farmers indicate the immense latent potential in their contribution to the attainment of both food and nutrition security. This is because integrated farming systems in which the smallholder farmer produces simultaneously grains, fruits, vegetables, fodder and animal products by using locally available production methods is likely to out-produce yields per unit of single crops such as monoculture maize on large scale farms (Altieri *et al.*, 2012). On the other hand, alternative livelihood sources are a trade-off with on-farm agrobiodiversity when

## Chapter 1: Introduction

households diversify into high-return activities. With their access to increased incomes, such farmers may choose to either diversify their farms (as they can purchase more inputs to guarantee yields such as improved seeds and fertilisers) or compensate for reduced agrobiodiversity (for example, by purchasing nutrient-rich foods from markets). However, in most cases, high-return activities are the reserve of wealthier farmers, not low capital endowed smallholder farmers. The majority of smallholder farmers diversify into low-return activities because they have little choice, engaging in activities such as petty trading at weekly rural markets (Barrett *et al.*, 2000) or selling their labour locally, which results in severe labour shortages on their own farms (Tittonell *et al.*, 2005). The time constraints of these casual labourers on other people's farms may result in lower on-farm agrobiodiversity on their own farms. Other than the shortage of labour for their own farm management, socio-economic factors such as poverty and poor access to agricultural inputs could also contribute to low on-farm agrobiodiversity on these smallholder farms (Kehlenbeck *et al.*, 2007). Thus, the nature of income diversification options affects the level of on-farm agrobiodiversity maintained. This concern is probably why FAO's latest report highlights the need for social protection so as to allow poor smallholder farmers to have greater choice by shifting the time previously dedicated to casual labour on other people's farms to better paying non-farm livelihood options or working on their own farms (FAO, 2015).

Despite the advantage of diverse farms in contributing to food and nutrition security, the under-utilisation of agrobiodiversity could also partly reflect the changing cultural and social food preferences, which is an overlooked dimension in the food security debate (Noack and Pouw, 2014). For instance, consumption of traditional foods had been

## Chapter 1: Introduction

considered backward and a sign of poverty (Frison *et al.*, 2006). At the same time, the trend towards more energy-dense but nutrient-poor westernised dietary preferences is rising especially in rural Africa (Keding *et al.*, 2013), while the cultural importance attached to the rich diversity of traditional foods is declining in both rural and urban areas. For example, in urban northern Benin, different sorghum varieties are available but only those with a particular texture and taste are preferred for use as a main meal (Kayode *et al.*, 2005). In rural Tanzania, sorghum is used predominantly during dry seasons as a replacement for the preferred but nutrient-devoid finely milled white maize flour used in preparing *ugali*, a cooked maize paste that meets the acceptable socio-cultural standard of a main meal (Ohna *et al.*, 2012).

The socio-cultural norms are also determined by how locally available foods are perceived. For example, in rural eastern Kenya and northern Ethiopia, most adults attach low value to indigenous fruits growing on their own farms (Fentahun and Hager, 2009; Kehlenbeck *et al.*, 2013). As they are freely available in the natural environment (Fentahun and Hager, 2009), most of these nutrient-dense fruit trees are regarded as food for children and adults instead consume exotic fruits which can only be purchased in markets (Kehlenbeck *et al.*, 2013). There is also a lower cultural preference for many of the indigenous vegetables and legumes, which are seen in many sub-Saharan African countries as a poor-man's crop (Renzaho, 2004; Keding *et al.*, 2013). The consumption of a diversity of other locally available foods may also be dependent on the local ethnicity, which shapes food customs, and in turn dictates the level of dietary diversity ultimately attained by the households (Savy *et al.*, 2006; Savy *et al.*, 2007; Keding *et al.*, 2012). Thus, the availability of a diversity of local foods and its consumption may

## Chapter 1: Introduction

be mediated by a myriad of socio-cultural factors. These developments have contributed towards a low cultural value and consumer preference for diversity of local foods and in so doing contributed to exacerbated rural poverty levels. Approximately 75 to 80 per cent of the poor and hungry people in Africa reside in rural areas (Livingston *et al.*, 2011) and it is expected that the rural poor will outnumber their urban counterparts for at least another generation (Rietbergen *et al.*, 2002). Smallholder farmers, producers of around 80 per cent of Africa's food supply, make up approximately 60 per cent of this rural population (FAO, 2012).

Kenya's total population in 2015 is estimated to be close to 47 million people, with around three quarters of the population residing in rural areas (United Nations Department of Economic and Social Affairs, 2014). As in other African countries, maize is the staple crop in Kenya, with over 90 per cent of the population depending on it and smallholder farmers accounting for 75 per cent of the country's maize production (Mwololo, 2010). While national maize reserves disbursed from the government silos may reach a proportion of the population during severe drought periods, seasonal food shortages are largely left unchecked, and hence adversely affect the main maize producers, who are smallholder farmers, the most. Kenya faces periodic food insecurity, either in form of periodic droughts resulting in failure of the predominantly rain-fed crops, or the more common seasonal food shortages. The seasonal food shortages, commonly referred to as "hunger gaps", occur during the pre-harvest periods of annual staples (Kehlenbeck *et al.*, 2013), when staple food reserves from a previous harvest season have run out. Despite Kenya having over 35,000 known species of animals, plants and micro-organisms (Government of Kenya, 2001), this local agrobiodiversity is

not utilised as a primary resource for food security, economic development and health (Frison *et al.*, 2006). The under-utilisation of locally available agrobiodiversity could point to the broader historical agricultural policy context of Kenya that has shaped its agrarian economy.

### **1.4 Kenyan policy context and linkages to agrobiodiversity**

This section discusses the policies in the agriculture and land sectors with the aim of drawing out the various incentives and disincentives that exist for the management of agrobiodiversity. Kenya's agricultural sector had been governed by over 130 pieces of legislation but many of these were out of date with the current economic realities (Argwings-Kodhek, 2005). One of the most authoritative land use documents, the Agriculture Act (Chapter 318), was enacted on 1<sup>st</sup> July 1955 by the parliament, with the aim of promoting and maintaining a stable agriculture, conserving soil and its fertility and stimulating development of sustainable land management (Government of Kenya, 1955). Since it was launched in the colonial times, most of the entrenched principles are outdated and in the context of sustainable land management practices, no links to promotion of agrobiodiversity are featured. Section 191.1 of the Act mandates establishment of authorities (government bodies) in cases where a particular crop should be promoted (Government of Kenya, 1955). The concentration of these pieces of legislation is on the sub-sectors that were traditionally considered as major export earners and were developed during the colonial times including dairy, coffee, tea and maize. The impacts that these organisations have had on smallholder farmers vary, especially with the collapse of some key agricultural and marketing organisations, leaving the smallholder farmer vulnerable with potentially no easily accessible market

## Chapter 1: Introduction

for their produce, hence acting as a disincentive, unlike a large scale farmer who has a competitive advantage due to economies of scale and hence can easily access alternative markets for their produce.

Since 2006, a number of policies, legal and institutional reforms have been carried out by the Ministry of Agriculture and new management systems adopted. The Ministry's strategic plan (2006-2010) was revised in order to embrace new strategies that address emerging issues and constraints (Government of Kenya, 2006). Among the strategic issues and corresponding objectives flagged together with their implementation strategies is the Agricultural Sector Development Strategy (ASDS) 2010-2020 (Government of Kenya, 2010). The ASDS marks an ambitious approach of umbrella policy approach by merging ten different sectors hence providing a more integrated policy framework with minimum duplication and increased efficiency (Government of Kenya, 2010).

While the ASDS comprehensively addresses the many issues underpinning domestic crop and animal production, the 2011 Food and Nutrition Security Policy (FNSP) sets out to ensure that the efforts by ASDS also result in improved quantity and diversity of foods to meet nutritional needs, by addressing food availability and accessibility, including local food production, to improve quantity and diversity of food to meet nutritional needs (Government of Kenya, 2011). The FNSP thus explicitly creating links between nutrition security and agrobiodiversity, by also encouraging promotion of home gardens and rearing of small livestock as a means of diversifying diets to address widespread micro-nutrient deficiencies (Government of Kenya, 2011). However, the

## Chapter 1: Introduction

FNSP equally acknowledges that food availability in Kenya is equated to sufficient maize supply, albeit its deleterious effects on limited nutritional diversity, especially on the development of children (Government of Kenya, 2011). This heavy reliance on maize is probably why there still remains an underlying emphasis on the cereal as the main crop for which measures have been put in place to address post-harvest losses, agro-processing and safety concerns (FNSP Section 2.3) (Government of Kenya, 2011). While the FNSP proposes to transform the ‘strategic grain reserve’ into a ‘strategic food reserve’ by including other food products, this is only limited as a food emergency response measure during critical food shortage periods (Government of Kenya, 2011).

Regarding the land sector, the Sessional Paper Number 3 of 2009 on Kenya National Land Policy (NLP) has heralded the first single clearly defined and codified land policy in Kenya (Government of Kenya, 2009). It comprises an overall framework and a set of principles to guide reforms in land administration and management and will form the foundation upon which the administrative and legislative framework will be built. The three key categories of land recognised in the policy are community land (previously referred to as trust land), public land (formerly referred to as government land) and private land (Government of Kenya, 2009). The NLP offers a wide array of incentives in the aim of ensuring land tenure security. It recognises community land and sets out procedures in ensuring security, protection and registration of community rights to land and land based resources taking into account multiple interests of all land users, including women (Government of Kenya, 2009). Section 66d of the NLP incorporates mechanisms for community land management and dispute resolution as well allocating feasible options for members opting out of communal arrangements (Government of

## Chapter 1: Introduction

Kenya, 2009). Section 80b of the NLP will create flexible leasehold interests out of public, community and private land and it further gives an allocation of sharing leasehold rights (Government of Kenya, 2009). Section 84c also eliminates multiple land ownership and allocation of public land, which had exacerbated land insecurity (Government of Kenya, 2009). The process of land adjudication which entails individualisation of tenure had been a lengthy process, proving as a predicament especially for smallholder farmers who are unwilling to invest their limited capital with little or no surety of land security. The NLP ensures that land adjudication and consolidation processes are speedy, transparent and accountable and endeavours to complete on-going processes of adjudication and consolidation, as stipulated in Section 86 of the NLP (Government of Kenya, 2009). Additionally, succession processes have been ambiguous hence the NLP will educate Kenyans on the Law of Succession Act and disseminate information at accessible places such as markets and at the lowest administration levels as indicated in Section 91 of the NLP (Government of Kenya, 2009). However, the improved delivery services will need to be financed, and the establishment of a land taxation regime to facilitate efficiency in revenue collection, as stated in Section 168 (Government of Kenya, 2009), may prove to be a disincentive to smallholder farmers who already undergo excessive taxation when compared to their modest earnings. Furthermore, the NLP aims to privatise delivery of some of the services such as revenue collection, valuation, surveying and physical planning, as stated in Section 253 (Government of Kenya, 2009). Although this is an efficient tool, it may prove to be more costly to the smallholder farmers, both directly and indirectly in the sense that the surveying and valuation costs incurred may not be necessarily subsidised. In addition, the private surveyors who may have been contracted by the

## Chapter 1: Introduction

Ministry of Lands may not necessarily be facilitated hence in some inaccessible areas, the officers in charge may be demotivated to perform their duties.

In most households, most of the smallholder farmers engaging in the day-to-day farming activities are women and the youth. Women's rights have been protected especially through the requirement for joint spousal registration, joint spousal consent to land disposals, inheritance of unmarried daughters, as set out in Section 223 of the NLP (Government of Kenya, 2009). The barrier on land ownership due to one being a minor has been abandoned (Government of Kenya, 2009), providing a key incentive to youth and children, especially orphans. The rights of spouses and children are taken into account before private rights to land are taken into account, as stipulated in Section 68b (Government of Kenya, 2009). It also ensures that private land is held and transmissible without discrimination on grounds of sex, ethnicity or geographical origin as set out in Section 68e (Government of Kenya, 2009). Equal matrimonial rights have also been articulated in Section 225 of the NLP whereby rights of widows, widowers, divorcees are entitled to 'co-ownership of matrimonial property' (Government of Kenya, 2009). It also requires the involvement of spouses before selling and mortgaging family land (Government of Kenya, 2009). Further, it offers an incentive by virtue that land rights can be acquired by inheritance, with or without a will, as stipulated in Section 89. Family interests in land are also protected, whereby customary land rights are deemed to amount to ownership (Government of Kenya, 2009).

The NLP promotes sustainable land management principles in various ways. It will establish appropriate fiscal incentives to encourage optimal utilisation of private land

## Chapter 1: Introduction

and discourage land speculation as indicated in Section 68f (Government of Kenya, 2009). It also recognises traditional knowledge related to land-based resources and provides incentives for communities and individuals to invest in income-generating resource conservation programs, as stated in Section 69 (Government of Kenya, 2009). The NLP stipulates provision of appropriate incentives and sanctions to ensure land owners use land productively and sustainably and that there is no idle land (Government of Kenya, 2009).

Section 106 intends to introduce provision for implementation of cluster settlements so as to stop uncontrolled subdivision of land (Government of Kenya, 2009). The NLP proposes to determine the minimum land sizes according to different agro-ecological zones (Government of Kenya, 2009), which will be a disincentive to smallholder farmers, as they are unlikely to have the set minimum land sizes. According to the government of Kenya's (2010) estimates, smallholder farms in Kenya mainly range in size from below 0.2 to 3 ha. Section 120 of the NLP states that the government will provide incentives to stimulate voluntary readjustment of land sizes as well as review and provide for laws encouraging shared proprietorship, time sharing of land and property as opposed to individual ownership only (Government of Kenya, 2009). The voluntary approach may be the most practical route, as the promotion of conformity of land subdivisions with the set minimum economically viable land sizes is likely to meet high resistance. This issue still needs to be tackled creatively and in a participatory manner, especially as farm size is an important consideration for agrobiodiversity management. In this study, land scarcity was mentioned as a key disincentive for

maintaining agrobiodiversity by focus group discussion participants (see Paper 3 Section 6.4.4 for more details).

### **1.5 Impacts of underutilisation of agrobiodiversity**

Kenya is constantly confronted with food shortfalls and the rate of multiple forms of malnutrition, especially under-nutrition, is still high (Ekesa *et al.*, 2009). Overall, there are approximately 5.6 million people who are food insecure in Kenya and 50 per cent of the children below the age of five years suffer from under-nutrition (Abukutsa-Onyango, 2010). Children living in rural areas are moderately and severely stunted to a greater extent (37%) when compared with urban children (26%) and they are also more likely to be underweight (17%) than urban children (10%) (KNBS and ICF Macro, 2010). The double burden of under- and over-nutrition in some other parts of the world (Doak *et al.*, 2005) is also catching up in rural Africa, where there is an increase in overweight and obese adults as the trend towards more energy-dense but nutrient-poor westernised dietary preferences (such as sugar, black tea, high-fat breads and cakes) is rising (Keding *et al.*, 2013). Western Kenya, one of the high potential rural areas in Kenya (Jaetzold *et al.*, 2005) that is endowed with high levels of agrobiodiversity, also faces this burden of under- and over-nutrition (KNBS and ICF Macro, 2010) (See **Table 6.2** for details on the anthropometrics in the case study areas). With its high population density, Western Kenya is also characterised by a predominance of smallholder farms (Henry *et al.*, 2009). The decreased utilisation of agrobiodiversity has led to a simplification and decrease in the diversity of a large number of people's diets, relegating them to a limited number of energy foods that do not confer nutrients in the

required amounts (Ekesa *et al.*, 2009). Moreover, it is likely that if the locally available agrobiodiversity is harnessed, it can cheaply improve food security and nutritional status among these poor households (Ekesa *et al.*, 2009). Therefore, there is a need to understand the role of crop and livestock agrobiodiversity in contributing to smallholder farming households' food and nutrition security. While crops and livestock are integral parts of the local agrobiodiversity, this thesis focuses more on food plant and less on livestock diversity. Despite this, livestock numbers, productivity and the contribution of animal source foods to household food and nutrition security are reported in all the empirical chapters of the thesis.

### **1.6 Thesis aims, objectives and structure**

The overall aim of the thesis is to examine the availability, utilisation and linkages between agricultural, nutritional and dietary diversity among smallholder farmers in Western Kenya. This thesis contributes evidence-based knowledge on the interlinkages across food availability, accessibility and utilisation, which when addressed with equal weight, could unlock local agrobiodiversity's potential as a path to food and nutrition security of smallholder farming households. The specific objectives are:

1. To assess the food plant diversity of smallholder farms and the bio-physical and socio-economic factors influencing it.
2. To assess the relationship between agricultural and dietary diversity among smallholder farming households.
3. To understand the linkages between agricultural and nutritional diversity in smallholder farms.

## Chapter 1: Introduction

4. To assess the extent to which access to agrobiodiversity in local markets contributes to meeting household food needs as well as the extent of smallholder farmers' local market integration.

In order to address the aforementioned specific objectives, the thesis addresses nine research questions (RQ 1.1 to 1.9) in four empirical chapters (Papers 1 to 4), as below:

Paper 1: Variability of on-farm food plant diversity and its contribution to food security:

A case study of smallholder farming households in Western Kenya

RQ 1.1 How does food plant diversity vary in different smallholder farms?

RQ 1.2 What are the biophysical and socio-economic factors influencing food plant diversity in the smallholder farms?

RQ 1.3 Are households with high on-farm food plant richness and diversity more food secure?

Paper 2: Influence of seasonal on-farm diversity on dietary diversity: A case study of smallholder farming households in Western Kenya

RQ 1.4 How does dietary diversity at household and individual level compare during two seasons?

RQ 1.5 Is there a relationship between on-farm agrobiodiversity and dietary diversity among smallholder farming households?

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security: A case study of smallholder farming households in Western Kenya

## Chapter 1: Introduction

RQ 1.6 What nutrients are available for smallholder farmers to meet a balanced diet during two seasons?

RQ 1.7 How does seasonal food accessibility compare to income levels in the study sites?

Paper 4: Challenges and opportunities for market integration to improve food security:

A case study of smallholder farming households in Western Kenya

RQ 1.8 What is the role of markets in access to food at household level among smallholder farmers?

RQ 1.9 To what extent are smallholder farmers integrated into the market trading networks for selling their produce in regions with good market access?

This thesis follows the four-paper route, in which the aforementioned four empirical chapters (Papers 1 to 4) comprise of four articles that have been published or are submitted for publication in different peer-reviewed journals. Lists of species for some of the articles are found in Appendix I. Statements of co-author contributions to the four papers are in Appendix II. An additional output in the form of a policy brief emanating from some of the results of this research is included in Appendix III. The introduction, literature review and methodology chapters (Chapters 1 to 3) are followed by the aforementioned four empirical chapters (Papers 1 to 4) and overall conclusions (Chapter 8). Chapter 1 introduces the rationale for the study on the role of agrobiodiversity in household food security in Africa and in Kenya, in particular, and then discusses the aims and objectives of the research project. A review of the existing literature to identify key knowledge gaps as well as the conceptual framework that informs this

## Chapter 1: Introduction

study is discussed in Chapter 2, followed by a brief overview of the methods utilised to achieve the study objectives (Chapter 3).

The four papers (Papers 1 to 4) show the inter-linkages across the different household food security outcomes – food availability, utilisation and accessibility (based on the food system conceptual framework introduced in Chapter 2). Paper 1 centres on on-farm food availability, showing that predominant subsistence-oriented land use systems harbour low diversity and do not make smallholder farming households more food secure than those with market-oriented production systems. Paper 2 addresses both food availability and its utilisation by showing that dietary diversity is influenced less by food availability in different seasons but more by socio-economic and cultural factors limiting the consumption of locally available nutritious foods. Paper 3 further builds this food consumption narrative by taking into account food availability, utilisation and accessibility (of both on-farm and market species) during the same seasons. The paper provides further evidence to the low dietary diversity of consumed foods (measured in Paper 2). It does this by showing that functionally redundant and unique species (available from on-farm and market sources) that meet all the existing macro-and micro-nutrient needs under investigation are available during the different seasons. However, there is low appreciation for most of the existing on-farm local agrobiodiversity, suggesting that non-nutrient factors contribute greatly to an overall low nutritional diversity. Beyond these parallelisms (with Paper 2), Paper 3 goes further to show that the affordability of nutrient-diverse foods available in markets vary in the different seasons. This strand of argument is picked up in different ways in Paper 4, which focuses on food accessibility to a large extent, and also takes into account food

## Chapter 1: Introduction

availability (thus drawing a connection with Paper 1). With regards to food accessibility, Paper 4 shows that there is a high demand for cereals, animal source foods and fruits, the main food groups purchased from markets. Economic access to these preferred foods can be enhanced by (i) selling diverse local foods of high nutritional value but low desirability among the surveyed smallholder farming households (see Paper 3) (ii) selling products uniquely available through on-farm production but missing in local markets thus filling in the market gaps (see Paper 4), and (iii) improving smallholder farmers' access to formal markets in general and to market traders in particular by organising smallholder farmers to fill in these local market gaps and to add value to surplus perishable produce (see Paper 4). However, there still remains a need to stimulate the demand of most of these local produce, so that even if these foods are not necessarily preferred by rural households in one locality, they could still be sold in other rural and urban markets, especially as there will be a need to feed more people with the increasing population size. Paper 4 also shows that smallholder farming households utilise multiple food procurement sources (markets, working social networks and on-farm production) for food availability, thus connecting it back to Paper 1. Multiple food sourcing is a theme that cuts across the four papers in different perspectives, and also shows the inter-connections across the aforementioned food security outcomes (availability, utilisation and accessibility).

So as to bring the substantive issues raised in the empirical chapters (Papers 1 to 4) together, Chapter 8 further discusses how these four papers map onto the conceptual framework and what new knowledge they contribute together that each individual paper does not on its own. It does this by showing that the connections between food security

## Chapter 1: Introduction

outcomes and agrobiodiversity as a food source (in the conceptual framework guiding this thesis) are explained through both multiple food procurement and socio-economic and cultural factors, themes embroidered in the four papers from different perspectives, enabling the thesis to better illuminate the extent of food and nutrition security of the surveyed households from different angles. The chapter also offers suggestions on how the study's results may be useful to organisations working on conservation of agrobiodiversity and plant genetic resources, and provides policy recommendations based on this study's results.

## **2 Literature review and conceptual framework**

This chapter has three purposes. First is to examine strategies of achieving food security at three spatial levels – global, regional and local, in turn. Next, I review recent Kenyan policies shaping the agricultural sector. Lastly, I introduce the conceptual framework informing the study, which argues for a multi-dimensional approach to food security and the application of the food system concept (Ericksen *et al.*, 2010) as a useful frame for addressing agrobiodiversity and food security at the household level.

Based on current food and nutrition security literature, there exist various knowledge gaps (Herforth *et al.*, 2014; McDermott *et al.*, 2015; Powell *et al.*, 2015), four of which this study seeks to address. First is the gap on how different smallholder farming households with different environmental, farm and socioeconomic characteristics vary in terms of access to on-farm agrobiodiversity (Galhena *et al.*, 2013; Maroyi, 2013; Anderman *et al.*, 2014) (See Paper 1). Secondly, agriculture-nutrition linkages in smallholder farming systems remain sparse (Hillocks, 2011; Jones *et al.*, 2014; Qaim, 2014; Sibhatu *et al.*, 2015), with the need for changing emphasis from food production goals to better understanding underlying food consumption patterns that ultimately determine the extent to which food and nutrition security is attained (Noack and Pouw, 2014; Herforth and Ahmed, 2015; McDermott *et al.*, 2015), as discussed in Paper 2. Thirdly, the literature suggests that approaches that are gender-informed (those take into account gender roles within the farming households) in agricultural research have not yet been adopted (Fischer and Qaim, 2012; Chege *et al.*, 2015; Mason *et al.*, 2015), for which this study seeks to examine the relationship between gender perspectives on

seasonal availability of various foods and on incentives and disincentives of different farming systems (see Paper 3). Lastly, although it is suggested that on-farm food plant diversity cannot entirely meet rural households' food intakes (Baiphethi and Jacobs, 2009; Isakson, 2011; Lockett *et al.*, 2015), the diversity and amounts of food groups sourced from markets, in addition to other food channels, is rarely taken into consideration (for more discussion on this issue, see Paper 4). These knowledge gaps form the basis of this study, with an overall aim of contributing new knowledge on the availability, utilisation and linkages between agricultural, nutritional and dietary diversity.

### **2.1 Food security at the global, regional and local levels**

In this section, I will contrast the focus on food security at the global level with that at the regional and local levels, drawing out differences in approaches in tackling the challenge of food insecurity. In view of food security as a food production issue, I will contrast the global focus on use of fewer species to achieve high production levels and show that, at the local level, use of more varied species can attain the same, if not better, goals. Next, I will focus on food security as an issue of access to foods of high nutritional value. Based on this, I will examine studies that suggest that access to affordable foods does not necessarily equate to access to high nutritional value products. Lastly, I will examine studies that suggest that to tackle global food insecurity, the focus on agrobiodiversity at all levels - globally, regionally and locally, may be a more sustainable route.

## Chapter 2: Literature review and conceptual framework

Starting with food security as a food production issue, it is suggested that compared to Europe and other developed countries, biodiversity is a main feature of African agriculture (Reyniers *et al.*, 2002). In places where there is hunger, loss of agrobiodiversity and a need for improvement of agricultural systems are concomitant issues (DeClerck *et al.*, 2011). Globally, out of the approximately 7,000 plant species consumed by humans, only 150 species are commercially important (Thrupp, 2000), and only 94 species account for 90 per cent of the world's food crops (Khoury *et al.*, 2014). Just three crops - rice, wheat and maize, account for about 60 per cent of the calories people derive from plants (Tilman *et al.*, 2011). At the global level, the focus on reducing food insecurity in the developing world has been on increased crop productivity, improvement of staples and other market oriented crops (Thrupp, 2000). Though locally, in many developing countries, there is an abundance of less well-known agricultural species, commonly referred to as underutilised plant species, the global focus on modern crop production is based on only a few plant species (Gruere *et al.*, 2006).

Erosion of agrobiodiversity is primarily as a result of human activities (Abukutsa-Onyango, 2011). Contemporary forms of agriculture such as monoculture, producing commercial-oriented crops that enhance the income profitability of farming systems, have contributed to accelerated agrobiodiversity erosion by replacing traditional farming technologies with agricultural intensification (Netondo *et al.*, 2010; DeClerck *et al.*, 2011). Products originating from the so-called underutilised plant species are locally abundant but globally rare and currently have limited use in comparison to their economic potential (Kruijssen *et al.*, 2009). For example, in Bangladesh, the promotion

## Chapter 2: Literature review and conceptual framework

of rice monoculture with high yielding varieties has decreased the diversity of nearly 7,000 traditional rice varieties and many fish species (Thrupp, 2000). In Western Kenya, the increase in sugarcane farming due to the perception that it is more profitable has led to a reduction in farming indigenous traditional foods such as cassava (*Manihot esculenta*), finger millet (*Eleusine coracana*), sorghum (*Sorghum bicolor*) and bambara groundnuts (*Vigna subterranea*) (Netondo *et al.*, 2010). In Nyeri District in the central Kenyan highlands, one of the high potential areas in the country, monoculture cash crops, such as coffee (*Coffea arabica*), tea (*Camellia sinensis*), pyrethrum (*Chrysanthemum cinerariaefolium*), among others, cannot be intercropped with other crops, if high yields are to be achieved (Kiryty and Tisdell, 2002).

Food security also entails access to foods of high nutritional value. It is acknowledged that food security simultaneously entails food production, access and utilisation (Ericksen *et al.*, 2010). With this multi-dimensional view, it is highly probable that nutritious local foods are readily available and accessible but not consumed, hence highly underutilised (See Paper 3 Section 6.5). With increased globalisation, agrobiodiversity is being significantly undervalued and ignored (Thrupp, 2000; Abukutsa-Onyango, 2011), especially in rural areas. Kenya is one of the developing countries that faces recurrent food insecurity (Barrett, 2010), especially among rural households, either in form of periodic droughts resulting in failure of the predominantly rain-fed crops or the more common seasonal food shortages. The seasonal food shortages, commonly referred to as “hunger gaps”, occur during the pre-harvest periods of annual staples (Kehlenbeck *et al.*, 2013), when staple food reserves from a previous harvest season have run out. On the one hand, children living in rural areas are

## Chapter 2: Literature review and conceptual framework

moderately and severely stunted to a greater extent (37%) when compared with urban children (26%) and they are also more likely to be underweight (17%) than urban children (10%) (KNBS and ICF Macro, 2010). On the other hand, a study conducted in Western Kenya, a rural area, found that the provision of the major nutrients can be met by readily available foods in villages. For example, maize is a major source of carbohydrates while beans and amaranths are major providers of iron, protein and folate. Orange fleshed sweet potatoes provide vitamin A, while guavas provide vitamin C, with amaranths providing zinc (DeClerck *et al.*, 2011) (also see Paper 3 Section 6.5.1 for more discussion on this issue). Hence, agrobiodiversity has value and potential that needs to be exploited in food security and nutrition in Africa (Kirity and Tisdell, 2002).

The focus on agrobiodiversity at all levels may be a more practical, sustainable and cost-effective route to tackle food and nutrition insecurity. At global, regional and local levels, a probable recommendation could be the design of programmes that can meet the needs of the hungry without increasing other nutritional burdens, such as obesity, in those countries (Popkin, 2007). A shift away from conventional monoculture systems to multiple cropping may smooth out seasonal fluctuations in food supply (Kirity and Tisdell, 2002). The use of local foods, especially those that are early maturing, highly nutritious and adapted to local environments (Netondo *et al.*, 2010), could be a strategic entry point. Although agrobiodiversity is no guarantee to food sufficiency or adequate nutrition (Conelly and Chaiken, 2000) (also see Paper 1 Section 4.5.3, Paper 2 Section 5.5.2 and Paper 3 Section 6.5.2), loss of agrobiodiversity (Thrupp, 2000) and dietary diversity (Hoddinott and Yohannes, 2002; Ruel, 2002) jeopardises food security.

## **2.2 Drivers of agrobiodiversity at the farm level**

For smallholder farmers, agrobiodiversity is a crucial underpinning for their lives (Kaihura *et al.*, 2000). For these farmers, agrobiodiversity is not just about crop diversity but it also describes the variety of practices and attitudes of smallholder farming systems (Brookfield and Padoch, 1994), broadly capturing how farmers use that diversity (Kaihura *et al.*, 2000), especially in their day-to-day lives. With this, smallholder farmers have various motivations for maintaining high on-farm agrobiodiversity such as the need to spread risks, to ensure adequate food supply throughout the year, as well as to aim at the provision of good nutrition and dietary diversity at the household level. I will examine studies that highlight the above-mentioned motivational factors of smallholder farmers in their efforts to ensure food security. I will then discuss studies that also highlight various factors that de-motivate smallholder farmers, hence contributing to low on-farm agrobiodiversity. These factors broadly fall into the need for livelihood diversification and market-oriented farming.

Since farming involves risks (Onduru and Du Preez, 2007), agrobiodiversity is seen as a way that resource-poor farmers spread risk and support their own food security (Tengberg *et al.*, 1998). Risk management by smallholder farmers may take shape in the context of crop diversification, as a strategy to reduce the risk of crop failure (Tengberg *et al.*, 1998). In a study conducted among smallholder farmers in Kwara State, Nigeria, crop diversification was ranked as the main risk coping strategy (Ayinde *et al.*, 2008). Planting a mix of crops, especially with different variety combinations, is likely to ensure the same yield is obtained despite extremes of climate, pests, diseases, labour shortage or other constraints (Kaihura *et al.*, 2000). However, crop diversification does

not necessarily lead to similar individual crop yields being realised. Though lower yields could be obtained from crops dominantly under intercropped systems (Unruh, 2001; Onduru and Du Preez, 2007), studies indicate that other benefits could play overriding roles, for example the ability to harvest two crops from a field in one planting season and to minimise crop failure risks (Onduru and Du Preez, 2007), as the crops may be more resistant to changing conditions (Unruh, 2001). Although farm size may have an immense influence on agrobiodiversity, most home gardens are relatively small, with an average farm size of 0.144 hectares, yet the diversity of species in these farms is remarkable (Stocking *et al.*, 2003). In a Northern Tanzania study site, most smallholder farmers plant up to five different varieties of beans and bananas on their land. This reflects not only risk-spreading decisions but also matching particular varieties to scattered plots having different biophysical characteristics (Kaihura *et al.*, 2000). A study conducted in Eastern Kenya showed that in two different cropping seasons, medium resourced farmers had more diverse cropping systems than high resourced farmers (Tengberg *et al.*, 1998). A converse to this argument is that the poorest of households are not as diverse, yet they should be more risk averse (Abdulai and CroleRees, 2001), hence diversification strategies do apply to some extent, but one should not be blind to particular farmers' existing socio-economic situation.

Secondly, it could be that smallholder farmers are motivated to maintain high on-farm agrobiodiversity so as to ensure that there is enough food production throughout the year. This is expected, since poor people rely more heavily and directly on local resources for their livelihoods due to a lack of alternative options (Rietbergen *et al.*, 2002). A study conducted among smallholder farmers in Embu District, Eastern Kenya,

## Chapter 2: Literature review and conceptual framework

found that 39 per cent of the species grown in home gardens are food plants and that 76 per cent of farmers grow crops for consumption rather than for the market, probably due to poor market prices (Stocking *et al.*, 2003). The advantage of subsistence production, especially for resource-poor farmers, is the impact that household food production has on saving money mainly by reducing trips to the market for home consumption foods. This strategy on diversified, year round supply of products from home gardens works especially among poor households (Galluzzi *et al.*, 2010). For example, some crops, such as sweet potatoes (*Ipomoea batatas*), can be grown throughout the year and they also have the additional benefit of yielding even in drought seasons, hence can be utilised during the ‘hungry period’ before staple foods like maize (*Zea mays*) are ready for harvest (Kaihura *et al.*, 2000). An additional strategy utilised by smallholder farmers to ensure sustained food production throughout the year is crop-livestock diversification (Stocking *et al.*, 2003; Iiyama *et al.*, 2007; Onduru and Du Preez, 2007). In Mbeere District of Eastern Kenya, an average of two animal types contributed to sustainable food supply (Onduru and Du Preez, 2007). In most cases, livestock further play a major role in recycling nutrients in home gardens (Stocking *et al.*, 2003), contributing to the high soil fertility levels that help to improve food production throughout the year. While there could be multiple and sometimes imprecise sorts of risk-spreading decisions that smallholder farmers employ, these may also differ on the basis of multiple factors, including socio-economic status, land holdings and prior investments in crop and livestock production systems.

Besides food production, agrobiodiversity may also enable households to achieve dietary quality, as shown by a study assessing work done by Hellen Keller International,

## Chapter 2: Literature review and conceptual framework

an organisation focused on reducing under-nutrition through food-based approaches, which demonstrated that home gardens also play a big role in nutritional adequacy, especially as they provide direct access to nutritious foods for the food insecure, often on a daily basis (Marsh, 1998). A project evaluating agricultural intervention projects found that most of these interventions also result in nutritional improvement (Berti *et al.*, 2004), emphasising that home gardens, with their remarkable diversity (Galluzzi *et al.*, 2010), explicitly aim to provide nutritional adequacy.

Literature suggests that the main factors that de-motivate smallholder farmers from maintaining high on-farm agrobiodiversity include the need for livelihood diversification and market-oriented farming. To start with, the diversification of income has an influence on agrobiodiversity (Stocking *et al.*, 2003), and this is especially through the need for off-farm activities. Livelihood diversification was the second most important risk coping strategy among smallholder farmers in Kwara State, Nigeria (Ayinde *et al.*, 2008). Though livelihood diversification is not the same as income diversification (Ellis, 1998), some forms of the latter may be in the form of labour exchange or off-farm activities, which would essentially take a farmer away from his/her farm, and the less time spent on his/her farm may translate to less on-farm agrobiodiversity.

With market-oriented farming, there could be a prospect of increased cash investment enabling the diversification of farm activities which could lead to increased agrobiodiversity (Stocking *et al.*, 2003), although this may not always be the case. A study conducted in Western Kenya showed a strong relationship between sugarcane

farming and reduction in indigenous crops, highlighting that the commercialisation of agriculture is the main cause of food crop diversity loss in the region (Netondo *et al.*, 2010). On the one hand, commercialisation is not necessarily synonymous with specialisation and a decrease in food species diversity, as was found among sugarcane smallholder farmers in the same region (see Paper 1 for more discussion on this issue). On the other hand, agrobiodiversity is still under pressure to simplify (Brookfield and Padoch, 1994). The trend towards large scale agriculture leads to the simplification of agricultural systems and has resulted in the replacement of home gardens by monoculture systems (Galluzzi *et al.*, 2010). Traditional varieties are the most important in genetic diversity (Wood and Lenne, 1997), hence the reduced use of traditional varieties among smallholder farmers plays a major role in reducing on-farm agrobiodiversity. Although smallholder farmers experiment and rely on local knowledge (Beckford *et al.*, 2007), will this practice continue especially with the use of improved seed varieties? In smallholder farming systems, seed exchanges represent a key mechanism in the dynamics of crop genetic diversity (Deletre *et al.*, 2011). Farmers tend to utilise traditional varieties to enhance their livelihoods (Jarvis *et al.*, 2011), especially because traditional varieties may be more resistant to climate variability and hence may guarantee yields, even if it may not be optimal. An illustration of this is from a study in Gabon which documented an increased diversity in cassava due to seed exchange (Deletre *et al.*, 2011). However, with increasing use of modern varieties, traditional seed saving and selection practices are eroding (Momsen, 2007).

### **2.3 Gender roles in smallholder farming systems**

Gender does play a role in the extent of diversity in smallholder farming systems. In this section, I examine studies that highlight the changing gender roles in farming systems, the underlying implications of gendered patterns and existing gaps in gender-sensitive approaches in current agricultural research.

Gender roles are not static and change over time (Nuijten, 2010). A probable reason for this could be that not all farming activities are ‘gender specific’, where involvement is determined exclusively by gender, but rather, some farming activities may also be considered as ‘gender sequential’ (Warner *et al.*, 1997). Most crops cannot be distinguished as being grown either by men or by women farmers, though there are gender patterns in the crops that are grown (Doss, 2002). This could be because the gender-based division of labour has come about as a result of socio-cultural socialisation, and not necessarily from ability based on comparative advantage to determine gender suitability of tasks (Sikod, 2007). Though men farmers are more involved with cash crops while women farmers are involved more with subsistence crops (Hyder *et al.*, 2007), women work as both subsistence and commercial farmers, growing both food and non-food cash crops (Mehra and Rojas, 2008). In two rural districts in Kenya, in addition to their conventional food production work, women seem to have been better at diversifying into enterprises viable in local markets such as the production of tomatoes and kales, and local livestock husbandry such as dairy animals, goats and pigs (Whitehead, 2009). In Cameroon, though men farm what are traditionally non-food cash crops while women farm what the family consumes, today women are

## Chapter 2: Literature review and conceptual framework

including a market-oriented dimension to their farming activities (Sikod, 2007). In Tanzania, men market more non-food cash crops than women, but women have responsibility for some food cash crops (Whitehead, 2009). Whereas women are known to be more actively engaged in seed exchange systems, men can also perform different roles in these systems. In a village in Mexico, though women farmers were engaged in seed exchange systems through family networks, participation in communal work or political life enhanced the ability of male farmers to become involved in exchange networks as well (Aguilar-Stoen *et al.*, 2009).

By virtue of often farming different crops or farming the same crops for different reasons, men and women experience different vulnerabilities to such things as climate change and shifts in global markets for the crops under production, shifts that can filter down through households and other social units to impact long-term well-being of affected communities and individuals (Carr, 2008). Why then have gender-informed approaches not been fully adopted as yet? This gap persists probably because decision makers may still regard women more as home producers or assistants in farm households, and less as capable economic agents (Mehra and Rojas, 2008). While studies on changing gender relations under the unfolding impact of liberalisation in sub-Saharan Africa are exceedingly sparse (Whitehead, 2009), some recent studies have begun exploring gender relations on ‘non-traditional’ commercialised crops and their impact on household nutrition (Qaim, 2014; Qaim *et al.*, 2014; Chege *et al.*, 2015). Increased male dominance in these crops that were previously cultivated by women for subsistence needs has been found to result in reduced household dietary quality in banana (Fischer and Qaim, 2012) and vegetable (Chege *et al.*, 2015) smallholder

farming systems in Central Kenya, without reducing the calories consumed (Fischer and Qaim, 2012; Chege *et al.*, 2015). As control of income within the household does affect household nutrition depending on whether money is spent on healthy or unhealthy diets (Herforth and Ahmed, 2015), it could be that male household members may spend less money on purchasing a diversity of nutrient-dense foods (Qaim *et al.*, 2014; Chege *et al.*, 2015). Subsequently, a tackling of the changing dynamics on gender roles and the intra-household decision making process could contribute towards more nutritious diets at the household level (Chege *et al.*, 2015). See Paper 2 Section 5.5.3 for more discussion on this issue.

#### **2.4 Agriculture-nutrition linkages in smallholder farming systems**

There is still great scope for the contribution of evidence-based agriculture-nutrition linkages in smallholder farming systems. In this section, I examine studies that highlight some factors shaping food consumption patterns and existing gaps in the nutrition-sensitive agriculture research focus.

While pathways between agriculture and nutrition are well known, evidence-based linkages on how agricultural interventions can improve nutrition remain weak (Haddad, 2013), partly because linkages between agricultural diversity and dietary diversity are not universal (Sibhatu *et al.*, 2015). For instance, economic access to markets is likely to substitute for diversified farm production's contribution to the dietary diversity of households (Hoddinott *et al.*, 2014). As an illustration, market-oriented smallholder farmers in Indonesia and Kenya had more diverse diets when compared to their subsistence-oriented counterparts in Malawi and Ethiopia (Sibhatu *et al.*, 2015). While a

direct linkage is more likely to apply in cases where food markets are weak with heavy reliance on own agricultural production for household dietary diversity (Haddad, 2013; Hoddinott *et al.*, 2014; Sibhatu *et al.*, 2015), this is not always the case. Even if nutrient-dense foods are highly available through on-farm production, there could be non-agronomic factors influencing their low or non-intake. For example, while there was high on-farm diversity of indigenous fruit trees in rural Eastern Kenya, adults viewed these indigenous fruits as food for children and instead consumed exotic fruits which could only be purchased in markets (Kehlenbeck *et al.*, 2013). There is also a lower cultural preference for many of the indigenous vegetables and legumes, which are seen in many sub-Saharan African countries as a poor-man's crop (Renzaho, 2004; Keding *et al.*, 2013).

Local ethnicity is also likely to influence the local food culture, as particular ethnic groups had higher dietary diversity when compared to the rest of the surveyed households in rural Malawi (Jones *et al.*, 2014), Tanzania (Keding *et al.*, 2012) and Burkina Faso (Savy *et al.*, 2006). Even the nutritional value of food is unlikely to be the only determinant of food consumption, as shown among urban households in northern Benin who prepared different sorghum dishes based on the colour, texture, taste and smell of the different sorghum varieties (Kayode *et al.*, 2005). Furthermore, it is suggested that food consumption is influenced not only by its availability and affordability but also by its desirability and convenience (Herforth and Ahmed, 2015), creating the need to incorporate the highly overlooked socio-cultural factors, if food and nutrition insecurity is to be accurately tackled (Noack and Pouw, 2014). The international agricultural research for development community is further urged to

refocus its implementation of the nutrition-sensitive agriculture agenda (McDermott *et al.*, 2015). The research focus needs to shift away from food production goals to a good understanding of factors limiting consumption of nutritious foods (McDermott *et al.*, 2015). For more discussion on these issues, see Paper 2 Section 5.5.3 and Paper 3 Section 6.5.2. The integration of vital support systems that equally determine the nutritional diversity of local food systems, especially markets (Luckett *et al.*, 2015), is also paramount.

## **2.5 Markets and their role in regional food security**

In this section, I will start by discussing studies that have investigated the effects that markets have on food availability and affordability, specifically among smallholder farmers. Next, I will consider the literature that has documented both the positive and negative impacts that markets have on on-farm agrobiodiversity. In an effort to link markets to the wider food system, I will then discuss the status of market integration among smallholder farmers and how this impacts on food self-sufficiency.

Unlike in the developed world where food purchases are cheap, accounting for close to 15 per cent of consumer budgets (Regmi and Meade, 2013), food itself represents 50 to 80 per cent of developing country consumers' budgets (Smale *et al.*, 2009). In sub-Saharan Africa, 60 to 80 per cent of rural households, including a large proportion of smallholder farmers growing food crops, are net purchasers of these same crops (Barrett, 2008; Smale *et al.*, 2009). This is mainly because they are unable to meet the subsistence needs of their families through their own production and must purchase the remainder, usually at higher prices (Smale *et al.*, 2009; Smale *et al.*, 2012).

Hence, foods in the markets may always be readily available, but how about its affordability - is it an issue? I will first of all discuss this in light of studies that expound on the impact of price changes irrespective of market distances, and in the second scenario, affordability will be discussed in relation to the nearness to markets. In the first instance, change in prices of staple foods has a big effect on the livelihoods of smallholder farmers as they rely on food crops such as rice, wheat and maize for a large share of their daily calories (Smale *et al.*, 2009). The high cost implication would then have an impact on the purchase of other foods that would enhance overall dietary diversity. A study in Mali showed that the market purchase of millet grain enhanced food security but reduced dietary diversity, as households that used scarce cash to purchase grain were unable to allocate cash to purchase foods that diversify their diets (Smale *et al.*, 2012). However, though an increase in the prices of major cereals may lead to greater availability of cheaper substitute cereals (such as sorghum and millet), roots and tubers crops (such as cassava and sweet potatoes), these foods can be considered as 'inferior' economic goods (Smale *et al.*, 2009). This perception may have an influence on the preference for such foods, though this is not always a linear relationship. For instance, under-utilised plant species are highly regarded locally and regionally, but this is not the case at the global level, one of the reasons being that their current use is limited relative to their economic potential (Gruere *et al.*, 2006; Horna *et al.*, 2007). The African eggplant, which has limited global marketability, is one of the most important vegetables in West Africa, where it is not only consumed on a daily basis by rural and urban families but also represents the main source of income for many rural households in the country (Horna *et al.*, 2007). Hence, market prices can

## Chapter 2: Literature review and conceptual framework

have multiple effects on food availability. In the second scenario, market food affordability is linked to the nearness of markets. Markets exist but with transaction costs, households choose whether or not to enter into market exchanges (Omamo, 1998). In the drylands of India, rural households with poor access to roads fail to go to markets due to higher transaction costs and they, instead, grow millet crops to remain self-sufficient, consuming what they produce (Nagarajan *et al.*, 2007). For similar reasons, food acquisition from markets is considered an illogical option among rural residents in Siaya District of Kenya, which has a poor road network (Omamo, 1998). In both contexts, as in many other rural areas with poor infrastructure, increased market food prices, combined with additional costs incurred by farmers (such as transport costs to travel to the market), may in turn shape farm cropping options.

Markets have a positive, negative or no effect on on-farm agrobiodiversity. In rural Sweden, the selling of farm products at local markets improves on-farm biodiversity due to interactions between farmers and consumers (Bjorklund *et al.*, 2009) - their customers. However, most smallholder farmers in sub-Saharan Africa don't participate as sellers. They consistently represent a minority of farmers or rural households across multiple countries, crops and years, with the majority of sellers being wealthier farmers (Barrett, 2008), or middlemen who buy farm produce at farm gate prices. Markets are considered a component of seed systems, which consist of all channels through which farmers acquire genetic materials (Nagarajan *et al.*, 2007). However, a study of millet transactions in market fairs in Mali showed that none of the farmers reported to have procured their seeds with cash in their most recent transaction. Though genetic dissimilarity was higher in markets, purchasing seeds in markets was negatively

associated with on-farm diversity. The market purchase of millet seed was due to seed shortage, not due to diversity or experimentation (Smale *et al.*, 2012). This could be because transactions in grain markets are unfavourable because they provide no assurance of seed quality, unlike transactions with other farmers and kin, which are based on trust or direct observation (Smale *et al.*, 2009). Hence, in this case, markets have no effect on on-farm agrobiodiversity.

A focus on market-oriented crops at the expense of other farm crops may have a negative influence on on-farm agrobiodiversity, as it could be that the more volumes they sell the more biodiversity is likely to decrease (Dury *et al.*, 2011). For instance, indigenous crops may be allocated less farming area and more space allocated for more marketable products (Gruere *et al.*, 2006). Though marketing of underutilised plant species such as the African eggplant (Horna *et al.*, 2007) and African leafy vegetables (Gotor and Irungu, 2010) is being promoted, what stands in the way of fast paced progress is a lack of incentive to market underutilised plant species due to the presence of other competitive crops (Gruere *et al.*, 2006). Among the competitive crops are non-food cash crops, for which there may be a positive relationship with farm sizes (Fafchamps, 1992), implying that fewer smallholder farmers would engage in it and instead focus on subsistence crop production. This is not always the case as one study notes that, among smallholder farmers, more land is devoted to non-food cash crops and less to subsistence crops the closer the households are to a road (Omamo, 1998). In Western Kenya, sugarcane cash crop farming among smallholder farmers has led to a decline in the cultivation of indigenous crops in the area (Netondo *et al.*, 2010). In contrast, it does not always imply that non-food cash crop farming is necessarily

synonymous with reduced agrobiodiversity. The conventional view that non-food cash crops compete with food crops for land and labour neglects the potential for non-food cash crop schemes to make available inputs on credit, management training and other resources that can contribute to food crop productivity (Govere and Jayne, 2003), including increased agrobiodiversity. Once people are connected to markets, the act of selling more may have a negative effect on biodiversity (Dury *et al.*, 2011).

Certainly, farms in close proximity to markets may positively contribute to on-farm agrobiodiversity. A study conducted in Mali indicates that farms near markets have more varieties, indicating that opening up farms may have more effect than the specialisation and simplification of crop systems (Dury *et al.*, 2011). A study conducted in four West African urban centres showed that proximity or linkage to markets increased the diversity of crop cultivation, away from rice to more varied market-oriented food products which were often of higher value and more perishable than rice (Erenstein *et al.*, 2006). It is also likely that nearness to markets may provide livelihood options out of agriculture, as a study in Mali indicates that households closer to markets are more likely to participate in non-food productive activities (Abdulai and CroleRees, 2001), which could potentially either reduce or improve on-farm agrobiodiversity.

The nature of income diversification options affects the level of on-farm agrobiodiversity maintained. While some households diversify into relatively lucrative activities because they have a choice, others must diversify into low-return activities, such as petty trading at weekly rural markets, because they have little choice (Barrett *et al.*, 2000). Those who do high-return activities may diversify their farms. A study in

## Chapter 2: Literature review and conceptual framework

Mali comparing villages near to markets (referred to as ‘connected’ villages) and those far from markets (referred to as ‘isolated’ villages) indicates that the farms of connected villages have more diverse incomes than those of isolated villages and 58 per cent of farmers in the connected villages practised market-oriented gardening, while only 16 per cent did so in the isolated villages (Dury *et al.*, 2011). In most cases, high-return activities are the reserve of wealthier farmers, not low capital endowed smallholder farmers. Market-oriented farming, which, in most cases, may entail contract farming, excludes the smallest and poorest farmers due to the high transaction costs involved in setting up a contract (Kruijssen *et al.*, 2009). Smallholder farmers also face numerous constraints resulting from high transaction costs in the market chains, such as limited access to financial resources and technical skills, to a lack of bargaining power (Barrett, 2008; Kruijssen *et al.*, 2009).

As a strategy to link markets to the wider food system, market integration diminishes the need for food self-sufficiency (Fafchamps, 1992). Although smallholder market participation is important for economic growth and poverty reduction (Barrett, 2008), many smallholder farmers in low-income rural areas opt out of markets (Barrett, 2008). They normally devote a larger share of their land and other resources to low-yielding food crops than cash crops with higher market returns (Omamo, 1998). Indeed, food crops also have the same potential to become cash crops given a proper market environment and infrastructure (Fafchamps, 1992), which could play a vital role in reducing transaction costs that render foods unaffordable, a key handicap to achieving food security. A key reason why market food prices may be high, hence unaffordable to most locals, may be the result of high transaction costs (Nagarajan *et al.*, 2007; Dury *et*

*al.*, 2011). This may mean that just ‘getting prices right’ does not necessarily induce broad based, welfare-enhancing market participation (Barrett, 2008). Such holistic considerations need to be factored in an effort to integrate smallholder farmers into the existing market system. Moreover, linking markets to the wider food system is a step towards the much-needed multi-dimensional food system agenda (McDermott *et al.*, 2015). At the same time, it is important to be cognisant of the multiple challenges when it comes to the marketing agrobiodiversity by smallholder farmers, including their limited access to market information which is linked to the under-developed co-operation between smallholder farmers and market traders (KIT and IIRR, 2008), among other challenges. See Paper 4 Section 7.5 for more discussion on this issue.

### **2.6 Recent Kenyan policies shaping the agricultural sector**

Kenya’s economic expansion has been driven through key policy documents that provide sectoral priorities cascaded from the Economic Recovery Strategy for Wealth and Employment Creation (ERS) 2003–2007 (Ministry of Agriculture, 2008). In the agricultural sector, the Strategy for Revitalising Agriculture (SRA 2004–2014) remains the main reference document supplemented by specific Agriculture and Rural Development (ARD) sector ministries’ strategic plans (Ministry of Agriculture, 2008). After the expiry of the ERS in December 2007, Kenya Vision 2030 is the country’s new development blueprint covering the period 2008 to 2030, with economic, social and political pillar strategies (Government of Kenya, 2007). The economic pillar aims at providing prosperity of all Kenyans through an economic development programme aimed at achieving an average Gross Domestic Product (GDP) growth rate of 10 per cent per annum over the next 25 years (Government of Kenya, 2007). Drawing from

## Chapter 2: Literature review and conceptual framework

this broader political-economy context of Kenya and its agrarian economy, the Government perceives that the agricultural sector has been revived and is now set on the path for further development, hence the Agricultural Sector Development Strategy (ASDS) 2010-2020 (Government of Kenya, 2010). It is a strategy to position the agricultural sector as the key driver for delivering the 10 per cent annual economic growth rate envisaged under the economic pillar of Vision 2030, hence it is a means of achieving the Vision 2030 for the agricultural sector. In essence, it is a successor to the SRA. The dynamism and forward looking approach of the ASDS integrates 10 key ministries in the agricultural sector (Government of Kenya, 2010), thus reducing the number of highly fragmented commodity-specific policies that were prone to duplication and inefficiency (for example, the Pyrethrum Industry Policy and Amendments of the Pyrethrum Act Chapter 340, Sugar Policy and Amendment of Sugar Act No. 10 of 2001, Coffee Act No. 9 of 2001, Cotton Policy and repeal of Cotton Industry Act Chapter 335, among others).

Complementing this overarching agricultural policy document is the 2011 Food and Nutrition Security Policy (FNSP), which sets out to ensure that the efforts by ASDS also result in improved quantity and diversity of foods to meet nutritional needs, by addressing food availability and accessibility to improve quantity and diversity of food to meet nutritional needs (Government of Kenya, 2011). In Section 3.1 of the FNSP, the explicit guidelines around food utilisation, an equally critical element in the food and nutrition security equation, have been limited to that of genetically modified foods, in the context of food safety concerns (Government of Kenya, 2011).

### **2.6.1 Incentives and disincentives in the context of agrobiodiversity management and marketing**

An incentive that closely relates to agrobiodiversity management is the facilitation of multiple cropping with the aim of enhancing productivity per unit of land as well as agroforestry projects introducing high-value commercial tree species. However, high costs associated with certified seeds may prove to be a disincentive to smallholder farmers, who may end up going for inferior quality seedlings and after disappointing yields, give up on the project. According to the Kenya forest service general order, indigenous and exotic single plants are charged at KES 15 and KES 10 (about 0.2 USD and 0.1 USD), respectively, in less than 15 centimetre of polythene tube per plant, and at KES 75 and KES 50 (about 0.7 USD and 0.5 USD), respectively, for the same single plants in more than 15 centimetre diameter of polythene tube per plant (Kenya Forest Service, 2010). The ASDS also seeks to explore the possibility of providing a livestock insurance scheme for producers in arid areas (Government of Kenya, 2010), which is well-intended but may prove to be impractical as far as regular premium contributions by the smallholder farmers are concerned.

In the context of strengthening extension, research and training, the ASDS seeks to strengthen its extension service delivery system as well as empower farmer organisations and communities to provide these services at the grassroots. It also seeks to improve and strengthen support services to encompass production and market-related information and appropriate technologies which will improve accessibility to appropriate information for the smallholder farmers (Government of Kenya, 2010). The ASDS also aims at strengthening research-extension links to ensure demand-driven

## Chapter 2: Literature review and conceptual framework

research and effective application of research technologies on the farm (Government of Kenya, 2010). There has been a deficit of extension officers in the recent past, due to public service hiring constraints in efforts to lower public expenditure, hence the demand-driven approach has mostly been a disincentive to the smallholder farmers rather than an incentive, with these farmers opting to solve their own farming challenges and learning by ‘trial and error’. Nevertheless, smallholder farmers can still benefit from alternative agents to these mainstream service providers that are emerging, as discussed in more details in Chapter 8 Section 8.4 recommendation 1.

The ASDS is also tailored to benefit smallholder farmers in its aim to improve agribusiness and market access. Among the key incentives is the development of appropriate credit packages for small scale producers so as to facilitate their access to key inputs. It will also implement flagship fertiliser cost-reduction investment projects (Government of Kenya, 2010). There is also the commitment to support and empower farmer organisations so that they can play their role in providing market support services (see Paper 4 Section 7.5.6 for more discussion on how this measure could be operationalised at the grassroots). It will also aim to support mobilisation of financial resources through Savings and Credit Co-operative Organisations (SACCOs) and other community-based lending organisations to accelerate agricultural development (Government of Kenya, 2010). In the effort to address the high cost of agricultural inputs, the ASDS will promote a rationalised input distribution system that will compete within the supply chain, provide information on availability and cost of inputs as well as formulate and implement farmer-friendly policies (Government of Kenya, 2010). Agribusiness strengthening has also been addressed in the ASDS by prioritising rural

## Chapter 2: Literature review and conceptual framework

industrialisation and forging partnerships between smallholder farmers and agribusinesses in the form of out-grower and contract farming schemes through supply of inputs on credit basis or through input voucher schemes whereby a flexible system will ensure that the smallholderfarmers have market for their produce (Government of Kenya, 2010). However, the high cost of inputs and poor market prices are still challenges being experienced by smallholder farmers in this study (see Paper 3 Section 6.4.4).

Although the ASDS strongly promotes internal and external trade by incorporating measures to improve farmers' capacity to add value to the diversity of their produce to make it more competitive (Government of Kenya, 2010), this requires high initial capital investment by a smallholder farmer. These standardisation and quality control measures cost money - for example the introduced eco-labelling mechanism, aiming at African products competing at a more competitive platform with internationally recognised brands, requires a huge capital investment that mainly large scale farmers can afford. Nevertheless, the private sector and other development agencies are increasingly supporting smallholder farmers so they can make use of this well-meaning incentive. For more discussion on ways to encourage longer-term commitments by these organisations, see Chapter 8 Section 8.4 recommendation 3. In addition to the need for enabling incentives, it is essential to stimulate high demand for the diverse local foods of high nutritional value that smallholder farmers produce (see Paper 3 Section 6.5.2 and Chapter 8 Section 8.4 recommendation 4 for more discussion on this issue).

## Chapter 2: Literature review and conceptual framework

The effective implementation of the Food and Nutrition Security Policy (FNSP) is also contingent on produce marketing (Government of Kenya, 2011), where the role of the private sector in food marketing and processing is acknowledged (FNSP Section 8.3.2). The role of maize as a key mono-crop is evident as it's the main crop for which measures have been put in place to enhance storage and agro-processing concerns so as to improve its market development (FNSP Section 2.3). Besides maize, other food groups such as fruits and vegetables are also lost at the post-harvest stage, as shown in Paper 4 Section 7.4.3. Nevertheless, the FNSP does take into account the potential role of a diversity of other food crops appropriate to different local conditions in combating food insecurity in Section 2.4 of the FNSP (Government of Kenya, 2011).

### **2.7 Conceptual framework guiding the study**

#### **2.7.1 The multiple dimensions of food security**

The widely accepted definition of food security is 'physical and economic access by all people at all times to sufficient, safe and nutritious food for an active, healthy life' (FAO, 1996). This definition emphasises the greater importance of increased food access over increased food production (Ingram, 2011). It is acknowledged that sufficient global food production is not synonymous with guaranteed food security for all (Beddington, 2011). While lack of, or poor access to, food is the main cause of food insecurity in general, some parts of the world, especially Africa, face chronic hunger mainly due to low food production (Ingram, 2011). Although famines in Africa mainly persist as a result of food under-production coupled with frequent and unpredictable production shocks, low food production played a minor role in the recent famines in Ethiopia, Niger and Malawi. In Ethiopia, for example, famine in the lowland pastoral

## Chapter 2: Literature review and conceptual framework

areas occurred in the face of sufficient food availability in other crop-producing highland areas (Devereux, 2009), which is often the case in many other African countries. This suggests that solely relying on increased food production is insufficient to ensure food security for all (Misselhorn *et al.*, 2012).

Hunger results from a failure in any of the three main interconnected food entitlement sources: own production, exchange (in-kind exchange or purchase) and household transfers (Sen, 1981), with lack of economic and social access to food as the main cause (Ericksen *et al.*, 2010; Garnett and Godfray, 2012). There is also the need to support more than access to sufficient calories (Misselhorn *et al.*, 2012). While the FAO food security definition also captures the nutritional dimension of food (Ericksen *et al.*, 2010), food security as commonly used in the development discourse emphasises food quantity more than food quality, hence the term ‘nutrition security’ is now commonly used to capture the quality dimension (Smith *et al.*, 2013). Stability is an equally important dimension of food security (Ericksen *et al.*, 2010; Ingram, 2011; Garnett and Godfray, 2012), as all food security components have to be satisfied and stable over time for food security to be met (Ingram, 2011). The multiple dimensions of food security necessitate research on a more integrated food security concept which focuses not only on food production (Ingram, 2011), but also on other aspects such as food access, allocation and nutritional adequacy. As an outcome of multiple factors operating at household up to international levels, whether or not food security exists for any unit of analysis requires the consideration of multiple factors (Ericksen *et al.*, 2010).

### **2.7.2 Food security in the context of global environment change: the food system concept**

Though food systems and agricultural production are closely linked (Hawkesworth *et al.*, 2010), enhancing food security needs to occur without further environmental degradation (Ericksen *et al.*, 2010; Foley *et al.*, 2011; Ingram, 2011). This is especially so for low-income households who depend on food systems that are sensitive to changing climatic conditions (Vermeulen *et al.*, 2012b). Given the multifaceted nature of food security that increases its complexity, especially in the context of global environmental change (Ingram, 2011), solving food insecurity needs to centre on a comprehension of complex interactions, and system-based approaches can facilitate this understanding (Ericksen *et al.*, 2010). System-based approaches which address the multiple dimensions of food security on a single framework while at the same time considering its impacts on global environmental change are considered holistic.

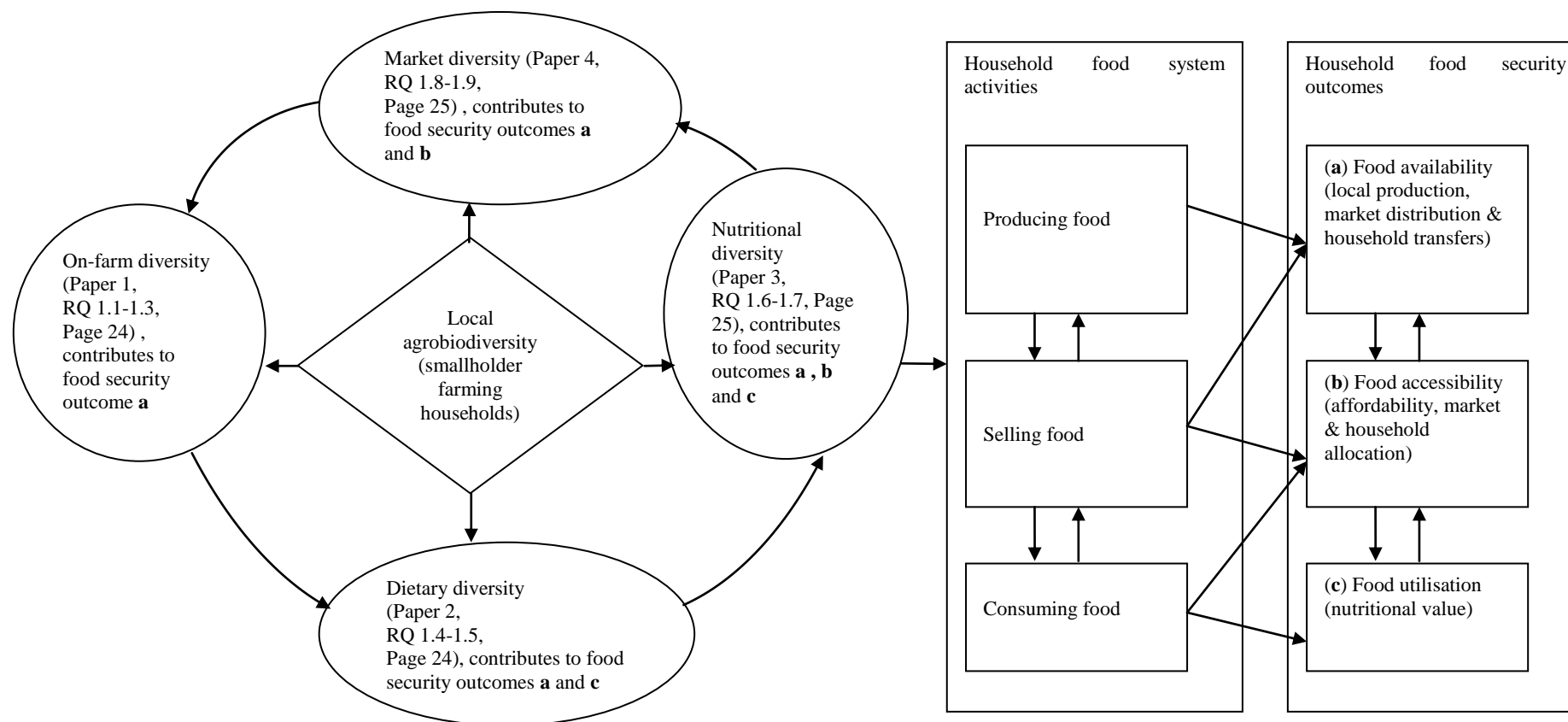
In the late 1990s, as research interest on interactions between global environmental change and food security increased (Ingram, 2011), the Global Environmental Change and Food Systems (GECAFS) project was set out to research on strategies of enhancing food security without further environmental degradation (Ericksen *et al.*, 2010). One of GECAFS's main research outputs, the food system concept, served the purpose of enhancing interdisciplinary research on the two-way interactions between food security efforts and global environmental change (Ericksen *et al.*, 2010; Ingram, 2011). Food systems entail a number of activities which give rise to a number of food security outcomes (Ingram, 2011). Essentially, a food system includes the set of activities involved in producing, processing, packaging, distributing, retailing and consuming

food (Ericksen *et al.*, 2010). Undertaking these activities leads to a number of outcomes, which not only contribute to food security but also relate to environmental outcomes (Ingram, 2011).

### **2.7.3 Application of the food system concept at the household level**

This study adapts the food system concept in its conceptual framework, as a rationale for considering household food security outcomes as a determinant of household food security activities mediated by sustainable utilisation of an environmental resource, local agrobiodiversity. The food security outcome at the household level can be explained in terms of three components: food availability, accessibility and utilisation (**Figure 2.1**).

## Chapter 2: Literature review and conceptual framework



**Figure 2.1:** Conceptual framework investigating the economic and nutrition contribution of local agrobiodiversity among smallholder farmers (through market, on-farm, dietary and nutritional diversity) using four empirical chapters (Papers 1 to 4) with nine research questions (RQ 1.1 to 1.9) in leading to household food system activities and ultimately household food security outcomes (food system activities and food security outcomes adapted from Ericksen *et al.* (2010)). Local agrobiodiversity, as a set of food system activities, contributes to household food security outcomes, and the four papers (Papers 1 to 4) depict the inter-linkages across the three household food security outcomes – food availability (a), accessibility (b) and utilisation (c). Thus, these four papers map onto the conceptual framework in a cyclical manner, finally closing the ‘local agrobiodiversity circle’.

## Chapter 2: Literature review and conceptual framework

With regards to the three food security outcomes, food availability is the amount, type and quality of food a unit of analysis has to consume (Ericksen *et al.*, 2010). Food availability, in terms of calories, protein and micronutrients (Foley *et al.*, 2011), can be achieved through local production as well as distribution channels and mechanisms to exchange money, labour or other items of value for food (Ericksen *et al.*, 2010; Ingram, 2011). In sub-Saharan Africa, the consistently large numbers of subsistence producers is evidence of the importance they attach to such production, as it contributes directly to household food security as a supply of food (Aliber and Hart, 2009). Secondly, access to food is the ability to obtain the type, quality and quantity of food required, and it can be analysed in terms of the affordability of food that is available and how well allocation mechanisms such as markets work (Ericksen *et al.*, 2010; Ingram, 2011). Rural farming households predominantly access their foods from subsistence production, markets and households transfers (Baiphethi and Jacobs, 2009) such as gifts and food aid (Negatu, 2004). Lastly, food utilisation refers to the ability to consume and benefit from food and one of the factors determining this is the nutritional value of food (Ericksen *et al.*, 2010; Ingram, 2011).

At the household level, the main food system activities comprise of food production, mainly for food consumption but also for commercial purposes, where the surplus produce is distributed and retailed, for example in local markets (**Figure 2.1**). Simply feeding the world's growing population by 2030 brings into focus a threat of large-scale destruction of natural resources (Johns and Sthapit, 2004) including biodiversity, in and around agricultural land (Thrupp, 2000). The narrowing of diversity in crop species contributing to the world's food supplies has been considered a potential threat to food

## Chapter 2: Literature review and conceptual framework

security (Khoury *et al.*, 2014). Over many centuries, farmers have employed numerous practices to use, enhance and conserve agrobiodiversity in traditional farming systems. Agrobiodiversity includes not only a wide variety of species and genetic resources, but also the many ways in which farmers can exploit biodiversity to produce and manage crops, with such practices serving as a basis for survival and livelihood for millions of people (Thrupp, 2000). For many rural families, the sustainable use of local agrobiodiversity is their key to survival, since it allows them to exploit marginal lands and ensure a minimum level of food production even when faced with extremely harsh living conditions (Ekesa *et al.*, 2009). There is a growing realisation worldwide that biodiversity is fundamental to agricultural production and food security, as well as a valuable ingredient of environmental conservation (Thrupp, 2000).

Local agrobiodiversity, as a set of food system activities, can contribute to household food security outcomes. The four papers (Papers 1 to 4) show the inter-linkages across the different household food security outcomes – food availability, utilisation and accessibility. Paper 1, with a focus on on-farm agricultural diversity, assesses food availability and its connection to household food security by examining on-farm food plant and livestock diversity, as well as identifying the biophysical and socio-economic factors influencing food plant diversity, by making use of the first three research questions (RQ 1.1 to 1.3) outlined in Section 1.6. Picking up from Paper 1, the second empirical chapter (Paper 2) addresses both food availability and its utilisation by simultaneously exploring linkages between agricultural and dietary diversity. It does so by answering the next two research questions (RQ 1.4 to 1.5) outlined in Section 1.6. This paper focuses on dietary diversity, a broad multi-indicator measurement tool that

## Chapter 2: Literature review and conceptual framework

reflects economic access to food (for households) and dietary quality (for women) and is computed by summing up (different) food groups consumed over a given reference period. Some food types in the same food group may comprise of different or multiple nutrients, and this is what defines the subtle but important distinction between foods (dietary intake) and nutrients. Subsequently, their methodological approaches differ, as food consumption data are utilised when assessing dietary diversity measurements while food composition databases are used to generate nutrient composition data so as to compute nutrient diversity metrics. One type of a nutrient diversity metric is functional diversity, which has been utilised as one of the seven agricultural diversity indicators in this empirical chapter, as well as in Paper 3, which builds on the utilitarian value of the metric as a visual aid in conceptualising the existing nutrient diversity on farms and in markets. However, nutritional diversity is comprised of both nutrient and non-nutrient factors, which is already alluded to in Paper 2, by showing that dietary diversity is influenced less by agricultural diversity available in different seasons but more by socio-economic and cultural factors limiting the consumption of locally available nutritious foods.

Paper 3 provides further evidence to the low dietary diversity of consumed foods (measured in Paper 2) and builds onto this food consumption narrative by taking into account food availability, utilisation and accessibility (of both on-farm and market species) during the same seasons, by addressing two research questions (RQ 1.6 to 1.7) listed in Section 1.6. This empirical chapter starts by investigating a different aspect of diversity - that of nutrient diversity (of foods obtained from both on-farm and market sources) and shows that functionally redundant and unique species that meet all the

## Chapter 2: Literature review and conceptual framework

existing macro-and micro-nutrient needs under investigation are available during the different seasons. As nutritional diversity is comprised of both nutrient and non-nutrient factors, the paper goes on to show that there is low appreciation for most of the existing on-farm local agrobiodiversity, suggesting that non-nutrient factors and non-farm diversity factors (identified in Paper 2) contribute greatly to an overall low dietary and nutritional diversity. Beyond these parallelisms (with Paper 2), Paper 3 goes further to show that the affordability of nutrient-diverse foods available in markets vary in the different seasons. This strand of argument is picked up in different ways in Paper 4, which focuses on food accessibility to a large extent, and also takes into account food availability (thus linking back to Paper 1), by covering the last two research questions (RQ 1.8 to 1.9) outlined in Section 1.6. With its focus on the role of markets in improving household food access, Paper 4 shows that there is a high demand for cereals, animal source foods and fruits, the main food groups purchased from markets. Economic access to these preferred foods can be enhanced by (i) selling diverse local foods of high nutritional value but low desirability among the surveyed smallholder farming households (see Paper 3) (ii) selling products uniquely available through on-farm production but missing in local markets thus filling in the market gaps (see Paper 4), and (iii) improving smallholder farmers' access to formal markets in general and to market traders in particular by organising smallholder farmers to fill in these local market gaps and to add value to surplus perishable produce (see Paper 4). Paper 4 also shows that smallholder farming households utilise multiple food procurement sources (markets, working social networks and on-farm production) for food availability, thus connecting it back to Paper 1.

## Chapter 2: Literature review and conceptual framework

Multiple food sourcing also provides empirical explanations for the interconnected nature of the aforementioned food security outcomes, as shown by the inter-linkages across local agrobiodiversity's availability (in Paper 1), utilisation (in Papers 2 and 3) and accessibility (in Papers 3 and 4). Thus, the four papers map onto the conceptual framework in a cyclical manner, finally closing the 'local agrobiodiversity circle'. Together, the four papers (Papers 1 to 4) show the linkages between the 'agrobiodiversity circle' and the 'food security outcomes compartment' through two key empirical themes embroidered in the four papers from different perspectives – that of the aforestated multiple food procurement, and the pivotal role of socio-economic and cultural factors (see Chapter 8 Section 8.3 for more discussion on these themes). In between the 'agrobiodiversity circle' and the 'food security outcomes compartment' is the 'food system activities compartment' (**Figure 2.1**). The intricate relationship between the 'food security outcomes' and 'food system activities' is illustrated by two-way arrows (**Figure 2.1**), showing the inter-dependence of these food security components.

Agriculture provides a source of income as well as a source of food (Malapit *et al.*, 2013). Although gaining more desired nutrients from food is dependent on multiple factors beyond the scope of the agricultural sector (FAO, 2013), local agrobiodiversity can contribute to dietary improvement (through on-farm food diversity and dietary diversity) and to economic gain (through income generation) among smallholder farmers (**Figure 2.1**). Dietary and economic improvement may be mutually reinforcing of local agrobiodiversity conservation (Johns and Sthapit, 2004). This is because when people perceive that agrobiodiversity has greater value through positive impacts on both

## Chapter 2: Literature review and conceptual framework

health and income, they are more likely to maintain and protect it (Frison *et al.*, 2004). Healthy diets for populations depend on the availability and accessibility of a variety of plant and animal foods, and both of these resources are characteristic of traditional food systems where the diversity of indigenous crops and wild plant and animal species available in tropical countries provides essential nutrients (Johns and Sthapit, 2004). Though the availability of processed calorie-rich foods at affordable prices contributes to food security and has generally reduced the number of undernourished people (Johns and Maundu, 2006), agrobiodiversity plays a pivotal role since even if dietary energy needs can be met without dietary diversity, micronutrient needs cannot be met without diversity (Fanzo *et al.*, 2011).

Agrobiodiversity is also the basis of dietary diversity, the preferred choice for nutrition and health (Frison *et al.*, 2004; Johns and Maundu, 2006; Fanzo *et al.*, 2011). Agrobiodiversity within food systems not only provides a wide and varied range of nutrient-rich foods and dietary components with important health properties, it is also a resource that is locally available (Fanzo *et al.*, 2011), hence, quality and quantity of food need not be mutually exclusive (Johns and Sthapit, 2004). In addition to its role on dietary improvement, linking agrobiodiversity and health can be a way to direct economic growth in a positive manner. Smallholder farmers and local communities can manage and use traditional agrobiodiversity to comparative economic advantage to improve their livelihoods by developing products that can be marketed to meet demands of local food cultures and offer nutritional and cultural benefits to both rural and urban consumers (Johns and Sthapit, 2004; Johns and Maundu, 2006). An additional route to economic growth is business and trade in agricultural produce, which provides income

generating opportunities that even those with limited land can take up (De Weerdt, 2009).

#### **2.7.4 Extent of local agrobiodiversity utilisation for household food security**

The irony is that though highly agriculturally diverse systems are found in the developing world among smallholder farmers (Johns *et al.*, 2006), most of the food insecure people (70%) live and work in rural areas and smallholder farmers still constitute 50 per cent of developing country rural populations (FAO and PAR, 2011). This could mean that though local agrobiodiversity is widely available and accessible, sustainable optimal utilisation of this resource remains untapped (see Paper 3 for more discussion on this point).

As smallholder farmers represent a heterogeneous group (IFPRI, 2015), the extent of optimal utilisation of local agrobiodiversity as a path to household food security is likely to vary. A majority of smallholder farmers focus on growing subsistence food crops to meet their family food needs (Stocking *et al.*, 2003; Aliber and Hart, 2009). Although nutritious crops may be cultivated in smallholder farms, this does not necessarily translate to equal access to nutritious foods among all household members, due to socio-cultural contexts, among other factors. For example, women and children may hold lower social status which limits their access to nutrient-rich foods and instead, household allocation preferences could be biased towards older boys, men and elders (Girard *et al.*, 2012). Hence, although available on-farm agrobiodiversity needs to serve as a source of nutritious food, equal access to and utilisation of increased on-farm diversity among all household members could be limited by other underlying factors

## Chapter 2: Literature review and conceptual framework

(Malapit *et al.*, 2013), including food taboos (for more discussion on this issue, see Paper 2 Section 5.5.3) and low preferences for a diversity of nutrient-diverse foods (see Paper 3 Section 6.5.2 for more details).

Other than the food quality dimension, quantities of on-farm produce may not be adequate to feed an entire household for twelve months, especially due to crop seasonality brought about by changes in climatic conditions throughout the year (Bernholt *et al.*, 2009). Nevertheless, contrary to standard wisdom, agrobiodiversity could benefit from externally driven processes of change, suggesting that diversification is a strategy where external pressures, such as climatic change, can be withstood (Stocking *et al.*, 2003; Ayinde *et al.*, 2008). For example, though lower yields are achieved by crops dominantly under agrobiodiverse systems such as intercropped systems (Unruh, 2001; Onduru and Du Preez, 2007), studies indicate that other benefits could play overriding roles, for example the ability to harvest two crops from a field in one planting season and to minimise crop failure risks (Onduru and Du Preez, 2007) as the crops may be more resistant to changing conditions (Unruh, 2001). Nevertheless, though poor smallholder farmers rely more heavily and directly on local resources for their livelihoods due to the lack of alternative options (Rietbergen *et al.*, 2002), it cannot be assumed that all smallholder farmers in rural households will have diversified farms. For instance, Abdulai and CroleRees (2001) suggest that the poorest of households may not be as diverse, yet it may be important for them to have more diversified systems as a risk aversion strategy. In addition, predominantly subsistence-oriented production systems are likely to harbour lower food plant diversity and not necessarily make

## Chapter 2: Literature review and conceptual framework

smallholder farming households more food secure as compared to market-oriented farming systems (see Paper 1 for more discussion on this matter).

Although rural households both consume and sell food crops (Mehra and Rojas, 2008), the majority of smallholder farmers also rely on markets for household food needs (Jayne *et al.*, 2006; Baiphethi and Jacobs, 2009) (Paper 4 addresses this topic in more details). Though there could be a diversity of foods available in markets, access to quality food comprising of a diversity of nutrients is often a problem of affordability rather than availability (Johns and Sthapit, 2004). It is likely that dietary options are limited for these poor smallholder farming households whose food choices are determined by economic means (Johns and Maundu, 2006).

In the coming decades, improving food security, reducing poverty and improving environmental sustainability will be closely linked to the development of strategies that are relevant and appropriate for smallholder farmers (FAO and PAR, 2011), especially on enhanced sustainable utilisation of their most readily available resource, local agrobiodiversity. Research plays a role in contributing knowledge on the utilisation of local agrobiodiversity. However, there exist several research gaps, three of which this study seeks to address. Firstly, farming system interventions have not effectively documented the way in which the use of indigenous crops by poor smallholder farming households can simultaneously achieve the outcomes of micronutrient adequacy, poverty reduction and agrobiodiversity conservation (Frison *et al.*, 2006). Secondly, food composition provides an important link for biodiversity and nutrition and further research is needed to increase the evidence base by filling our knowledge gaps with

better inventories and more data on food composition and consumption (Toledo and Burlingame, 2006). Thirdly, there is relatively little hard information on the links between agrobiodiversity, dietary diversity and its association with nutrition (for example, nutrient diversity) among rural producers (Johns and Maundu, 2006). Much of what has been reported on is anecdotal (Frison *et al.*, 2004) and there is a pressing need for this relationship to be confirmed based on empirical evidence (Fanzo *et al.*, 2011). As food availability data cannot be used interchangeably with food consumption data (Hawkesworth *et al.*, 2010), the links between agrobiodiversity, nutrient diversity and dietary diversity could vary depending on various factors, such as different agro-ecological contexts. In addition, some important barriers to food availability, accessibility and utilisation may vary at the household level (Remans *et al.*, 2014), thus they may be better understood if the primary unit of analysis used is the household (Hesselberg and Yaro, 2006). This study utilised a case study of smallholders in two different agro-ecological zones to address the above gaps.

### **2.8 Summary and knowledge gaps**

The literature review has aimed to examine the existing knowledge on food security strategies at the global, regional and local levels in the context of food production systems. At the global level, this literature review has examined studies on food security from a food systems approach by synthesising studies that address food security in the context of food production, food allocation and food accessibility, with accessibility to nutritious foods as the desired end goal. The literature suggests that the global focus on modern crop production methods and on staples and other market-oriented crops has diminished the role of indigenous crops in farming systems. It further suggests that

## Chapter 2: Literature review and conceptual framework

diverse agricultural systems may not have been given due attention in their role to achieve food security. Most populations in developing countries reside in rural spaces where traditional farming systems are employed, with the majority of rural households as smallholder farmers, yet these are the same areas that face more food and nutritional challenges, possibly due to undervaluation of agrobiodiversity.

At the local level, studies exploring various incentives and disincentives for on-farm agrobiodiversity have been discussed. Though the literature suggests that there are multiple factors that could influence plant diversity, there is a knowledge gap on a comparative analysis on factors influencing plant diversity among smallholder farmers in close geographical proximity with different environmental, farm and socioeconomic characteristics (see Paper 1). This study fills this knowledge gap, as well as a gap on the variation in diversity with seasonality and how this crop diversity is utilised by evaluating the sources of foods for home consumption (see Paper 2).

Though it is acknowledged that on-farm agrobiodiversity is insufficient to meet rural households' food needs, there exists a knowledge gap on a comparative analysis on the relationship between household food consumption and food available in local markets and on mixed farms, which this study fills. Further, though literature suggests that smallholder farmers are rarely involved as sellers in local markets, there exists a knowledge gap on what factors influence the level of their involvement in market trading networks, in regions with good market access, which this study also addresses

In conducting agricultural research, the literature suggests that gender-informed approaches have not yet been adopted, which this study seeks to incorporate by

## Chapter 2: Literature review and conceptual framework

conducting a comparative analysis of gender-specific perspectives on the key incentives and disincentives for agrobiodiverse and specialised smallholder farming systems (see Paper 3). At the household level, this study also reinforces the need to integrate gender relations and intra-household decision making in food security research, by highlighting how seasonal availability and perceptions of various food groups differ between men and women smallholder farmers in the study area (see Papers 2 and 3). In addition to this, socio-cultural factors shaping household food consumption patterns have been often overlooked when examining agriculture-nutrition linkages, and studies suggest that if they are taken into account, food and nutrition insecurity will be more accurately tackled.

At the regional level, this chapter has reviewed studies on the effects that markets have on food availability and affordability, on on-farm agrobiodiversity and the status of market integration among smallholder farmers and how this impacts on food self-sufficiency. While there could be a diversity of foods available in markets, access to these foods is often an issue of affordability rather than availability (see Papers 3 and 4 for more details) (See Paper 4).

When taking up a multi-dimensional focus in addressing agrobiodiversity and food security at the household level, an argument has been made for the application of the food system concept as a useful conceptual framework for addressing the multiple dimensions of household food security.

### **3 Methodology overview**

This chapter serves three purposes. First, it provides an overview of the location and data collection methods for the study. Specific methods used for data collection, processing and analysis are explained in more details in the respective empirical chapters (Papers 1 to 4). Second, the methodological approaches utilised to enhance data collection are drawn out. Lastly, it discusses in details the limitations experienced while collecting data and how they may have affected the study results.

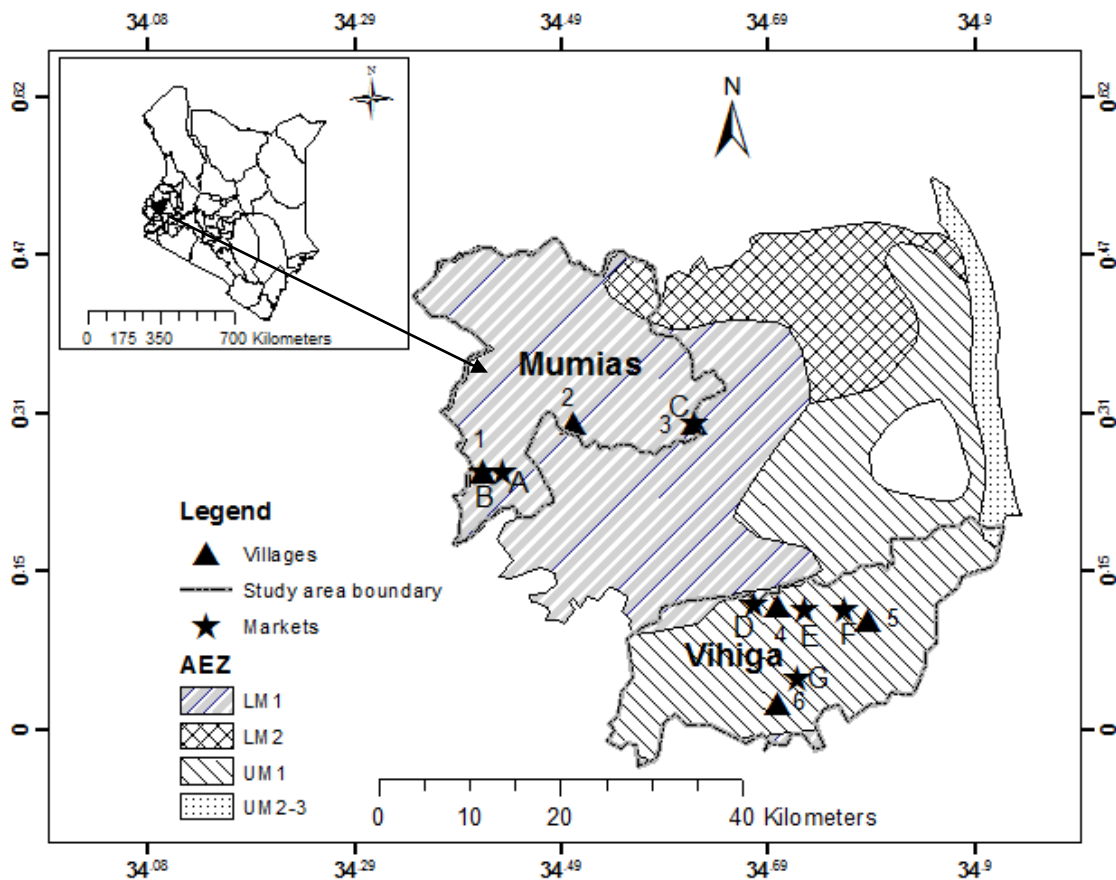
#### **3.1 Overview of the study area and research boundaries**

This research is based on fieldwork where primary data were collected in two districts in Western Kenya. The survey was carried out in three villages in Mumias district and three villages in Vihiga district, representing Lower Midland (LM1) and Upper Midland (UM1) agro-ecological zones, respectively. Mumias district predominantly lies in the Lower Midland (LM) agro-ecological zone (Jaetzold *et al.*, 2005) with annual mean temperature of between 22.2 and 21.0 °C, altitude of between 1300 and 1500 m above sea level (a.s.l) and total annual rainfall ranging from 1650 to 1850 mm. The rainfall is bimodal with long rains from the end of February to the end of March and short rains from the end of July to November/December. It is well suited for sugarcane growing as a cash crop. The soils are mainly ferrasols (Jaetzold *et al.*, 2005). Vihiga district mainly lies in the Upper Midland (UM) agro-ecological zone (Jaetzold *et al.*, 2005). It has an annual mean temperature of between 18.5 and 21.0 °C, altitude of between 1500 and 1900 m a.s.l, and annual average rainfall ranging from 1800 mm to above 2000 mm. The rainfall is bimodal with long rains from the end of February to the end of March

### Chapter 3: Methodology overview

and short rains from mid-July to November/December. It is well suited for sugarcane, coffee and tea as cash crops, as well as staple food crops, such as maize, beans and cowpeas, among others. The soils are predominantly a combination of cambisols and lithosols (Jaetzold *et al.*, 2005).

Mumias district was chosen as a study site because it was a research study site in a previous project by an organisation I collaborated with for this research, Bioversity International. The comparative advantage of choosing this study site was that some information was already available through the previous Bioversity International project, for example, the distance of sub-locations to markets, which was utilised by the present study. Vihiga district, lying in the Upper Midland Zone, was selected to represent a different agro-ecological zone, and thus most likely a different level of agrobiodiversity, with an added advantage of geographical closeness to Mumias district. **Figure 3.1** below shows a map of the two study areas, Mumias and Vihiga districts, indicating six villages and seven markets where the survey was carried out.



**Figure 3.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kililingili, E=Mudete , F= Chavakali, G= Majengo

The present study was conducted in tandem with a larger, cross-sectional research project entitled ‘Improving nutrition through local agrobiodiversity’, where I was responsible for coordinating the research outputs on agriculture, namely, availability and utilisation of local agrobiodiversity on farms and in markets. Working alongside me, were two doctoral students responsible for the collection of nutrition data. Some of the data collected by these students, including nutritional knowledge of women, child

### Chapter 3: Methodology overview

feeding practices, and anthropometric measurements of both women and children, were made available for use in the present study.

Except for the exchange of the aforementioned nutrition and agriculture data (in the 2012 survey), there were low synergy points between the agriculture and nutrition studies, primarily because the overall objectives of the two studies differed. The larger study design (utilised by the two nutrition doctoral students) was a repeated cross-sectional study, which included a nested cohort longitudinal study (employed in the present case study) over three periods of time. The nutrition doctoral students chose the cross-sectional study design because they aimed to assess the nutritional knowledge of women household members and health of their children aged between six and 23 months (as this age represents the ‘window of opportunity’ for children receiving complementary foods, after which the effects of under-nutrition are hard to change). Rather than focusing on women and children, I collected data on overall household members as my objective was to examine the availability, utilisation and linkages across agricultural, dietary and nutritional diversity among the same households during different seasons, hence the longitudinal study approach. By the 2014 survey, most of the households interviewed by the nutrition students in the 2012 survey no longer met their 2-year age criteria, and their exclusion meant that we only had three (10%) of households in common during the 2014 survey. Therefore, I collected all the nutrition data that I required from the same 30 households in the 2014 survey (which are mainly reported in Paper 2).

### Chapter 3: Methodology overview

For the present case study, the selection of 30 households in six villages in the two districts was linked to the 2012 nutrition study's baseline survey. In this nutrition study, 30 research villages with ten households per village were selected (details on the village selection criteria and how possible biases were dealt with are explained by one of the two nutrition doctoral students in the methods section of her co-authored publication, Waswa *et al.* (2015)). From the nutrition study's sample size of 300 randomly selected households in 30 villages, six villages - three villages in each of the two districts, were purposively sampled for the present study. The selection of these six villages was according to two indicators: (i) agro-ecological zone, ensuring that the villages were not too close together, but yet covered the whole district, (ii) child dietary diversity scores, which aimed at three villages with different child dietary diversity score means of four, six and eight, representing low, medium and high dietary diversity, respectively (dietary diversity scores in Mumias and Vihiga districts were collected by Kipkorir (2012), the other doctoral nutrition student). In each of these six villages, five households were randomly selected from the aforementioned pre-selected list (meeting the above two indicators) of the ten household members per village surveyed in the nutrition study. This was done by generating random numbers to each of them by use of Excel, followed by sorting the random numbers in descending order, and picking the top five households. In cases where one of the five selected household members were unavailable for the study, the next household on the randomly generated list was selected. Thus, 30 households (15 households in each of the two districts) were selected to represent 10 per cent of the overall sample size of 300 households.

### **3.2 Overview of the data collection methods**

In light of the multiple dimensions of food and nutrition security, this study utilises the food systems concept (Ericksen *et al.*, 2010) to examine the availability, utilisation and linkages between agricultural, nutritional and dietary diversity among smallholder farmers in Western Kenya. This study goes a step further to ground the theoretical conceptual framework with empirical data, where local agrobiodiversity as a source of food and income leads to household food system activities and food security outcomes. There is a need to simultaneously investigate multiple food security components, by moving beyond food production factors to consumption (Herforth and Ahmed, 2015; McDermott *et al.*, 2015; Powell *et al.*, 2015), access (Ziervogel and Ericksen, 2010) and socio-cultural (Noack and Pouw, 2014) dimensions of food, if agricultural research is to contribute to holistic food and nutrition security (Noack and Pouw, 2014; McDermott *et al.*, 2015).

This study contributes to the field by employing multi-method approaches that have rarely been applied together when addressing the food and nutrition insecurity challenge among smallholder farming households. Paper 1 examines biophysical and socioeconomic factors underlying agrobiodiversity on smallholder farms, by use of quantitative methods, as opposed to the majority of studies that have remained descriptive (Bernholt *et al.*, 2009). In the second paper, this study simultaneously assesses agricultural and dietary diversity at an individual and household level, by use of both one-day and seven-day dietary diversity indicators. There are only a few studies that have explored linkages between agricultural and dietary diversity (Ekesa *et al.*,

2008; Herforth, 2010; Keding *et al.*, 2012; Jones *et al.*, 2014). Even fewer studies have explored these linkages based on both one-day and seven-day food consumption recall periods (Jones *et al.*, 2014), and at both household and individual levels (Rajendran *et al.*, 2014). These multiple assessments allow the capture of snapshot one-day and regular seven-day food consumption patterns, as predictors of economic access to food (for households) and dietary quality (for women) (FAO, 2011).

Paper 3 assesses the nutrient diversity of food species in smallholder farms by incorporating scarce empirical data on crop abundance, livestock diversity and household income ranges (DeClerck *et al.*, 2011; Remans *et al.*, 2011). While recent research using national-level data has enabled the incorporation of quantities of foods produced and supplied (Remans *et al.*, 2014) and presence/absence of market food purchases (Luckett *et al.*, 2015), this study uses different approaches to generate both farm and market abundance data. In addition to this, using market food prices as a proxy for food accessibility allows this research to contribute to understanding how food accessibility compares to smallholder households' income ranges. Moreover, as nutrition security entails more than just nutrients (Acharya *et al.*, 2014), this study goes a step further to incorporate farmers' food perceptions. As this additional layer integrates the important dimension of food utilisation, which is best captured using household-level data (Remans *et al.*, 2014), it allows a more accurate prediction of overall nutritional diversity among the smallholder farming households. Paper 4 assesses the extent that access to agrobiodiversity in local markets contributes to meeting household food needs. Although it is acknowledged that on-farm food production is insufficient to meet smallholder farming household food needs (Negatu,

2004; Baiphethi and Jacobs, 2009), there exists a knowledge gap on the diversity and amounts of other food groups sourced from markets, besides staple food grains (Jayne *et al.*, 2006), which this study seeks to address, as well as the extent of smallholder farmers' local market integration.

With the case study design utilised in the four papers (Papers 1 to 4), the thesis aimed to gain insights into possible food and nutrition security inter-linkages using multi-method approaches in the specific local context, rather than provide sample representativeness and cultural generalisation.

### **3.2.1 Quantitative data**

Farm surveys were conducted to examine food plant and livestock diversity and to identify the biophysical and socio-economic factors influencing food plant diversity during September/October 2012, November/December 2012 and July/August 2014 periods in the same 30 smallholder farms. In addition, during both the September/October 2012 and July/August 2014 seasons, dietary diversity scores of different household members and for women were assessed, as well as nutrient diversity on smallholder farms. Based on structured questionnaires (Appendix IV), most of the farm, dietary and nutrient diversity data are described in Papers 1, 2 and 3, respectively.

Market surveys were carried out during the September/October 2012 and July/August 2014 seasons to determine the prices of different foods available in seven markets and the extent of smallholder farmers' involvement in the market trading systems. Most of the market data presented in Paper 4 are based on structured questionnaires (Appendix IV).

### **3.2.2 Qualitative data**

Focus Group Discussions (FGDs) were employed to assess the seasonal availability and perceptions on locally available foods as well as preferences on different farming systems. The FGDs were conducted among 97 men and women smallholder farmers during September/October 2012 and most of the FGD data analysed in Paper 3 are based on data from semi-structured checklists (see Appendix IV for the facilitator's and note-taker's versions).

### **3.3 Research Ethics**

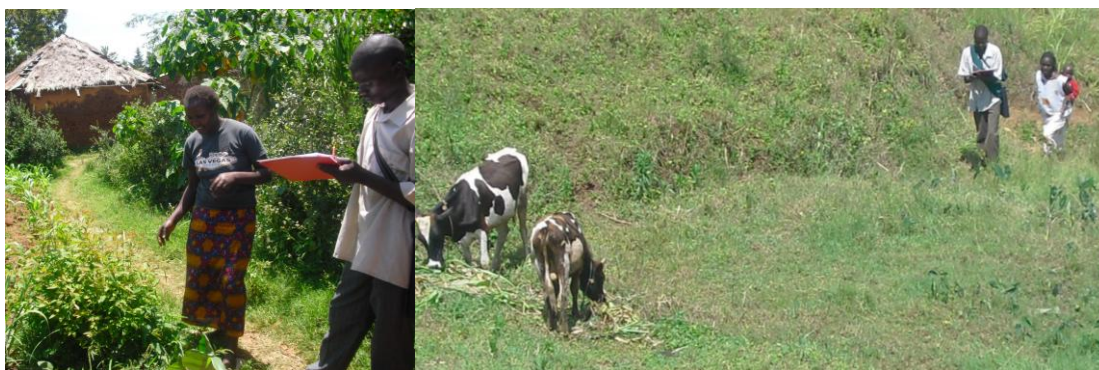
Ethical clearance for this research study was approved by the Central University Research Ethics Committee (CUREC) at the University of Oxford. Research permission was granted and a research permit issued to the thesis author by the National Council of Science and Technology in Nairobi, Kenya. Oral consent was obtained from each participant by the thesis author prior to conducting the interviews. Anonymity of respondents interviewed was adhered to when writing up the data collected.

### **3.4 Methodological approaches and possible success factors**

#### **3.4.1 Farm surveys**

All the farmers were very willing and happy to show us their farms and identify their various food plant and livestock species, as well as participate in the species counting (**Figure 3.2**). We were open to different gender insights during the on-farm walks, as it was not always possible to have both the male and female respondents join us for the walks, especially as different household members still had pending routine tasks that

needed to be carried out despite our presence. Engaging the farmers in these activities enabled us to establish rapport with them, which created a relaxed atmosphere and the feeling that they were the experts in their own farms.



**Figure 3.2:** farm walk with farmers (far left and far right) identifying their plant and livestock species

In addition, this procedure enabled the capture of an exhaustive species catalogue. The use of on-farm walks with farmers to observe, identify and record available species also proved successful in smallholder farming systems in northern Uganda (Agea *et al.*, 2007) and central Zimbabwe (Maroyi, 2013), while simply requesting farmers to list all their on-farm species resulted in an incomplete species inventory in a smallholder farm survey in south Brazil (Kawa *et al.*, 2015). In the few cases where farmers had more than one farm, the additional farms were mostly within walking distance, which required additional time. Some cues noted during the farm walks were that farmers were generally very conversant with the local nomenclature and nutritional benefits of the various indigenous vegetables they possessed, especially *Amaranthus* species. This high awareness could be as a result of efforts by various organisations to reinvigorate the status of African indigenous vegetables (Gotor and Irungu, 2010; Muhanji *et al.*, 2011). However, most of the on-farm indigenous fruit trees grew on their own, were generally

left unmanaged and farmers were generally unaware of their nutritional value, which are similar experiences shared by researchers in eastern Kenya (Kehlenbeck *et al.*, 2013), northern Uganda (Agea *et al.*, 2007) and northern Ethiopia (Fentahun and Hager, 2009).

The participation of farmers was and still is also vital for the validation of results (Waithaka *et al.*, 2006), for a variety of reasons. Fully engaging the farmers enabled us to screen out edible plant and livestock species that were not consumed by particular households, even if other surveyed families used them for food - and the converse was also true. This approach also enabled us to capture the different parts of a single food species consumed, data that were necessary for accurate analysis of the nutrient diversity of different food parts (Remans *et al.*, 2011). For example, leaves and fruits of *Cucurbita* species contain different types and amounts of nutrients.

A common limitation experienced by researchers investigating cropping systems is the incorporation of quantities of harvested plants (Remans *et al.*, 2011; Jones *et al.*, 2014; Lockett *et al.*, 2015). This research sought to fill this gap in various ways, as the data were a prerequisite for the computation of abundance-weighted nutrient diversity of food species in both farms and markets. While we always carried a portable weighing scale with us, taking actual measurements was often inappropriate (for example, for big livestock species such as cattle and for busy market traders where an alteration of their displayed produce could result in a lost sale from a potential customer). When used, the weighing scale often acted as a bridge to the actual quantities of production outputs. For example, farmers and market traders usually approximated the number of some starchy roots harvested/sold using bags. They estimated that a 90-kilogram bag of cassava

### Chapter 3: Methodology overview

(*Manihot esculenta*) contained roughly 300 cassavas, and the actual weight of one cassava was at an average of 0.3 kilograms. Hence, when conducting this interview section, different dimensions and number of bags of either cassava, sweet potato (*Ipomoea batatas*) or taro (*Colocasia esculenta*) harvested or sold were recorded. After the interview, we computed the actual quantities of any of these starchy roots on the basis that the average weight of one piece was estimated at 0.3 kilograms.

For other food groups, the majority of farmers and market traders quantified their production outputs in different ways, which generally meant that we needed to ‘speak their language’ to enable us to translate from local to standard measurements. One exception was the use of a common local term, ‘gorogoro’, which referred to a 2-kilogram container and was usually used to weigh dried grains or pulses. We generated standardised weights based on an average of empirical measurements (mainly for plants) or published average weights of livestock in East Africa. More details on the various dimensions used to translate different food plant and livestock species into the standard measurement for use in this study (grams) are in Appendix V. A similar locally adapted approach was utilised to convert various local dimensions of crop outputs into standard measurements (kilograms and litres) in a rural South African village, facilitating the calculation of the monetary value of farmers’ production outputs (Dovie *et al.*, 2003).

While interviews with the household head or his/her representative sufficed for the 2012 farm survey data collection, as in other crop production surveys (Dovie *et al.*, 2003; Fifanou *et al.*, 2011; Wiehle *et al.*, 2014) the collection of dietary diversity data during

the 2014 farm survey required the presence and participation of both the household head and their wives (or only women in female-headed households). As food preparation is usually under the women's domain (Quisumbing *et al.*, 1995; Mehra and Rojas, 2008), accuracy in both one-day and seven-day food consumption data were achieved when the female home managers were present, which necessitated contacting households in advance to schedule appointments. So as to ensure the households' availability for the scheduled face-to-face interview sessions, we visited each of the households in advance to request an appointment at a convenient day and time, especially as the rigorous nature of the farm surveys required a time commitment of about half a day on average. In addition, we noted their phone numbers and called them before the scheduled appointment to re-confirm their availability.

### **3.4.2 Focus group discussions**

As in the farm survey, similar prior arrangements to confirm the attendance of respondents were made for the Focus Group Discussions (FGDs). Another probable reason why the FGD participants attended our sessions was based on how we presented the research aims to each of the proposed respondents prior to the FGD session. Taking the time to visit each of the households, instead of simply relying on local contact persons to recruit participants on our behalf, enabled us to directly expound on the overall study objectives. This interaction also enabled us to ascertain that the proposed participants met two key criteria for inclusion in the FGDs, namely (i) their experience as smallholder farmers (ii) their ability to communicate in Kiswahili, the national language spoken in Kenya, which was to be used during the FGD sessions. Thus, the FGD participants were selected purposively according to the aforesaid criteria. For the

### Chapter 3: Methodology overview

selected participants, we requested for their voluntary participation and for some of their personal information (age and phone number). Our active involvement in the recruitment exercise also ensured that the short-listed participants were of varying age groups and from different parts of the village, so as to achieve demographic representativeness (Kitzinger and Barbour, 1999). We also informed participants that the discussions could take up to two and a half hours, and checked on their day and time preference, which are some of the recommended FGD recruitment practices (Rabiee, 2004). Prior to the scheduled FGD session, we called to re-confirm their attendance, which is another helpful approach to enhance participation (The Health Communication Unit, 2002). By the fourth FGD session, we had learnt that so as to maximise turnout numbers in view of other gender-specific general time commitments, it was best to interview female and male participants in the mornings and afternoons, respectively. Therefore, for most of the remaining FGD recruitments, we informed participants of the set time but continued to consult on their preferred day. In consultation with the local contact person in each village, the selected FGD venues were also communicated to the participants during the recruitment stage. FGD sessions were held in different places in the village which were centrally located, familiar and interruption-free (Kitzinger and Barbour, 1999), such as local churches, health centres and open shaded places within the home compound of the village elders or local contact people, venues also successfully utilised in other Western Kenya studies (Mbagaya *et al.*, 2005; Shaffer *et al.*, 2006; Waswa *et al.*, 2015).

On the chosen day, two FGDs, based on gender (Satzinger *et al.*, 2009) were held, a women-only and a men-only FGD. This is because it was deemed men and women may

offer different views on the same set of questions and they talk more openly when separately grouped, as also shown by Shaffer *et al.* (2006). The FGD sessions were facilitated by the thesis author, who moderated the sessions in the national language, Kiswahili, using FGD guideline questions formulated beforehand (Appendix IV). During each FGD session, a field assistant who aided in note-taking was present (see Appendix IV for the note-taker's FGD guidelines). The note-taker was helpful in translating any local terminologies or examples communicated by participants of relevance to the flow of the discussion, as he also spoke the dominant local language in the study area, Luhya. At the start of the FGD sessions, the moderator introduced herself and the note-taker as well as the overall research objectives and the specific goals of the FGD session.

In the 'warm-up' session of the FGD, the participants were requested to write their names on two sets of name-tags, one of which was used for identification purposes. After briefly introducing themselves, the moderator showed them a pictorial scale representing different levels of on-farm diversity. She explained that the scale was divided into three parts – the left side representing farms with few types of plants and livestock species, the middle with an average number of species, and the right side with high food species numbers (**Figure 3.3**). Each of the participants was then requested to rate the level of their on-farm agrobiodiversity by placing the second set of their name-tags in any of the three positions on the pictorial scale (**Figure 3.3**).



**Figure 3.3:** Pictorial scale indicating the different levels of on-farm agrobiodiversity in one men-only (left side) and one women-only (right side) group

Each farmer then explained to the rest of the group their rationale for placing the name-tag in the particular place, citing the number of different plants and livestock they possessed. This discussion was designed to encourage interaction among participants (Kitzinger, 1994) where each of the participants could freely seek clarifications from the rest of the group, and where necessary modified their ratings, based on the number of their on-farm species. This exercise laid the foundation for the rest of the FGD session, and brought the agrobiodiversity topic to the level of participants' understanding and relevance. The scale was referred back to in different sections of the discussion where it was necessary to remind the participants of the concept, especially pertaining to discussions on incentives and disincentives of agrobiodiverse and specialised farms. In addition, the importance of these 'warm-up' sessions in creating rapport and providing a non-intimidating atmosphere has also been acknowledged (Kitzinger and Barbour, 1999; The Health Communication Unit, 2002).

### Chapter 3: Methodology overview

The second part of the discussion captured food lists and seasonal calendars of two (out of six) food groups. Focusing each FGD session to a set of two specific food groups was achieved by pre-selecting and pre-testing six food groups of research interest to ensure that a mix of one short and one long food group (for example, vegetables with fats/oils) were discussed in one FGD session so that all the FGDs could all fit within the expected time range of a maximum of two and a half hours. In each village, the set of two specific food groups to be discussed by participants in each FGD session were randomly selected, but so as to document the differences in gender views on similar food groups, the second FGD session in each village focused on the same set of two food groups.

Various researchers have utilised simple participatory rural appraisal tools such as seasonal calendars (Dovie *et al.*, 2003; Noack and Pouw, 2014; Waswa *et al.*, 2015) and matrix ranking (Dovie *et al.*, 2003) to elicit information through FGDs. So as to also make the FGD sessions more engaging and interesting, matrix and group ranking participatory approaches were utilised in the subsequent discussion part to capture farmers' perceptions on agrobiodiverse and specialised farms. As a starting point, the FGD moderator facilitated the discussion and listed all the incentives and disincentives for high on-farm agrobiodiversity mentioned by the participants on a flip-chart. So as to ensure the generated points reflected views of all the group members rather than opinions of a few dominant individuals (IIRR, 1996), each participant was asked why they placed their name-tag in a particular position on the scale. They were also requested to explain what motivated or discouraged their maintaining high on-farm agrobiodiversity, whether from personal or observational experience. All the points mentioned were summarised in the flip-chart and read out to the group. The participants

were asked if the information reflected what they had said and if any points were missing or misrepresented, changes were made accordingly. Incentives and disincentives for maintaining specialised farms were also captured in a similar fashion, in a separate flip-chart paper.

Ranking of incentives and disincentives for diversification and specialisation was then done. In the first set of discussions pertaining to agrobiodiverse farms, an adaptation of the matrix ranking participatory approach (IIRR, 1996) was utilised. Each participant individually assigned different weights to all the points listed on the flip-chart (**Figure 3.4**). This was achieved by giving participants a number of sticky notes, which had been assigned with different numbers of dots, for them to stick next to the listed points, starting with a sticky note with the highest number of dots to the most preferred incentive and disincentive. The numbers of dots for each point were then summed up to arrive at an overall score. After this, the points were ranked according to the overall scores and the results presented to the participants. In the second set of discussions with regards to specialised farms, group consensus views were prioritised by an adaptation of the ‘group ranking’ system (IIRR, 1996). This entailed one participant, selected by the rest of the group, facilitating the ranking process (**Figure 3.4**), which was based on counting the number of participants who raised their hands for each of the listed points. The most important incentive/disincentive was ranked number 1. The ranked results were then read out to the group and if the ranking for any of the points did not reflect their views, the ranking process was repeated.



**Figure 3.4:** Women-only (left-side) and men-only (right side) group members participating in matrix and group ranking exercises, respectively

At the end of each of the FGD sessions, we offered refreshments to the participants as a token of appreciation for their time and helpful insights. This provision also contributes to making their experience a pleasant one (The Health Communication Unit, 2002).

### 3.4.3 Market surveys

While market surveys were brief, their less time consuming nature allowed us to take about fifteen minutes at each of the market stalls visited. After a short introduction of our research aims and how the data generated could be of benefit, we explicitly informed the market traders that we were willing to wait for them to serve their customers first and were open to interruptions during the short interview session as well. This reassured them that they would not lose customers while responding to our questions, as our research offered them no immediate financial benefits. While we were sometimes unable to conduct interviews with very busy market traders, successful interviews with other market vendors generated curiosity from their colleagues and buyers as well, which could have made the interviewed market trader feel highly valued

(Figure 3.5). Another strategy to enhance the feasibility of these surveys lies in the design of market stalls. Their row arrangement enables the visiting of each of the stalls and recording observations (Ekesa *et al.*, 2009), especially during market days (Abukutsa-Onyango, 2002). Making use of this approach was helpful in not only recording overall produce available in markets, but also as a ‘back-up’ for the random selection of alternative market traders to interview if the first randomly selected market trader was unavailable. Random selection of market traders selling different food categories was done by assigning and recording numbers to each of the food stands observed (in the ‘number of stands’ column in the market inventories (Appendix IV, Sections 9.4.6 and 9.4.7) and picking any of these numbers at random so as to select the market trader to interview for each of the available food categories.



**Figure 3.5:** Interview with a market trader selling grains and pulses

#### **3.4.4 General reflections**

A common approach applied in the market and farm surveys as well as FGDs was pre-testing of the research instruments, which I had translated from English into Kiswahili, to assess their validity. For the farm survey, a farmer in Central Kenya was visited and

### Chapter 3: Methodology overview

the preliminary questionnaire administered, including a farm walk to inventorise on-farm agrobiodiversity. For the FGD, a group of ten women-only farmers from the outskirts of Nairobi were engaged in a pilot FGD session. A market survey was also conducted at a farmers' market in Central Kenya, where preliminary market interview schedules were administered to several market traders at randomly selected stalls. Based on the pilot experience, the survey instruments were further improved and data entry and analysis plans mapped out before embarking on data collection at the research sites. Upon reflection, the rigorous research planning immensely contributed to the use of nearly all the data collected. Conducting interviews in Kiswahili, the national language spoken in Kenya, did not pose a challenge in the farm and market surveys as all the respondents were conversant with the language. However, by selecting and conducting the FGDs among only Kiswahili-speaking participants, we may have inevitably introduced a bias to the study by excluding much older and more knowledgeable smallholder farmers who could not communicate in Kiswahili. We still chose Kiswahili as the medium of communication because, as the FGD moderator, I needed to communicate with the participants using a common language, especially as I speak a different ethnic language. While I worked with a field assistant fluent in the dominant local language in the study sites, Luhya, there are about 26 distinct sub-tribes within the Luhya ethnic group. We encountered a number of these sub-tribes during the FGD participant recruitment stage, and in most cases it was difficult or sometimes impossible for the field assistant to communicate with these farmers in their native sub-tribe, hence the other reason for selecting Kiswahili-speaking FGD participants. Nevertheless, we made a conscious effort to select and interview FGD participants of varying ages, and the selected FGD participants ranged from 22 to 79 years.

Looking back, consultations with locals when using the three methodological approaches were pivotal for the timely and smooth data collection period. Besides obtaining formal consent to conduct research from national and district level authorities, local contact persons (village elders and community health workers) facilitated introductions to FGD and farm survey respondents, an approach that has been successfully applied in other recent studies (Netondo *et al.*, 2010; Maroyi, 2013; Kawa *et al.*, 2015; Waswa *et al.*, 2015). These service providers usually have extensive community reach and trust (Fanzo *et al.*, 2015), crucial skill-sets when engaging with the local community members. While the assistance of the local contact persons was helpful, enlisting the support of these gate-keepers when recruiting FGD participants unavoidably influenced which social spaces were available and which were not in the different villages. Nevertheless, this social space limitation did not affect the farm surveys, as the respondents were already pre-selected. The local contact persons directed us to participants' homes and formally introduced us, which enabled us to create rapport and trust with these community members.

For the 2014 farm survey, the local contact person's help enabled us to maintain consistency in the respondents interviewed during the 2012 farm survey. In two cases where either the household head or their spouse had migrated and was unreachable, the local contact persons were in a better position to suggest an alternative household member we could interview (thus enabling us to retain constancy in farms surveyed during both the 2012 and 2014 surveys). We especially needed to interview the lead woman of the household or another household member in charge of home food

### Chapter 3: Methodology overview

preparation, for accuracy of dietary diversity data. While gender sensitivity shaped the dietary diversity data collected in Paper 2, we were open to different gender insights for the rest of the data reported in Papers 1, 3 and 4. This approach was necessary as it was not always possible to have both the male and female respondents with us for the entire duration of the interview, especially as different household members still had their routine tasks that needed to be carried out, in spite of our presence. Instead, when one of the respondents deemed that a particular question suited their spouse better, they would then request them to join us so they could offer their insights. It is interesting to note that even when both spouses had the time to join us for the entire duration of the interview, it was common for them to assign different questions to the spouse they deemed best suited to respond. During the 2012 survey, the interviewed smallholder farming households and FGD participants also participated in the selection of the seven major local markets that were surveyed by explicitly asking them for the names of the nearby markets where they purchased most of their food from.

My affiliation to Bioversity International, which was one part of my professional identity in the fieldwork context, also facilitated a smooth data collection period. This was because the villages that I surveyed were also some of the ones that were sampled by the nutrition students during their 2012 baseline survey. So as not to over-burden the respondents, the nutrition students conducted their interviews one month before my start date. This approach also enabled them to pre-introduce me to the households and in so doing, the farmers were already aware of my expected arrival by the time I was contacting them to schedule appointments, resulting in a very receptive atmosphere. This overlap in the study sites also benefited the surveyed households from a nutrition

### Chapter 3: Methodology overview

point of view, especially as my agricultural research focus did not allow me to offer tangible benefits to the people at the time. One of the objectives of the nutrition study was to conduct nutrition education intervention sessions through group trainings and cooking demonstrations among the surveyed women household members, and the ripple effect was heartening. When I visited the households for the first time and introduced myself as one of the other Bioversity colleagues, it was common for the farmers to show me the colourful pictorial nutrition brochures emblazoned with the Bioversity logo that my nutrition colleagues had given them.

I also introduced myself as an agriculture research student, the other part of my professional identity. While this meant I was unable to feed back financial benefits to the respondents, they did not seem to be expecting any pay as a compensation for their time and participation, given my student status. Instead, they were very happy to respond to the interview questions and they usually went out of their way to engage with me in-depthly on various questions – evidence of their pleasant and warm-hearted personality, and a deeper understanding among the farmers who had either their own or their relatives' children enrolled in colleges as they explicitly mentioned that they hoped to provide sufficient data that would enable me to fulfil my study requirements. The on-farm walks with the farmers also offered me an opportunity to feed back benefits to the farmers in a unique way. While the atmosphere was such that the farmers were the experts in their farms, especially in terms of the local nomenclature of their species, they were usually oblivious of the nutritional value of some of the indigenous food plants they possessed, for example indigenous fruit trees, and they were eager to learn more from us. This need tied in quite well as I always carried a reference book with me

### Chapter 3: Methodology overview

to consult on the species that neither the farmers nor us could identify (Maundu *et al.*, 1999), which also served as a nutrient composition database for most of the traditional food plants in Kenya, thus enabling me to provide the farmers with very accurate information on the nutrient content of the species they possessed. In addition, I gave a non-monetary token of appreciation to the households at the end of each of the interview sessions, in form of household utensils for everyday use, comprising of plates, tea strainers and cups, with an *asante* (thank you) label attached to the gift-packs.

The FGD sessions were also voluntary, as during the recruitment stage I was explicit about my inability to pay them for their time. Nevertheless, the turnout was quite good, and looking back, this could be because they may have valued the time I took to visit each of them individually and request for their participation, instead of leaving the recruitment of participants to the local contact persons (who I paid for their services). Despite the non-monetary compensation to the FGD participants, I still found a small way to feed back benefits to some of their community members. The refreshments offered to the participants at the end of the sessions as a token of appreciation for their time and insights were usually bought and prepared by the host of our FGD session venue, whom I paid for their services. The refreshments consisted of the recommended local delicacies, usually chapattis and tea. For the market interviews, participation was also on voluntary basis and thus my field assistant and I were open to interruptions and usually waited for the market traders to serve their customers first and thus they did not lose out financially, especially as we were unable to pay them. Sometimes, after we completed conducting interviews with all the market traders in a particular market, we

### Chapter 3: Methodology overview

bought ready-to-eat produce from some of them, for example, fruits, although this was not obligatory.

The non-monetary but immediate form of feeding back benefits to the respondents was a deliberate choice, to a large extent due to my limited budget as a student, as aforementioned. Another subtle reason for this form of benefit has to do with the study context. Western Kenya is a well-researched study area and while this is a helpful feature for researchers when it comes to logistical planning and comparison of research outputs, farmers may have been over-strained and disappointed with previous research efforts when it comes to researchers making futuristic promises that they do not or cannot fulfil, sometimes due to unavoidable circumstances. Hence, voluntarily participation in the surveys was explicit from the outset so as to prevent any unmet financial expectations. The non-monetary tokens of appreciation provided at the end of each of the surveys, though small, the respondents were always appreciative. In addition, we were cognisant that paying respondents for their time could make it difficult for other researchers with small budgets to conduct research in the same sites in the future.

While the support of the local contact people was also necessary as it was my first time to work in these villages hence my background knowledge of the field-sites was low, my own role in conducting research in a new context facilitated the success of this study. In particular, coming from a different geographical, language/cultural and ethnic background essentially positioned me as an outsider, which in retrospect, enhanced my open-mindedness and curiosity as a response to being in a different environment. With

this mind-set, I generally went beyond the confines of the pre-set questions to learn more about elements that though common to the local community members, were quite unfamiliar to me. In particular, this approach enabled me to pick up one important issue shaping the dietary diversity of the households which was not pre-formulated in the survey instruments - that of food taboos, and I was able to interrogate further and gain deeper insights on this matter. Food taboos, alongside other cultural and socio-economic factors, offered qualitative explanations for the quantitative-based non-linkages across the food security outcomes in the four empirical chapters (Papers 1 to 4), from different angles. However, being an outsider also does come with some inherent limitations, and there could have been multiple impacts I may have had while in the field - both positive and negative, most of which I may never quite know. Nonetheless, as a stranger in a community, it is likely that some areas of enquiry may remain harder or even impossible to access, as it may take time for respondents to connect with and open up to a stranger. Having said this, a researcher's personality disposition may also have a role to play in shaping this process, which may have also enabled me to pick up the elusive food taboo theme.

At the time, integration of both qualitative and quantitative methodological approaches felt quite strenuous. As well as the often laborious farm surveys, there were steep learning curves in correct plant identification. Looking back on this, these multi-method approaches are the ones that laid the foundation for the success of this research. Various researchers consider the combined use of qualitative and quantitative data collection approaches as a step towards capturing a holistic view of the complex mixed smallholder farming systems (Waithaka *et al.*, 2006) and understanding the inter-

connected factors shaping household food and nutrition security (Noack and Pouw, 2014; McDermott *et al.*, 2015). The intensiveness of the multi-method approaches when using the available time and financial resources implied contending with a modest sample size, especially for the farm surveys, without compromising on the quality, depth and breadth of the research outputs. The use of a limited sample size is consonant with other intensive empirical studies (DeClerck *et al.*, 2011; Djurfeldt, 2012), probably because mixed smallholder farming systems are generally highly complex and tough to study sufficiently, especially if the aim is to capture holistic rather than isolated farming system elements (Waithaka *et al.*, 2006). It is suggested that small sample sizes are adequate (Cohen, 1990), especially if the research aim is to explain phenomena rather than to estimate the statistical representativeness of data (Djurfeldt, 2012). So as to present nationally representative descriptions, some of the recent studies focusing on agriculture-nutrition linkages have analysed secondary data (Jones *et al.*, 2014; Remans *et al.*, 2014; DeFries *et al.*, 2015; Lockett *et al.*, 2015). At the same time, the acknowledgment that field-based studies offer room to augment these multi-dimensional linkages (Fanzo *et al.*, 2011; Remans *et al.*, 2014) was one of the contributions that this empirical research using multi-method approaches offered.

### **3.5 Study limitations and data manipulation**

During the farm survey, plant counting was sometimes a challenge, for example, for large plots of plants propagated by vegetative materials, such as sweet potatoes (*Ipomoea batatas*), or multi-stem plants, such as bananas. Plant identification at species and variety level was a challenge that required constant learning and consultations for accurate identification. Prior to the first field visit in September 2012, it was necessary

to spend time at the Kenya National Museums herbarium to learn about different plants species specific to Western Kenya. Though a good starting point, the experience in the field in plant identification proved to be a constant learning curve in the first few farms surveyed during September/October 2012, when some ‘forgotten’ species were later identified and re-counted during November/December 2012. In the recent July/August 2014 farm survey, some of the seasonal fruit trees were fruiting, which aided in verification and proper identification of the previously unavailable fruit samples. Though most plants were correctly identified up to variety level during these three time points, some limitations were still observed. Even in cases where it was possible to collect plant specimens, plant identification at the species level was in some instances still challenging. This was the case with different *Amaranthus* species, since there are known to be about 60 different *Amaranthus* species for which distinction by morphological characteristics is a challenge (Maundu, 2012. pers. comm.). In the field, it was difficult to differentiate *Amaranthus cruentus* from *Amaranthus hybridus* hence it was decided to name species closely resembling any of these two morphologically as *Amaranthus cruentus subspecies hybridus*. It was also problematic to differentiate *Amaranthus hybridus* from *Amaranthus spinosus*, as the two form a hybrid complex (Maundu, 2012. pers. comm.), hence it was decided to name them as *Amaranthus hybridus* complex. For the sake of data accuracy, consistency and comparability, data on plant species richness and abundance were analysed at species level, omitting data on varieties. Despite this limitation, the number of each of the plant species varieties identified was recorded (though in some cases there could have been double or even triple counting of morphologically quite similar varieties). This is in line with an agreed

### Chapter 3: Methodology overview

convention to list the number of cultivars/varieties/breeds per species even if not described by taxonomic or local names (FAO, 2010b).

A challenge encountered during FGDs was that during recruitment of FGD participants, though in all cases a minimum of ten participants were successfully recruited, the ones who actually turned up for the FGD sessions was less than 100 per cent in nine out of 12 of the FGD sessions. A probable reason for this could have been that the selected participants may have had more urgent and important tasks during the day and time scheduled for the FGDs. In addition, by selecting and conducting the FGDs among only Kiswahili-speaking participants, we may have inevitably introduced a bias to the study by excluding much older and more knowledgeable smallholder farmers who could not communicate in Kiswahili.

Market surveys were generally successful, though it was challenging to interview market traders specialising in ‘pulses-only’ market stalls. In most cases they had a queue of customers waiting to buy their range of pulses, and promptly attending to their customers was understandably of more financial benefit to them as compared to volunteering to answer questions that offered no financial incentive.

Most of the study limitations on FGDs and market surveys did not affect the quality of the results but rather necessitated additional time budget while conducting fieldwork. Conducting the FGD sessions with only Kiswahili-speaking participants may have limited access to possibly richer data that could have been collected without the language barrier. The methodological limitations on the farm survey as a result of

### Chapter 3: Methodology overview

challenges with identification of most plants up to variety level did not enable analysis of plant diversity up to variety level, an equally critical element of biodiversity. Some of these limitations to the study that offer opportunities for future research are discussed in the conclusion of the thesis.

#### **4 Paper 1: Variability of on-farm food plant diversity and its contribution to food security: A case study of smallholder farming households in Western Kenya**

This chapter is based on the following paper published in the journal *Agroecology and Sustainable Food Systems*:

Ng'endo, M., Keding, G.B., Bhagwat, S. and Kehlenbeck, K. (2015) Variability of on-farm food plant diversity and its contribution to food security: a case study of smallholder farming households in Western Kenya. *Agroecology and Sustainable Food Systems*, 39 (10), 1071-1103.

This paper assesses food availability and its connection to household food security by examining on-farm food plant and livestock diversity, as well as identifying the biophysical and socio-economic factors influencing food plant diversity during November/December 2012.

##### **4.1 Abstract**

Traditional mixed agroforestry farms are regarded as sustainable agro-ecological systems contributing to agrobiodiversity conservation and household food and nutrition security in sub-Saharan Africa. However, in Kenya little is known on the level of agrobiodiversity of these mixed farms and its contribution to food and nutrition security.

A case study was conducted to assess food plant and livestock diversity and to identify the biophysical and socio-economic factors influencing food plant diversity in 30

smallholder farms in Western Kenya. The survey identified six livestock and 59 food plant species. Higher food plant species richness was found on farms managed by wealthier households and older household heads. However, households with high on-farm food plant richness and diversity were not more food secure than households managing species-poor farms. The non-significant relationship between food security and agrobiodiversity during the time of this case study may have resulted from the fact that the surveyed 30 families sourced significant proportions of their food from markets and did not fully depend on their farms for food, particularly for spices/condiments, fruits and animal source foods. Therefore, we suggest a diversification of farms through livestock and fruit tree farming for improving dietary diversity and incomes of the surveyed households.

*Key words:* agroecology, agroforestry, food and nutrition security, food system, fruit tree, sustainability

## **4.2 Introduction**

Although global food availability for the past two decades has been higher than at any other time before (Holt-Gimenez *et al.*, 2012), food production in sub-Saharan Africa lags behind its population growth (Tittonell and Giller, 2013). With increasing population growth and changing diets, global food demand is likely to have substantially increased by 2050 (Rabbinge and Bindraban, 2012). One of the global strategies on reducing food insecurity in the developing world has been by increasing agricultural productivity through intensification (Govere and Jayne, 2003). In many sub-Saharan African (SSA) countries, however, there is little access of smallholder farmers to technologies needed for intensified systems (such as improved seeds, fertilisers and pesticides). There are also many challenges brought about by the

changing climate which will impact the yields, even if the needed inputs are given. With increased agricultural productivity by promotion of simplified and intensive cropping systems, agricultural biodiversity (agrobiodiversity) is threatened (Brookfield and Padoch, 1994; Galluzzi *et al.*, 2010). Traditional mixed farms with their diverse set of food crops, often interplanted with trees, and their focus on local production, are said to be sustainable and resilient agro-ecological systems (Kremen *et al.*, 2012). Based on a food system approach (Francis *et al.*, 2003), such systems not only significantly contribute to sustainable food production (Gliessman, 2013) that meets farming households' food and nutrition needs (Dury *et al.*, 2014) but also meets socio-economic requirements (Amekawa, 2011) such as monetary needs when additional income is obtained through sale of surplus produce. The value of diversified farming systems has been recognised by some global players in agricultural research and development such as the World Bank (2011) and FAO (2014) with the need for research in sustainable intensification being pushed for (Godfray *et al.*, 2010). This also involves the need for research on the management of agrobiodiversity and eco-system services.

Africa has approximately 33 million smallholder farms (Altieri, 2008), representing 80 per cent of all farms in the region (Garrity *et al.*, 2010). Traditional smallholder farming systems in developing countries are characterised by high levels of agrobiodiversity, with smallholder farmers as the principal managers of this diversity while at the same time depending on it for their livelihood (Almekinders, 2001). In many countries of SSA, smallholder farmers mainly cultivate a diverse mix of annual and perennial food plant species and varieties, which is likely to ensure stable yields despite labour shortages or abiotic and biotic stresses such as climate variability, pests and diseases

(Kaihura *et al.*, 2000). Although high yields are not always achieved by crops dominantly under intercropped systems (Onduru and Du Preez, 2007), other benefits could play overriding roles, for example the ability to harvest more than one crop from a field in a planting season, to have early and late crops for the wetter and drier part of the season and to minimise total crop failure risks (Onduru and Du Preez, 2007). An additional strategy of farmers to ensure sustainable year-round food production is through crop-livestock diversification (Iiyama *et al.*, 2007). The majority of smallholder farmers in SSA have mixed farms, defined as intensive production systems involving tree species, shrubs and annual crops cultivated for different purposes (Kusumaningtyas *et al.*, 2006). In East African highlands, most smallholder farmers only have one rather small piece of land on which all cultivated plant species are mixed (Abebe *et al.*, 2006). These farms are often located around the house (similarly to home gardens) and may be separated into plots for annual crops and cash crops, vegetable plots, tree zones and living fences (Henry *et al.*, 2009).

According to the government of Kenya's (2010) estimates, smallholder farms in Kenya mainly range in size from below 0.2 to 3 ha. Rural Western Kenya with its high population density is characterised by a predominance of such smallholder farms (Henry *et al.*, 2009). These farms, however, are highly variable regarding their levels of crop diversity, ranging from monocropping of cash crops such as sugarcane to very species-rich crop-tree-livestock systems (Henry *et al.*, 2009; Netondo *et al.*, 2010). Reasons for this variability are very complex, and many agro-ecological, socio-economic and cultural factors are influencing plant species richness and diversity on farms. Regarding SSA, little is known on these factors and the few studies published

have mainly focused on certain plant types, such as trees only (Kindt *et al.*, 2004; Boffa *et al.*, 2008; Bayala *et al.*, 2011). The mentioned studies mainly reported market accessibility, farming years and farm size as some of the factors influencing on-farm tree species richness and diversity. Most literature on factors influencing on-farm plant diversity in SSA focuses more on home gardens and less on whole farms (which comprise of both home gardens and surrounding crop fields), characterised by additional crops such as cereals and cash crops and thus offering a more complete picture of the overall on-farm food plant agrobiodiversity. Therefore, with a stronger focus on home gardens in existing literature, this study has to compare some of its results with home garden literature. In home gardens, plant species richness and diversity are dependent on multiple factors (Trinh *et al.*, 2003; Kehlenbeck and Maass, 2004; Kehlenbeck *et al.*, 2007; Bernholt *et al.*, 2009; Huai and Hamilton, 2009), with a complex interaction between them (Kehlenbeck *et al.*, 2007). While home garden size influenced species richness in rural central Sulawesi, Indonesia (Kehlenbeck *et al.*, 2007) and in urban and peri-urban gardens of Niamey, Niger (Bernholt *et al.*, 2009), species richness was not related to size of home gardens in a village in northeastern Peru where land remained abundant (Coomes and Ban, 2004). The size could also only influence the number of plant individuals, but not the number of species as shown by studies in northeastern Brazil (Albuquerque *et al.*, 2005) and in agroforestry home gardens in southern Ethiopia (Abebe, 2013). Higher plant diversity may also be found among older garden managers or on home gardens cultivated for a longer time (Quiroz *et al.*, 2002). There could also be differences among male and female farmers with men being the key decision-makers on crops to be cultivated, especially on more market-oriented crops (Trinh *et al.*, 2003). However, as food and subsistence-oriented plant

species (such as starchy roots, vegetables and pulses) fall under women's domain (Wiersum, 2006), women farmers may have more species-rich farms for a diversified food supply. Migration of households to new areas could either hinder or enhance on-farm crop diversity, depending on a household's socio-economic conditions (Mutenje *et al.*, 2010).

For meeting a household's food and nutrition needs all year round, the pure number of different food plant species cultivated on a farm is not as important as a good mixture of species from different food groups including fruits, vegetables, cereals, starchy roots/tubers, pulses and spices (Abebe and Bongers, 2012). There are so far few studies that have focused on the diversity of all on-farm food plant species, especially in mixed smallholder farming systems characteristic of rural East Africa (Abebe *et al.*, 2006). While most of the few studies on food plant diversity on whole farms are rather descriptive (Kumar and Nair, 2004; Galhena *et al.*, 2013), little is known about underlying causes of variations in species composition and diversity in different farms (Maroyi, 2013) and rarely any quantitative, explanatory methods such as multivariate statistics are used (Bernholt *et al.*, 2009). In view of the scarcity of such information for smallholder mixed farms in rural Kenya and the possible transition of these mixed systems into more intensified monocultures, this study not only documents on-farm food plant diversity in Western Kenya, but also utilises multivariate analysis to test the hypothesis that food plant diversity in smallholder farms is influenced by a combination of factors interacting together rather than individual isolated factors. The key research questions guiding this study are:

1. How does food plant diversity vary in different smallholder farms?

2. What are the biophysical and socio-economic factors influencing food plant diversity in the smallholder farms?
3. Are households with high on-farm food plant richness and diversity more food secure?

### 4.3 Methodology

#### 4.3.1 Study area and data collection

The study was conducted in November and December 2012 in Mumias and Vihiga districts in Western Kenya. Mumias and Vihiga districts mainly represent the humid Lower Midland (LM1) and Upper Midland (UM1) agro-ecological zones, respectively (Jaetzold *et al.*, 2005). With Western Kenya as one of the most densely populated areas in the country (Jaetzold *et al.*, 2005), the population density in Mumias and Vihiga districts is at about 600 and 1100 inhabitants/km<sup>2</sup>, respectively (KNBS, 2009). The Luhya ethnic group is the predominant community occupying most of Vihiga (Tittonell *et al.*, 2005) as well as Mumias districts. The selection of Mumias and Vihiga districts as study sites was with an aim to represent different agro-ecological zones, and thus most likely a different level of agrobiodiversity, with an added advantage of geographical closeness to each other. **Table 4.1** shows details on geographical, climatic and agricultural characteristics of the two districts.

**Table 4.1:** Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold *et al.* (2005))

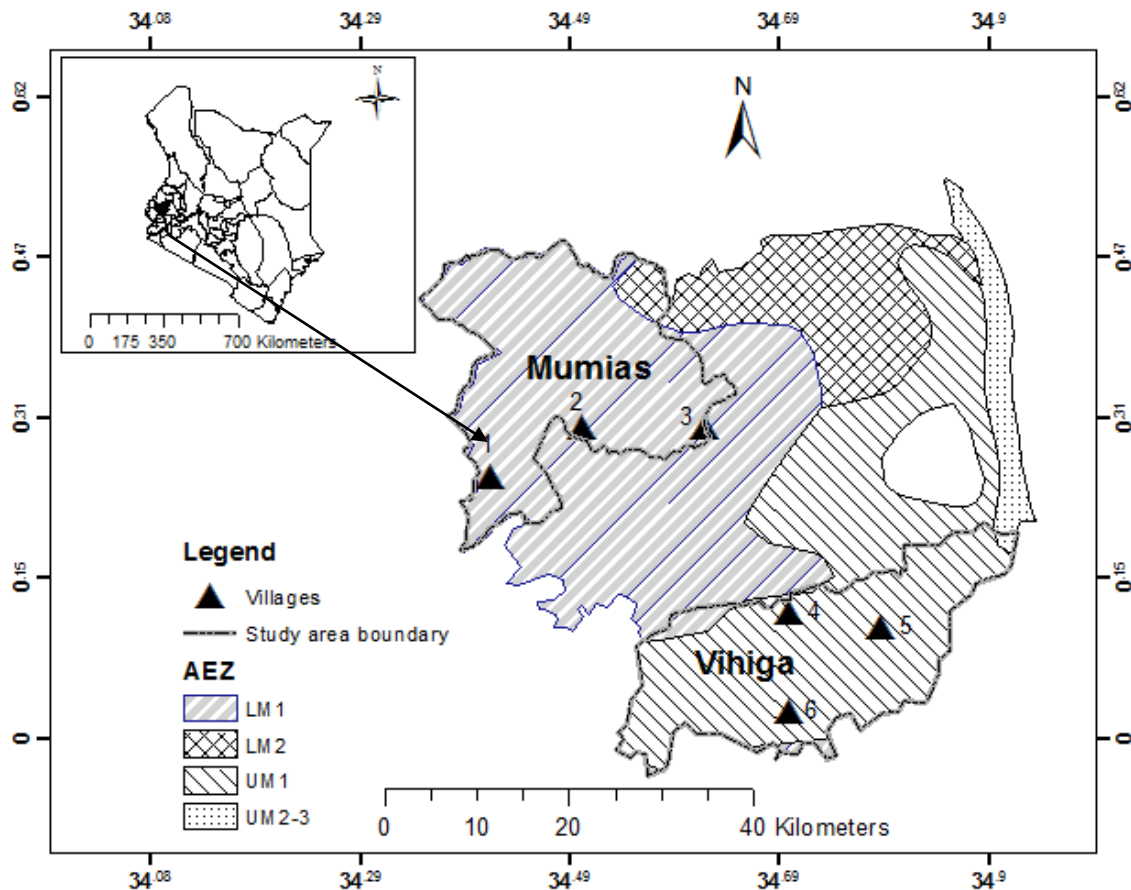
Characteristic	Mumias District	Vihiga District
Main agro-ecological zone	Humid Lower Midland (LM1)	Humid Upper Midland (UM1)
Altitude	1300-1500 m above sea level	1500-1900 m above sea level
Annual mean temperature	21.0- 22.2 °C	18.5- 21.0°C

## Paper 1: Variability of on-farm food plant diversity and its contribution to food security

Characteristic	Mumias District	Vihiga District
Total annual rainfall	1650-1850 mm	1800-above 2000 mm
Rainfall pattern	Bimodal with long rains from end of February to end of March and short rains from end of July to November/December.	Bimodal with long rains from end of February to end of March and short rains from mid July to November/December
Soil types	Ferrasols	Combination of cambisols and lithosols
Main crops	Cash crops: sugarcane Food crops: sorghum, cassava, sweet potatoes	Cash crops: tea, coffee, sugarcane Food crops: maize, beans, cowpeas

The present study was conducted in tandem with a larger, cross-sectional research project entitled ‘Improving nutrition through local agrobiodiversity’. The present study purposefully selected six villages in order to cover the above mentioned different climatic zones, three villages in Mumias and three in Vihiga districts (**Figure 4.1**), out of 30 villages from the larger study. The latter were sampled according to district village lists with number of households per village applying a ‘probability-proportional-to-size’ approach (Magnani, 1997), with larger villages given a greater chance of selection than smaller villages. A total of 30 households, 15 in Mumias and 15 in Vihiga districts, in the six villages (five households per village) were then randomly selected to represent 10 per cent of the 300 households sampled by the larger study. This sample size was calculated according to feasibility where the aim of the study was to gain insights into the biophysical and socio-economic factors influencing food plant diversity, rather than to estimate sample representativeness among smallholder farming households. For each of the 30 farms, exact geographic location and altitude as well as whole farm areas (including non-crop areas such as homestead area) and cropped farm areas were each measured with a Global Positioning System (Garmin nuvi GPS). All present food plant and livestock species were inventoried per farm by recording species

names and counting individuals of each species. For plant species grown in large numbers on homogeneously planted subplots of the farm (e.g. sugarcane, maize), estimate numbers were computed by counting individuals in a representative  $1 \times 1$  m quadrant and multiplying by the subplot area measured by GPS. Intra-specific diversity plant data was also collected by recording local variety names, but correct identification by triangulation with various sources (mainly existing literature and consultations with a taxonomist) was not always possible, especially for morphologically similar varieties. Therefore, we decided that the species level was the taxonomic level of all our analyses.



**Figure 4.1:** Map of the study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga districts mainly categorised as humid Lower Midland (LM 1) and humid Upper Midland (UM 1) agro-ecological zones, respectively. The sampling sites indicating the six villages (triangular symbols) are coded as: 1=Khushipari A, 2= Emahanga, 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo

On each farm the head of the household or his/her representative was interviewed by using a semi-structured questionnaire to collect data on: (1) Basic demographic and socio-economic household characteristics, (2) names, production data and uses of food plant and livestock species/varieties produced on the farm, and (3) products of plant and livestock species consumed by households. To assess the importance of the surveyed farms for the food systems of the farming households, the main sources for obtaining food items mentioned during the interview were obtained for the last five times of consumption, which ranged from the last 24 hours to the last three months. Data on household size, education level and hunger scores (computed according to Ballard *et al.* (2011)) were obtained from the above mentioned larger study (Kipkorir, 2012).

#### **4.3.2 Data analysis**

All present on-farm food plant species grown/collected were assigned to one out of the seven major FAO-defined (2011) food plant groups, according to farmers' statements on their main use: (i) cereals, (ii) vegetables, (iii) starchy roots/tubers/green bananas, (iv) pulses/nuts/seeds, (v) fruits, (vi) spices/condiments, and (vii) high-sugar foods.

To identify and compare the importance of on-farm food plant species belonging to the different food groups, a Summed Dominance Ratio (SDR) was calculated per food group by using relative abundances and relative occurrences for each of the food plant species and then summing up the values per food group (McCune *et al.*, 2002). Simple descriptive statistics such as means or medians (for normally distributed or skewed variables, respectively), frequency counts and percentages were done to characterise

## Paper 1: Variability of on-farm food plant diversity and its contribution to food security

farms according to species richness and abundance. To account for the different farm sizes, individual density was calculated, defined as the number of individuals of a species available in a 1000 m<sup>2</sup> farm area. Two diversity indices, Shannon diversity index and Shannon evenness (similar to 'Pielou's J'), were computed as measures of species dominance by using Multi-Variate Statistical Package (MVSP) version 3.22 (Kovach Computing Services, 2013), which was also used for cluster analysis. Statistical Package for Social Sciences (SPSS) version 22.0 (IBM Corporation, 2013) was used for all other analyses. To check for significant differences among variables represented as percentages, Chi-square test was computed. For all other analysed variables, normal distribution and homogeneity of variances were tested by Shapiro-Wilk and Levene's test, respectively, before applying parametric (t-test or one-way ANOVA followed by post-hoc Tukey's test) or non-parametric tests (Mann-Whitney's U test or Kruskal-Wallis H test followed by pair-wise Mann-Whitney's U test) for identifying differences between two or more groups, respectively (Field, 2013).

To determine bivariate relationships between food plant species richness or diversity variables and biophysical or socio-economic variables, Pearson's correlation coefficient was computed. Among the socio-economic variables, the dependency ratios were depicted as the number of children over adults. As a wealth indicator proxy, Tropical Livestock Units (TLUs) were computed using livestock units coefficients for the SSA region (Chilonda and Otte, 2006) to represent a common unit for the different types and numbers of livestock present. So as to strengthen the analysis based on strong initial bivariate relationships, multiple linear regression analysis, using a forward stepwise regression method (Field, 2013) was performed to identify the possible influence of 12

## Paper 1: Variability of on-farm food plant diversity and its contribution to food security

independent farm, environmental and socio-economic variables on four dependent variables: species richness, individual density, Shannon diversity index and Shannon evenness, each calculated separately for total food plant species and for fruit tree species. The independent variables included in the model were: (i) number of adults in the household, (ii) TLU per household member, (iii) main income source is crop farming, (iv) main income source is off-farm, (v) walking distance to nearest market, (vi) cropped farm area, (vii) number of farming years, (viii) household head's age, (ix) household head had completed primary education, (x) household head and/or spouse had migrated from outside the study area, (xi) ethnicity of the household head is Luhya, and (xii) ethnicity of the spouse is Luhya.

To identify farm, environmental and socio-economic factors that may have influenced the food plant species composition on each of the farms (and not only the number of species or their evenness as achieved through multivariate regression analysis), hierarchical cluster analysis was conducted. The cluster algorithm was based on individual density data per species and per farm that was natural log transformed before analysis (McCune *et al.*, 2002), by using squared Euclidean distances and minimum variances method. Outliers were determined by the 'nearest neighbour' approach (McCune *et al.*, 2002) and excluded from the final cluster analysis. To define the correct number of different clusters, the 'elbow criterion' was used (Mucha *et al.*, 2003). Stepwise discriminant analysis was carried out with SPSS to determine whether the cluster groups significantly differed from each other and to reveal those food plant species mostly responsible for cluster formation (Dytham, 2011; Field, 2013). Finally, the farms grouped in different clusters were analysed for significant differences in

characteristics such as farm or household size, wealth status, level of commercial orientation of farm production, species richness and diversity variables as well as food security indicators.

#### **4.4 Results**

The average farm size in the six villages was 0.37 ha (median=0.23, range=0.01-1.82), with farms in two villages in Mumias district being significantly larger as compared to farms in the other four villages (**Table 4.2**). Age of farmers (median=37 years) and number of years that the respondents had cultivated their farms (median=7 years) did not significantly differ among villages (**Table 4.2**). Each household mainly comprised of a nuclear family with the majority of households (90%) as male-headed and an average household size of six members (**Table 4.2**). In both districts, there was an average of 13 years since either household head or their spouse had migrated to the study sites. All the households in Emahanga village in Mumias district had migrated from outside the study area and only 40 per cent of the household heads in Emahanga village had finished primary school (**Table 4.2**). In both districts, at least 60 per cent of the household heads and their spouses belonged to the dominant local ethnic group, Luhya, while the remaining proportion belonged to different ethnic groups, including the Luo ethnic group.

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

**Table 4.2:** Socio-economic and demographic characteristics (means, medians or percentages; ranges given in brackets) of 30 smallholder farmer households and their farms surveyed in six villages of Mumias and Vihiga districts, Western Kenya, n=5 per village

Characteristic	Mumias			Vihiga			Overall
	Khushi- pari A	Busokho	Emahanga	Lodondo	Wambenge	Hombala	
Median cropped farm area ( ha)	0.52 (0.24-1.27)	0.61(0.23-1.82)	0.09 (0.02-0.69)	0.12 (0.02-0.19)	0.23 (0.09-0.32)	0.11 (0.01-0.50)	0.23 (0.01-1.82)
Mean age of household head (years)	37 (23-49)	42 (34-57)	35 (25-47)	32 (22-41)	37 (28-49)	39 (32-55)	37 (22-57)
Median farming years at this farm ( years)	2 (1-8)	8 (1-30)	6 (2-21)	10 (0.5-15)	7 (3-11)	8 (3-29)	7 (0.5-30)
Median household size (members)	4 (3-11)	8 (6-9)	6 (5-10)	6 (4-9)	7 (5-13)	6 (3-7)	6 (3-13)
Main household occupation is crop farming (%)	60	60	40	20	40	20	40 (20-60)
Portion of households migrated to the current village from other areas (%)	40	80	100	60	20	60	60 (20-80)
Ethnicity of household head is Luhya (%)	100	100	100	80	80	80	90 (80-100)
Ethnicity of wife is Luhya (%)	100	80	60	100	80	80	83 (60-100)
Portion of household heads having completed primary education (%)	80	80	40	80	60	80	70 (40-80)
Median walking distance to nearest local market (minutes)	60 (5-60)	7 (5-15)	30 (10-60)	30 (10-45)	30 (30-60)	30 (30-45)	30 (5-60)
Median	0.12 (0.00-	0.82	0.01 (0.00-	0.80	0.78 (0.06-	0.07	0.68

Characteristic	Mumias			Vihiga			Overall
	Khushi-pari A	Busokho	Emahanga	Lodondo	Wambenge	Hombala	
Tropical Livestock Units (TLU)	1.62)	(0.75-1.70)	0.27)	(0.24-0.97)	1.05)	(0.00-1.14)	(0.00-1.70)

Means (for normally distributed variables), medians (for non-normally distributed variables) or percentages in a row

Of the surveyed smallholder farmers, 83 per cent reared livestock. Out of the documented total of six livestock species, the most frequent species were indigenous chicken (reared by 70% of the households), followed by cattle, goats, sheep, rabbits and pigs (57%, 10%, 10%, 3% and 3%, respectively). Overall, the median Tropical Livestock Unit (TLU) was 0.68 (range=0.0-1.7) (**Table 4.2**). Chicken were reared mainly for their eggs and meat, but in three villages (Hombala, Wambenge and Emahanga), no eggs were available for consumption during the survey period, as chicken were either allowed to brood all their eggs or were too young to hatch. Although the highest TLU was found in Busokho village in Mumias district (**Table 4.2**), where all the households possessed cattle, no milk was produced as the majority of the cows were still young. In the rest of the villages, milk production greatly differed, ranging from 11 to 1205 litres per household per year, with varying proportions of its use for both home consumption and for sale. Upon maturity, sheep, goats, rabbits and pigs were mainly sold for their meat.

#### 4.4.1 Plant species richness and diversity variation

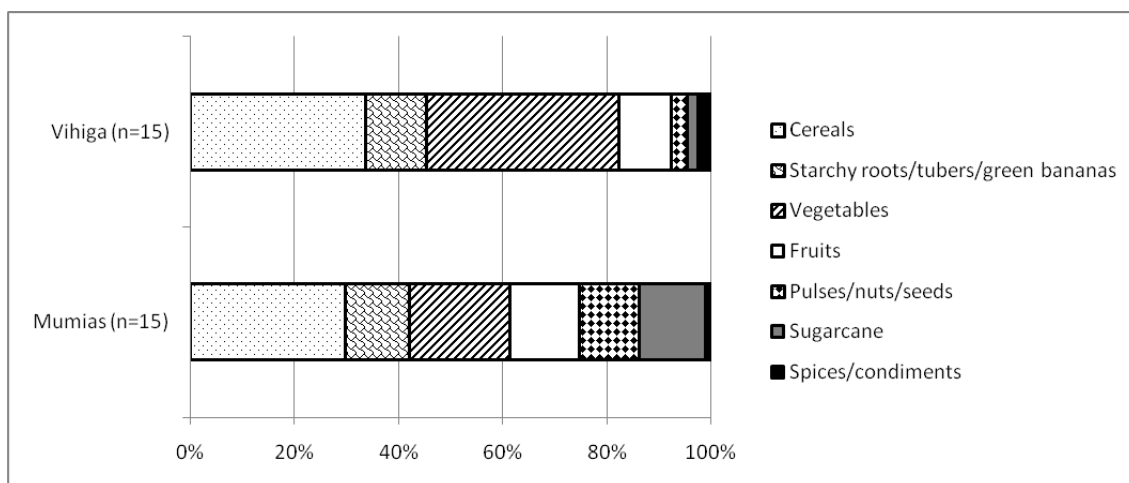
A total of 59 food plant species, including 13 fruit tree species, were identified in the 30 surveyed farms. The 59 species comprised of two cereal species, five starchy root species, 24 vegetable species, 17 fruit species, seven pulse species, three spices/condiments and one high-sugar food, namely sugarcane (*Saccharum officinarum*)

(Appendix I, Species List 4.1). As the latter group consists of only one species, it will be referred to as sugarcane from now on. With the exception of one wild *Commelina* species used as a vegetable, the remaining food plant species were all cultivated plant species. Out of the 59 food plant species, a total of 47 species were recorded in Vihiga district while 48 species in Mumias district (Appendix I, Species List 4.1). The five most frequent species with regard to occurrence in Vihiga district were *Zea mays*, *Brassica oleracea* var. *acephala*, *Musa paradisiaca*, *Persea americana* and *Vigna unguiculata*. In Mumias district, *Zea mays* was similarly the most frequent species, followed by *Manihot esculenta*, *Musa sapientum*, *Vigna unguiculata* and *Ipomoea batatas* (Appendix I, Species List 4.1). The most abundant species in Vihiga district were *Zea mays*, *Crotalaria ochroleuca*, *Vigna unguiculata*, *Ipomoea batatas* and *Brassica oleracea* var. *acephala*, while in Mumias district, *Zea mays*, *Saccharum officinarum*, *Sorghum bicolor*, *Phaseolus vulgaris* and *Commelina* species were the most abundant (Appendix I, Species List 4.1). For some of the cultivated food plant species, a high intra-specific diversity was found. This includes sweet potato (*Ipomoea batatas*) and avocado (*Persea americana*) with six varieties each, maize (*Zea mays*) and dessert banana (*Musa sapientum*) with seven each, sugarcane with eight and common beans with nine (Appendix I, Species List 4.1). Sugarcane is a main cash crop in Mumias district, while in Vihiga district, the few existing sugarcane plants were predominantly utilised for home consumption.

Each farm had an average of 14.7 food plant species (range=1-28) including 2.3 fruit tree species (range=0-6). Median total abundance of food plants was 9,626 individuals per farm (range=203-100,720), including 3.5 fruit trees (range=0-20), while individual

density was 43,588 plants per 1000 m<sup>2</sup> (range=3,556-127,371), including 15.4 fruit trees per 1000 m<sup>2</sup> (range=0-250) (data not shown). The mean total food plant Shannon diversity index per farm was 1.05 (range=0.00-1.87) with a mean Shannon evenness of 0.40 (range=0.00-0.71).

Calculation of the Summed Dominance Ratio (SDR) per district revealed that the food group ‘cereals’ was the most important with a SDR value of 30 and 34 per cent (**Figure 4.2**). While ‘vegetables’ was second most important in Vihiga district, the different food groups were more equally distributed in Mumias district. In Mumias, sugarcane, the main cash crop in the area, was more important than in Vihiga. While the distribution of the food groups ‘starchy roots/tubers/green bananas’ and ‘fruits’ was relatively equal in both districts, ‘pulses/nuts/seeds’ was more important in Mumias district and ‘spices/condiments’ in Vihiga district (**Figure 4.2**).



**Figure 4.2:** Summed Dominance Ratio (SDR) of food plant species grouped into seven food groups, cultivated on 15 farms surveyed each in Mumias and Vihiga districts, Western Kenya, in 2012

#### **4.4.2 Biophysical and socio-economic factors affecting food plant species richness and diversity parameters**

Correlation analysis revealed that species richness was positively correlated with the household head's age ( $r=0.491$ ,  $p<0.001$ ), the TLU ( $r=0.598$ ,  $p<0.001$ ) and the dependency ratio ( $r=0.553$ ,  $p<0.001$ ). Shannon diversity index and Shannon evenness were weakly negatively correlated with farm size ( $r= -0.413$ ,  $p<0.05$ , and  $r= -0.414$ ,  $p<0.05$ , respectively).

Some of these results were confirmed by those of the multiple regression analysis, computed separately for total food plant species and for fruit tree species variables (species richness, individual density, Shannon diversity index and Shannon evenness). The models were strongest for species richness of total food plant and fruit species (49.1% and 57.9% of variation explained by adjusted  $R^2$  of the multiple regression models, respectively) as well as for fruit tree Shannon diversity index (53.1%) (**Table 4.3**). The models for total food plant Shannon diversity index and for total food plant and fruit tree Shannon evenness were rather weak (22.8%, 25.8% and 30.1% of variation explained, respectively (**Table 4.3**)). Densities of both total food plant and fruit tree species were not influenced by the included predictor variables. Species richness of total food plant species was positively influenced by the TLU per household member and household head age. In addition to these two factors, the fruit tree species richness was also positively influenced by the size of the cropped farm area. While the Shannon diversity index of total food plant species was positively influenced by farming years, Shannon diversity index of fruit trees was positively influenced by the TLU per household member, the age of the household head and the cropped farm size (**Table**

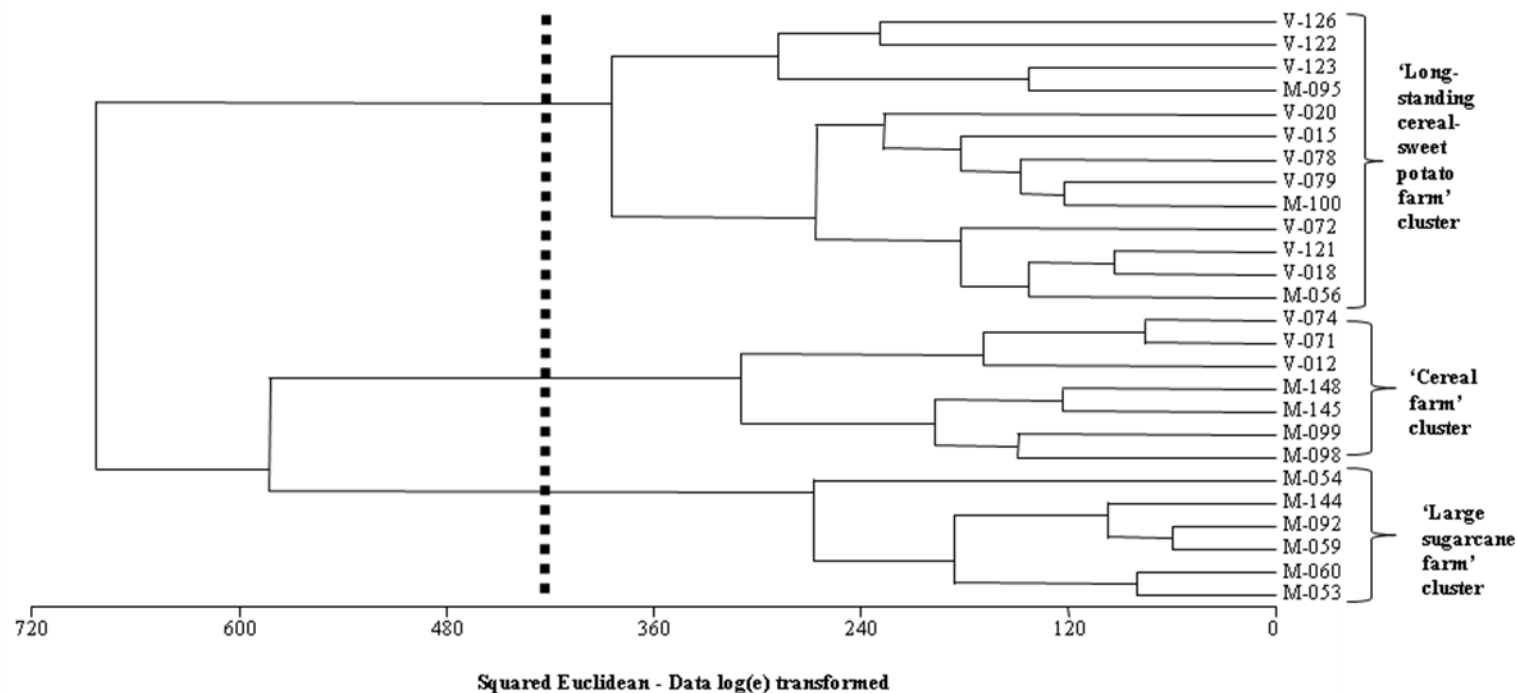
**4.3).** Shannon evenness of total food plant species was positively influenced by the number of farming years and the local ethnicity of the household head (Luhya). The Shannon evenness of fruit tree species was positively influenced by the household head's age but negatively by a migrant background of households (**Table 4.3**). The predictor variables that did not significantly influence any of the tested outcome variables were: (i) number of adults, (ii) main income source is crop farming, (iii) main income source is off-farm, (iv) walking distance to nearest market, (v) household head had completed primary education, and (vi) ethnicity of the spouse is Luhya.

**Table 4.3:** Results of stepwise multiple linear regression analyses using food plant species richness and diversity parameters as well as fruit tree richness and diversity surveyed on 30 farms in Mumias and Vihiga districts, Western Kenya, as dependent variables and selected farm and socio-economic household characteristics as independent variables

Dependent variables	Total food plant species			Fruit trees		
	Species richness	Shannon diversity index	Shannon evenness	Species richness	Shannon diversity index	Shannon evenness
Adjusted R <sup>2</sup>	49.1**	22.8**	25.8*	57.9*	53.1*	30.1*
<b>Independent variables</b>						
<i>TLU per household member (0.00-0.41)</i>	0.53***	ns	ns	0.40**	0.41**	ns
<i>Household head age (22-57 years)</i>	0.46**	ns	ns	0.43**	0.40**	0.50**
<i>Farming years (0.5-30 years)</i>	ns	0.50**	0.43*	ns	ns	ns
<i>Cropped farm area (0.01-1.82 ha)</i>	ns	ns	ns	0.35*	0.32*	ns
<i>Household migrated from outside local area (0=no, 1=yes)</i>	ns	ns	ns	ns	ns	-0.39*
<i>Ethnicity of household head is Luhya (0=no, 1=yes)</i>	ns	ns	0.39*	ns	ns	ns

For each of the predictor variables, standardised beta ( $\beta$ ) coefficients are indicated. \*, \*\*and \*\*\* represent significant differences at  $p \leq 0.05$ ,  $p \leq 0.01$ ,  $p \leq 0.001$ , respectively according to F-Test (for the model) or T-Test (for predictor variables), while 'ns' refers to non-significant variables

Additional characteristics influencing not only the number but also the composition of species on each of the farms were identified by cluster analysis of log-transformed food plant individual density data, which resulted in three clearly and identifiably different clusters (**Figure 4.3**) according to the elbow criterion, after four outlier farms were omitted from the analysis.



**Figure 4.3:** Classification dendrogram as a result of hierarchical cluster analysis (minimum variance method, squared Euclidean distances) on the basis of natural log (log e) transformed densities of 59 plant species cultivated in 26 farms in 6 villages of Mumias and Vihiga districts, Western Kenya. The thick dotted line marks the cut-off point to define the correct number of clusters according to the 'elbow' criterion. The alphanumeric codes in the clusters refer to the 26 farm codes (with V for Vihiga and M for Mumias farms). Out of the 30 farms in this study, four farms (M-143, M-146, V-014 and V-129) were identified as outliers and excluded from this analysis.

## Paper 1: Variability of on-farm food plant diversity and its contribution to food security

Discriminant analysis detected the following eight species as most responsible for the cluster formation (in order of their importance): *Ipomoea batatas*, *Saccharum officinarum*, *Physalis peruviana*, *Corchorus tridens*, *Camellia sinensis*, *Capsicum annuum*, *Cucurbita maxima* and *Morus alba*. The discriminant analysis also showed that 100 per cent of the original grouping was correct. In addition to differences in species densities of the above mentioned species, the three clusters also differed in some biophysical and socio-economic characteristics (**Table 4.4**) as well as in the Summed Dominance Ratios (SDRs) of food groups (**Figure 4.4**). Cluster 1 showed a rather equal mixture of different food plant groups (including ‘cereals’), but when compared with cluster 2, it had a higher proportion of the groups ‘vegetables’ and ‘starchy roots/tubers/green bananas’ (**Figure 4.4**). Most of the household members in cluster 1 had migrated from outside the study area. Cluster 1 also had a significantly higher density of *Ipomoea batatas* and a significantly higher number of cultivation years than the two other clusters (**Table 4.4**). Therefore, cluster 1 was named ‘long-standing cereal-sweet potato farm’ cluster. Cluster 2 was largely dominated by cereals, hence it was named ‘cereal farm’ cluster. The ‘cereal farm’ cluster was in addition characterised by the lowest percentage of households practising crop farming as their main occupation (**Table 4.4**). Although farms in cluster 3 had a diverse mixture of the different food groups, they were largely dominated by sugarcane, both regarding the individual density (**Table 4.4**) and the SDR proportion (**Figure 4.4**). Therefore, cluster 3 was named ‘large sugarcane farm’ cluster. All farms of cluster 3 were located in Mumias (**Figure 4.3**), an area extensively used for sugarcane cultivation and with a sugar processing plant close by. Farms in cluster 3 were of rather large size, managed by households with low member numbers and relying on crop farming as their main occupation (**Table 4.4**).

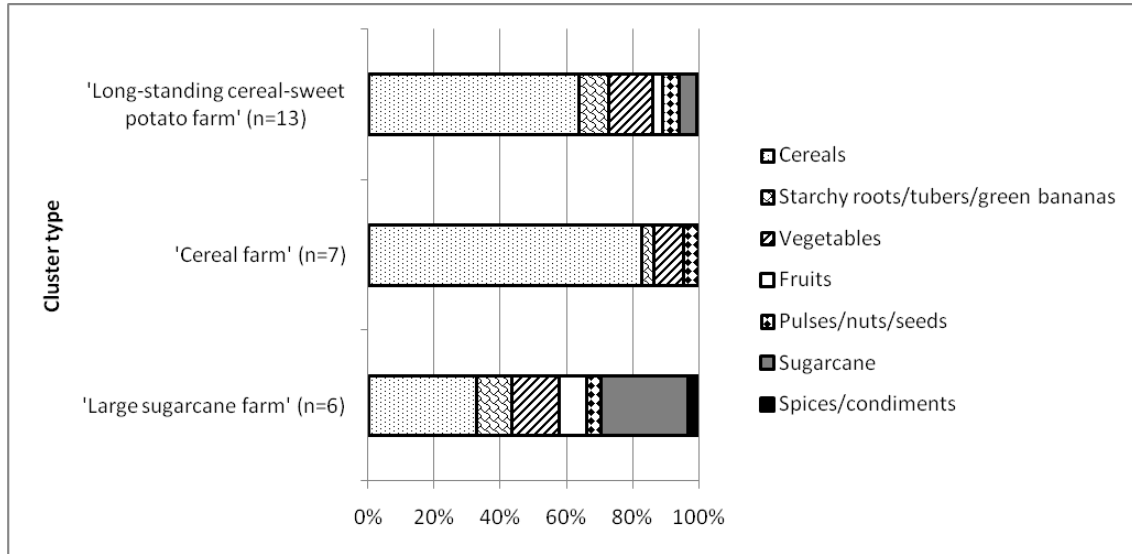
**Table 4.4:** Farm, socio-economic and food plant species diversity characteristics (ranges in brackets) of 30 farms grouped into three clusters and two outlier farm types, surveyed in Mumias and Vihiga districts, Western Kenya

Characteristic	Clusters			Outliers	
	‘Long-standing cereal-sweet potato farm’ cluster (n=13)	‘Cereal farm’ cluster (n=7)	‘Large sugarcane farm’ cluster (n=6)	‘Home garden’ type (n=2)	‘Large diverse subsistence farm’ type (n=2)
<b>Species richness and diversity characteristics</b>					
Median <i>Ipomoea batatas</i> density per 1000 m <sup>2</sup>	3 945 <sup>a</sup> (213-17,631)	0 <sup>c</sup> (0-0)	456 <sup>b</sup> (0-1,812)	0 (0-0)	590 (0-1180)
Mean <i>Saccharum officinarum</i> density per 1000 m <sup>2</sup>	11 <sup>b</sup> (0-15,088)	0 <sup>b</sup> (0-83)	16 481 <sup>a</sup> (9,742-30,141)	797 (93-1500)	0 (0-0)
Mean total species richness	17.3 (9-24)	11.0 (3-19)	13.2 (1-28)	17.0 (14-20)	12.5 (11-14)
Median total individual density per 1000 m <sup>2</sup>	47,810 (3,556-106,635)	42,905 (16,878-110,966)	36,878 (23,597-55,307)	29,246 (25,375-33,116)	121,395 (115,419-127,371)
Mean total Shannon diversity index	1.21 (0.46-1.75)	0.69 (0.08-1.37)	0.79 (0.00-1.59)	1.82 (1.77-1.87)	1.35 (1.30-1.41)
Mean total Shannon evenness	0.43 (0.17-0.70)	0.32 (0.04-0.48)	0.30 (0.00-0.48)	0.65 (0.59-0.71)	0.54 (0.54-0.54)
Mean fruit tree species richness	2.69 (1-5)	1.43 (0-4)	2.83 (0-6)	2 (2-2)	1.5 (1-2)
<b>Socio-economic characteristics</b>					
Median cropped farm area (ha)	0.20 <sup>b</sup> (0.02-1.00)	0.19 <sup>b</sup> (0.02-0.61)	0.88 <sup>a</sup> (0.14-1.82)	0.02 (0.01-0.02)	0.39 (0.09-0.69)
Mean household size (number)	7 <sup>a</sup> (4-11)	6 <sup>a</sup> (5-13)	5 <sup>b</sup> (3-6)	5 (3-6)	10 (9-10)
Mean household head age (years)	41 <sup>a</sup> (26-57)	30 <sup>b</sup> (22-38)	34 <sup>ab</sup> (23-49)	37 (35-38)	45 (43-47)
Median farming years at this farm	11 <sup>a</sup> (2-30)	2 <sup>b</sup> (0.5-7)	4 <sup>b</sup> (1-8)	7 (3-10)	16 (10-21)
Main household occupation is crop farming (%)	38	14	67	0	100
Portion of households	62	57	50	50	100

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

Characteristic	Clusters			Outliers	
	'Long-standing cereal-sweet potato farm' cluster (n=13)	'Cereal farm' cluster (n=7)	'Large sugarcane farm' cluster (n=6)	'Home garden' type (n=2)	'Large diverse subsistence farm' type (n=2)
migrated to current village from other areas (%)					
Ethnicity of household head is Luhya (%)	92	71	100	100	100
Median walking distance to nearest local market( minutes)	30 (6-60)	15 (5-60)	20 (5-60)	20 (10-30)	45 (30-60)
Median TLU	0.87 (0.00-1.70)	0.75 (0.00-1.05)	0.19 (0.00-1.62)	0.16 (0.07-0.24)	0.03 (0.01-0.05)
Portion of households suffering from severe hunger (%)	31	0	17	0	50
Portions of households suffering from moderate hunger (%)	15	57	17	50	50
Household hunger score mean , coded as below: 0-1:little hunger; 2-3:moderate hunger; 4-6:severe hunger	2.08 (0-6)	1.29 (0-2)	1.17 (0-5)	1.5 (0-3)	3 (2-4)

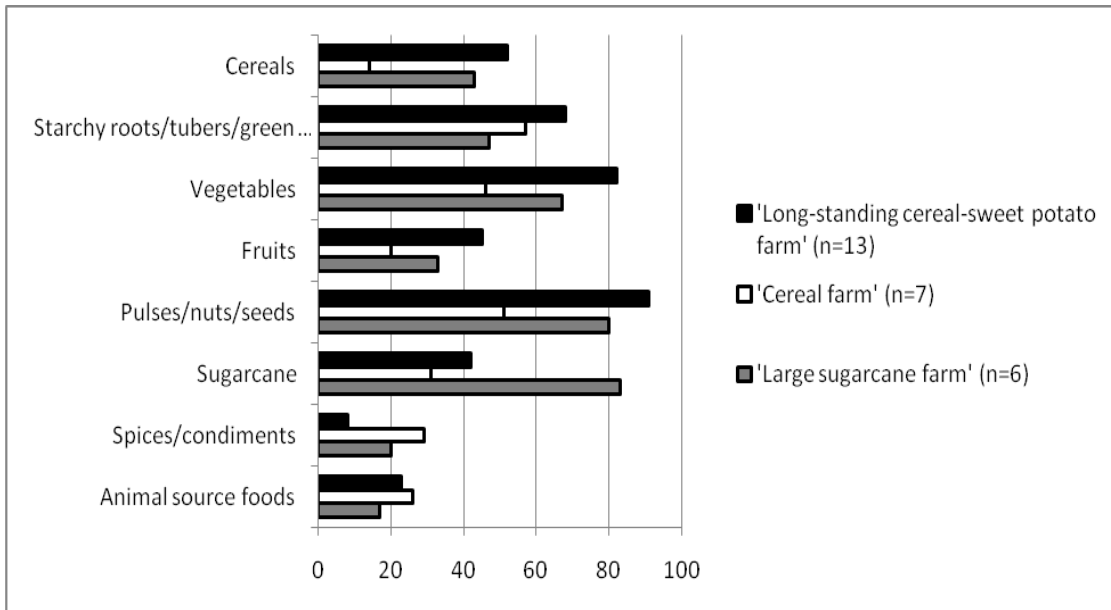
Means, medians or percentages in a row followed by different letters are significantly different at  $p \leq 0.05$  according to one-way ANOVA followed by post-hoc Tukey's test (for means), Kruskal-Wallis test followed by pairwise Mann-Whitney U test (for medians) or Chi-square test (for percentages)



**Figure 4.4:** Summed Dominance Ratio (SDR) of food plant species grouped into seven food groups, cultivated on 26 farms grouped into three clusters and surveyed in Mumias and Vihiga districts, Western Kenya, in 2012

#### 4.4.3 Household food security and on-farm agrobiodiversity

Household hunger scores as an indicator for food security showed that half of the households (50%) had little to no hunger in the last one month of the survey, while 30 and 20 per cent of the households experienced moderate and severe hunger, respectively. Regarding the three clusters, households grouped in the ‘cereal farm’ and ‘large sugarcane farm’ clusters experienced little to no hunger while those in the ‘long-standing cereal-sweet potato farm’ cluster experienced moderate hunger (**Table 4.4**). Households with severe hunger had significantly more children (mean of  $5.7 \pm 1.97$ ) as compared to households with moderate and low hunger scores (mean  $3.7 \pm 1.74$ );  $p < 0.05$ . During the last five times of consumption of different food groups, smallholder farming households did not entirely rely on their own farms as food source in the three clusters (**Figure 4.5**).



**Figure 4.5:** Proportion of food consumed during the last five times and produced on the farm, sorted by the different food groups for the three cluster types in Mumias and Vihiga districts, Western Kenya. Remaining percentages of food were procured through local markets or social networks. Please note that for the food groups ‘spices/condiments’, ‘animal source foods’, ‘sugarcane’ and ‘starchy roots/tubers/green bananas’, respondents could not remember the last five times they consumed it and only provided information on the last one to four times of consumption.

Instead, markets and family/friends/neighbours played a supporting role for the food systems of the surveyed households, in different proportions for the seven food groups and three clusters. However, for the food groups ‘spices/condiments’, ‘animal source foods’, ‘sugarcane’ and ‘starchy roots/tubers/green bananas’, respondents could not remember the last five times they consumed it and only provided information on the last one to four times of consumption. The main food groups sourced predominantly (above 50%) from on-farm production in the three clusters were ‘pulses/nuts/seeds’, ‘vegetables’ and ‘starchy roots/tubers/green bananas’ (**Figure 4.5**). Cereals, the main staple in the study area, however, were predominantly sourced from markets, with the lowest proportion of on-farm production (at 14%) surprisingly occurring in farms with the highest SDR of cereals, the ‘cereal farm’ cluster (**Figure 4.4**). Low proportions of

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

on-farm sourced foods were also reported for ‘animal source foods’ and ‘spices/condiments’, while those for ‘fruits’ and ‘sugarcane’ were quite variable among clusters (**Figure 4.5**), with an expected high on-farm sourcing of sugarcane in the ‘sugarcane farm’ cluster. Correlation and regression analyses revealed there was no significant relationship between agrobiodiversity (measured using the four variables: species richness, individual density, Shannon diversity index and Shannon evenness, each for total food plant and fruit tree species) and household food security measured as household hunger scores. However, some indirect links were detected for correlations between total food plant species richness and the percentage of farm-produced starchy roots/tubers/green bananas ( $r=0.519$ ,  $p<0.001$ ), cereals ( $r=0.444$ ,  $p<0.05$ ), vegetables ( $r=0.431$ ,  $p<0.05$ ) and pulses/nuts/seeds ( $r=0.375$ ,  $p<0.05$ ), while the percentage of on-farm produced fruits was independent from total food plant and fruit tree species richness.

## **4.5 Discussion**

### **4.5.1 Patterns of food plant species richness and diversity**

The plant and livestock species richness of the 30 surveyed farms in Western Kenya (59 and six, respectively, in total, and 14.7 and 1.8 in a mean) was lower than those in smallholder farms in the highland area of Kiambu, Central Kenya, with 77 crop and tree species and 11 livestock species in total (Kaihura *et al.*, 1999), but slightly higher or similar to those in 50 farms in western Nyanza province of Kenya with a total of 49 and a mean of 15 food plants (Remans *et al.*, 2011). The fruit tree species richness in the present study (total of 13, mean of 2 per farm) was relatively similar to that of traditional agroforestry farms in northwest Benin, where 12 fruit tree species with a

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

mean of 3 were recorded (Fifanou *et al.*, 2011). A slightly higher fruit tree richness of 17 (with a lower mean of 2) was recorded in farms of Amhara region of north Ethiopia (Fentahun and Hager, 2009) and in cocoa-based agroforestry farms in Ondo State, Nigeria, where 16 fruit tree species (no mean given) were recorded (Oke and Odebiyi, 2007).

The mean Shannon diversity index of 1.05 and mean Shannon evenness of 0.40 for food plant species in the present study's farms (with a mean size of 0.37 ha) were much lower than those of large-sized home gardens (with a mean size of 0.70 ha) in Sidama, southern Ethiopia, where a mean Shannon diversity index of 1.45 and a mean Shannon evenness of 0.53 were recorded for all cultivated crop species (including, however, even medicinal and fragrance plants) (Abebe *et al.*, 2010). In the much smaller urban and peri-urban gardens in Niamey, Niger (with a mean size of 0.086 ha), lower mean Shannon diversity index and evenness (of 0.96 and 0.39, respectively) were recorded for all human-used plants during the cold season (including plants used for firewood, medicine and as ornamentals) (Bernholt *et al.*, 2009). The lower diversity indices in the present study indicated the dominance of some food plant species in the surveyed farms, mainly cereal species (in both districts) and sugarcane (in Mumias district) (**Figure 4.2**). Comparing the two surveyed agro-ecological zones, no difference in total food plant species number or any other diversity variable was found, most probably due to their relatively similar climatic conditions (**Table 4.1**). Studies across more distant and contrasting agro-ecological zones usually report greater differences in total and mean number of species (Bennett-Lartley *et al.*, 2002; Bamidele *et al.*, 2011).

#### **4.5.2 Biophysical and socio-economic factors influencing food plant richness and diversity**

Multiple regression analysis showed that farms managed by wealthier households (those with greater TLU per household member) and older household heads usually have higher total food plant and fruit tree species richness (**Table 4.3**). This finding corroborates with a study of urban and peri-urban gardens in Niamey, Niger, where the highest total species richness was found in gardens managed by wealthier, older and retired farmers (Bernholt *et al.*, 2009). Wealthier farmers may have better access to financial resources (for example, remittances received from their adult children or retirement benefits), which is likely to facilitate greater mobility and access to new genetic plant materials which may be further incentivised by the social prestige associated with higher plant diversity (Shrestha *et al.*, 2002). The age of the household head is indicative of the position of the family in the ‘farm development cycle’, which is also associated with resource endowment (Tittonell *et al.*, 2010). Even in the absence of additional financial resources, older farmers may also just have ‘collected’ more plant species on their farms over time, particularly trees which stay for long (Boffa *et al.*, 2008). They may also have more time for farming and for testing new plants which is likely to contribute in increasing food plant species richness (Kehlenbeck *et al.*, 2007). Farming years positively influenced the diversity parameters of total food plant species in our study (**Table 4.3**) suggesting that recently established farms are rather dominated by a few food plant species, but over the years, farmers try to cultivate new crops while they continue to plant well-tried species as shown also for home gardens by Kehlenbeck *et al.* (2007).

## Paper 1: Variability of on-farm food plant diversity and its contribution to food security

Farm size had no influence on total food plant species richness and diversity indices in the present study, but positively influenced fruit tree species richness and Shannon diversity index (**Table 4.3**). A study of large enset-coffee agroforestry home gardens in southern Ethiopia (mean size of 0.75 ha) also found no influence of farm size on crop species richness and evenness, suggesting that farm size affects the number of food plant individuals rather than the number of species and diversity of cultivated crops (Abebe, 2013). However, if plots in a study area are rather small, increase in size may result in an increase of species richness and diversity. This was the case in the urban and peri-urban gardens of Niamey, Niger (with a mean of 860 m<sup>2</sup>, range=37-10,355 m<sup>2</sup>), where larger gardens had a higher plant species richness and Shannon diversity (Bernholt *et al.*, 2009). Contrary to the present study, fruit tree species richness increased with decreasing farm size in traditional agroforestry farms in northwest Benin, which was explained by the multipurpose use of fruit trees for food and income generation (Fifanou *et al.*, 2011). In the present study, however, the surveyed households mainly used the fruits from their farm for home consumption, but not for sale. Surplus fruits were mainly lost and no preservation for later use was being carried out. As there is no ready market for fruits in the study area, growing of high-value fruits for sale is not an option for coping with decreasing farm sizes.

A migration background of the household had a negative influence on Shannon evenness of fruit trees while a household head being from the local ethnicity (Luhya) had a positive influence on total species richness in our study (**Table 4.3**). Ethnicity is closely associated with a community's food culture which is highly likely to influence food plant species selected for cultivation (Shrestha *et al.*, 2002). Migrants may have

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

higher plant species richness and diversity in their farms or home gardens due to their increased mobility and contact with outside communities (Shrestha *et al.*, 2002; Bernholt *et al.*, 2009). However, despite migrants' efforts to introduce new species in their new farm environments, the establishment of the introduced species could be affected by ecological niche differences (Fentahun and Hager, 2009). In the present study, most of the migrant households had slightly (but not significantly) smaller farm sizes than the non-migrants, thus a slightly higher proportion of migrants were engaged in casual labour on other people's farms as a primary livelihood source, probably resulting in less time being spent on their own farms. Time and space constraints of these migrant farmers may have resulted in lower plant species richness and diversity, including fruit trees. This finding agrees with a Western Kenya study where the poorest farmers farmed small pieces of land and derived a large proportion of their income by selling their labour locally, which resulted in severe labour shortages on their own farms (Tittonell *et al.*, 2005). Other than shortage of labour for own farm management, socio-economic factors such as poverty, discrimination and poor access to agricultural inputs could also contribute to low crop diversity of migrant households as shown for home gardens by Kehlenbeck *et al.* (2007).

Some of the results of the regression analysis were confirmed by those of the cluster analysis, with the variables 'crop farm area' and 'farming years' being different among the three clusters. In addition to this, cluster analysis was useful in grouping and distinguishing farm types based on their subsistence-commercial production system gradient (**Table 4.4**). Farms focusing on subsistence-only food crops were grouped in the 'cereal farm' cluster while integration of commercial crops (mainly sugarcane) was

Paper 1: Variability of on-farm food plant diversity and its contribution to food security evidenced in the ‘large sugarcane farm’ cluster. Commercial farm types, however, harboured similar (and not less) plant species richness and diversity as compared to subsistence farm types (**Table 4.4**), as also shown by Wiehle *et al.* (2014) and Bernholt *et al.* (2009) in their cluster analysis results. Integrating commercial crops into mixed farms also has no negative impact on the diversity of food groups produced (**Figure 4.4**) and their contribution to home consumption (**Figure 4.5**).

#### **4.5.3 Contribution of agrobiodiversity of the surveyed farms to family food and nutrition security**

One of the ways to determine optimal food plant diversity for providing food security for the farming household is by assessing the species numbers and by evaluating if the different functional food use groups (e.g. fruits, vegetables, pulses) are all covered by the documented on-farm species (Abebe and Bongers, 2012). In the present study, SDR values were used to assess the importance of the different food groups and its evenness, that is, the proportions of the different food groups, at the district level (**Figure 4.2**). Combining the SDRs with the percentage of on-farm food sources for the different food groups served as a proxy in assessing the individual contribution of a farm to household food security levels. In Kenya, over 90 per cent of the population depend on maize as the staple crop (Mwololo, 2010). This is reflected by the high frequency of maize cultivation (90% of the surveyed farms had maize) and the dominance of the food group ‘cereals’ in both districts in our study (at a mean SDR of 32%, **Figure 4.2**). In addition to the main cereal (maize), starchy roots and tubers such as cassava (*Manihot esculenta*) and sweet potatoes (*Ipomoea batatas*), deliver an important alternative staple food in the Kenyan diet, reflected by the moderate proportion of this food group (at a mean SDR of

12%, **Figure 4.2**) and by the high intra-specific diversity of the mentioned species (Appendix I, Species List 4.1). Further, the average proportion of on-farm sourced starchy roots/tubers/green bananas (57%) was higher than that of cereals (36%) (**Figure 4.5**). As compared to cereals and starchy roots/tubers/green bananas, the importance of pulses/nuts/seeds was relatively lower (at a mean SDR of 7%, **Figure 4.2**). Nonetheless, pulses/nuts/seeds was the food group mostly sourced through on-farm production (at an average of 74%, **Figure 4.5**).

In addition to dietary energy, fruits provide an important source of essential micronutrients such as vitamins and minerals (Kehlenbeck *et al.*, 2013). However, the Kenyan average fruit consumption of 70 g/person/day (Ruel *et al.*, 2005) is much lower than the recommended rough estimate of 200 g of fruits (400 g of fruits and vegetables) per person per day (Ruel *et al.*, 2005). In the present study, the rather low importance of the fruit use group on farms (at a mean SDR of 12%, **Figure 4.2**) and low on-farm fruit sourcing (at an average of 33% at the time of the survey, **Figure 4.5**) is in turn likely to negatively affect household fruit consumption. Typical bottlenecks for sufficient fruit consumption include the high seasonality together with perishability of fruits and the lack of processing facilities during high season periods (Kehlenbeck *et al.*, 2013), which results in high fruit market prices and limited fruit consumption especially during out-of-season periods (Jamnadass *et al.*, 2011). The low intra-specific diversity of fruit species documented on the surveyed farms (76% of fruit species were represented by only one variety each) may have further contributed to low on-farm fruit sourcing. A smart combination of early, intermediate and late varieties of fruit species on a farm, for example by making use of some of the about 50 documented mango varieties available

Paper 1: Variability of on-farm food plant diversity and its contribution to food security in Kenya (Sennhenn *et al.*, 2013), could have significantly prolonged the harvesting season of fruits – and thus, their availability for family consumption. Indigenous fruit tree species are often important during droughts or pre-harvest hunger seasons and can serve as an immediate food source or be sold to raise incomes, thus contributing to both food and nutrition security (Kehlenbeck *et al.*, 2013). In the present study, however, farms were largely dominated by exotic fruit tree species and only one indigenous fruit species, *Vitex doniana*, was found growing wild in only one farm. The low importance of indigenous fruit trees could be because most Kenyans perceive them as food for children, thereby attaching higher value to exotic fruit trees (Kehlenbeck *et al.*, 2013).

Regarding vegetables, Western Kenya is one of the country's hotspots for cultivation of indigenous leafy vegetables (Abukutsa-Onyango, 2009), which generally serve as a cheap source of micronutrients (Figuroa *et al.*, 2009). This was reflected by the high SDR value of vegetables in both districts (at a mean SDR of 19% and 37%, **Figure 4.2**), high on-farm vegetable sourcing (at an average of 65%, **Figure 4.5**) and large species numbers (with 24 vegetable species; Appendix I, Species List 4.1). The four varieties of cowpea (*Vigna unguiculata*) cultivated for their leaves in 22 of the surveyed 30 smallholder farms (Appendix I, Species List 4.1) suggest its high popularity as compared to other vegetable species. Only one wild vegetable, a *Commelina* species, was used for food in only one farm. Despite the general assertion that wild foods significantly contribute to food and nutrition security in many African (and Asian) countries (Sthapit *et al.*, 2008), our study suggests that the low species numbers and minimal utilisation of wild vegetable and fruit species by the surveyed households is a probable indication of the intensive farming systems and the rather small farm sizes in

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

the research area which is one of the most densely populated areas in Kenya, characterised by periodic food insecurity (Conelly and Chaiken, 2000). In addition to this, there is a general low value attached to wild foods by Kenyans, commonly referred to as ‘weeds’, ‘famine foods’ or ‘poor-man’s crops’. Such an attitude has been reported not only for the wild *Commelina* species (Figueroa *et al.*, 2009), but also generally for indigenous leafy vegetables (Abukutsa-Onyango, 2011).

In addition to the mentioned food plants, animal sourced foods also substantially contribute to food and nutrition security, particularly as a source of proteins and micronutrients. Although the majority of the surveyed farmers (83%) possessed at least one livestock species, animal numbers and productivity (of chicken eggs and cow’s milk, for example) were generally low with highly variable amounts available for sale and home consumption. The fact that none of the respondents could remember the last five times of consuming animal sourced food in addition to the low proportion of consumed animal sourced foods that were on-farm sourced (**Figure 4.5**) suggests that its contribution to family nutrition was rather low among the surveyed households. An inadequate contribution of animal sourced food to meet the population’s nutritional needs is also stated for other low-income countries (Dror and Allen, 2011), and this food type is said to provide less than 5 per cent of total dietary energy intake in many SSA countries (Allen, 2006). Further, only six of the 30 interviewed farmers had sold any livestock in the last one year before the survey, with the raised money mainly used to cater for emergency situations, but not for meeting daily food needs. This limited use of livestock as a source of income is supported by an Eastern Kenya study suggesting that smallholder livestock keeping is more for socio-cultural reasons (Onduru and Du

Preez, 2007) such as their use during ceremonies (e.g. weddings, funerals). For income generation, the farm produce mainly utilised by the surveyed households were sugarcane, tea and coffee.

While smallholder farms as well as home gardens can be oriented towards commercial production for cash income generation or subsistence production for home consumption, the two production goals can also co-exist (Trinh *et al.*, 2003; Bernholt *et al.*, 2009; Wiehle *et al.*, 2014). Integration of commercial and subsistence production goals can also result in more diverse farms which are more sustainable and resilient than species-poor farms, according to Altieri *et al.* (2012). The compatibility of market integration and high diversity smallholder farms has been shown in Peruvian potato farms (Zimmerer, 2003) and in Guatemalan maize farms (Isakson, 2011). A slightly positive influence of commercial production was also seen in the present study. Farms focusing on subsistence-only food crops ('cereal farm' cluster) had the fewest functional food groups (**Figure 4.4**) and, in a trend, the lowest fruit tree and total species richness and diversity indices (**Table 4.4**). Integration of some commercial crops, as in the 'long-standing cereal-sweet potato farm' cluster and the 'large sugarcane farm' cluster (**Figure 4.4**), resulted in slightly higher total species richness and diversity indices (**Table 4.4**) and a more balanced proportion of functional food groups (**Figure 4.4**). However, there are exceptions to the general pattern, as shown in the two outlier farm types presented in **Table 4.4**. The two farms of the 'home garden' type, characterised by extremely small farm sizes and predominantly subsistence production (including sugarcane), had relatively high species richness (including fruit tree species) and diversity indices (**Table 4.4**). Even in the two farms of the 'large diverse subsistence

Paper 1: Variability of on-farm food plant diversity and its contribution to food security farms' type, where sugarcane, the main cash crop in the area, was not cultivated, intermediate species richness, but rather high diversity indices were found (**Table 4.4**).

The general finding that commercialisation is not always synonymous with specialisation and decrease in species richness is backed up by a study in Central Tanzania where commercial farms had more diverse crops (Mutabazi *et al.*, 2013). A similar result was reported for commercialised urban and peri-urban gardens in Niamey (Bernholt *et al.*, 2009) and rural home gardens in Sudan (Wiehle *et al.*, 2014). It is suggested that a well-balanced mix of subsistence and cash crops might lead to higher plant diversity (Kehlenbeck *et al.*, 2007) and dual-purpose smallholder farms may have higher diversity than subsistence-only farms (Abebe *et al.*, 2010).

On the one hand, the present study suggests that higher on-farm food species richness and diversity has no direct influence on household food security, which corroborates with other Western Kenya studies (Conelly and Chaiken, 2000; Figueroa *et al.*, 2009). On the other hand, higher on-farm agrobiodiversity as a result of mixing subsistence and cash food crops may translate to higher food security of the household and a more sustainable and resilient food system by increasing income and the household's ability to purchase food when on-farm food production is low. In our study, households with market-oriented sugarcane production (those in cluster 3) did not significantly differ from the more subsistence-oriented farming households with regard to food security (**Table 4.4**). Case studies in various African countries even suggest that subsistence-oriented smallholder farmer households are more food-insecure than market-oriented ones (Negatu, 2004; Tittonell *et al.*, 2010) that diversified into cash crop farming

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

(Chirwa and Matita, 2012) or into livestock keeping (De Weerd, 2009). However, local markets in remote areas may not always offer year-round supply of the needed nutrient-rich foods such as fruits and vegetables or households may prefer to purchase energy-rich, but nutrient-poor staples (Girard *et al.*, 2012). In many developing countries, men farmers control cash income (Kirity and Tisdell, 2002) and may even rather buy non-food items with the available cash instead of nutritious food for their families.

#### **4.6 Conclusions**

Species diversity was rather high in the farms included in this case study and with the exception of cereals, the other food groups dominant in the two study sites differed. Agrobiodiversity in the surveyed farms was mainly influenced by socio-economic factors, including wealth status and age of the household head. This case study shows that there was no significant relationship between on-farm food species diversity and food security of the surveyed farming families during the study period, as in addition to own production of food, markets and working social networks also contributed much to household food security. However, a repeated survey and calculation of household hunger scores at a different season may have given different results. Own production at the time of this study was mainly important for supplying vegetables and pulses/nuts/seeds to the families' diets. Pure subsistence-oriented agricultural production systems in this study harboured rather low food plant species diversity and did not necessarily make smallholder farmers more food-secure during the study period than farmers with market-oriented production such as sugarcane. Although the limitations of this study include the small sample size (n=30) with its implications on statistical power of the regression models and the short time scale of food security data

Paper 1: Variability of on-farm food plant diversity and its contribution to food security

collection (only one month), the study provides important insights into enhancing both rural food security and agrobiodiversity conservation because the data from farms are situated within the wider context of agricultural market economy in the study area. The study may also have benefited from inclusion of intra-species diversity, but its measurement in the field was accompanied by inconsistent use of local names by the interviewed farmers and identification challenges from other sources. The calculation of household hunger score as an indicator of food security could be improved through repeated collection of data at different seasons of the year, but in this study the hunger score provides a useful approximation of current household-level food security applicable for comparisons within the same groups of households. Despite these limitations, the study results suggested that agricultural interventions aiming at sustainable intensification on smallholder farms may need to simultaneously focus on increased diversification of both subsistence and cash crops. Integrating smallholder farmers into value chains for non-industrial cash crops such as fruits and vegetables will not only increase household incomes, but also contribute to an improved supply of these nutrient-dense foods at local markets, which are an important source of food for rural communities. We also recommend increasing the productivity of livestock species and integrating improved varieties of fruit tree species in the research location, particularly on farms with limited space, as these could also contribute to enhanced food and nutrition security, income generation and to more sustainable and resilient food systems. When factors influencing food plant diversity in different contexts are taken into consideration, transition of smallholder farms into diversified, highly productive and sustainable agro-ecological systems can be better targeted and behaviour change enhanced by measures such as creating awareness and improving access of farmers to

Paper 1: Variability of on-farm food plant diversity and its contribution to food security planting material of desired species. As staple food production on very small farms is unlikely to meet a household's food and nutrition requirements, integration of high-value, nutrient-dense crops such as vegetables, fruits and spices/condiments for home consumption and sale should be promoted to improve year-round food and nutrition security of smallholder farming households in Western Kenya and beyond.

#### **4.7 Acknowledgments**

We are grateful to all the farmers, local administration and contact persons who participated in this study, to Patrick Maundu (Kenya Resource Centre for Indigenous Knowledge) for assistance with identification of some plant species and to Felix Ngetich (Embu University College, Kenya) for assistance with map generation. We are also thankful to Patricia Daley (University of Oxford, UK) and to the anonymous reviewers for improving the initial and final drafts, respectively. Our sincere gratitude also goes to the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, for funding this study, implemented by Bioversity International, Regional Office for sub-Saharan Africa, Nairobi, Kenya. The Rhodes Trust is also acknowledged for their funds which supported the tuition fees of the first author to undertake this study in partial fulfilment for the Degree of Doctor of Philosophy at the University of Oxford.

## **5 Paper 2: Influence of seasonal on-farm diversity on dietary diversity: A case study of smallholder farming households in Western Kenya**

This chapter is based on the following paper submitted to the journal *Ecology of Food and Nutrition*:

Ng'endo, M., Bhagwat, S. and Keding, G.B. Influence of seasonal on-farm diversity on dietary diversity: a case study of smallholder farming households in Western Kenya.

Picking up from Paper 1, this empirical chapter simultaneously explores linkages between agricultural and dietary diversity during both September/October 2012 and July/August 2014 time points, representing planting and harvesting seasons, respectively. Dietary diversity represents a broad multi-indicator measurement, where the paper assesses food scores based on both one-day and seven-day food consumption recall periods, and at both household and individual levels, so as to reflect economic access to food (for households) and dietary quality (for women) (FAO, 2011). Two different food scores are used in this paper - dietary diversity scores (DDS, based on the one-day recall) and food consumption scores (FCS, based on the seven-day recall). These food scores are computed by summing up (different) food groups consumed over a given reference period, where some food types in the same food group may comprise of different or multiple nutrients. For example, *Psidium guajava* and *Carica papaya* are some members in the food group 'fruits' (FAO, 2011), and they contain two different main nutrients – Vitamin C and Vitamin A, respectively. Thus, what defines the subtle but important distinction between foods (dietary intake) and nutrients is the use of food

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

consumption data when assessing dietary diversity measurements, on the one hand. Food composition databases, on the other hand, are used to generate nutrient composition data so as to compute nutrient diversity metrics, for example, in form of a nutrient functional diversity (nFD) score, which has also been used as one of the seven farm diversity indicators (relative nutrient functional diversity, species richness, individual density, shannon diversity index, simpson's index of diversity, shannon evenness, and combined crop and livestock count) in this empirical chapter, as well as in Paper 3, where the concept is elaborated on as a visual aid in conceptualising the existing nutrient diversity on farms and in markets.

### **5.1 Abstract**

Although ecological and socio-economic studies on smallholder agriculture are widely reported in the literature, agricultural-nutrition linkages in smallholder production systems remain largely unexplored. This study explored the associations between dietary patterns and farm diversity as well as socio-economic variables during two seasons in rural Western Kenya. As a mean of the two surveys, the average dietary diversity scores (DDS) of households and women were low, implying low household economic access to food and low women's dietary quality, respectively. The Food Consumption Score (FCS) showed that acceptable levels of food consumption were realised over seven consecutive days in the 2014 survey by the majority of households (83%) and women (90%). While there was no strong association between the food scores (DDS and FCS for households and women) and seven farm diversity indicators (species richness, individual density, Shannon diversity index, Simpson's index of

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

diversity, Shannon evenness, combined crop and livestock count, and relative nutrient functional diversity), all food scores were significantly associated with the household's wealth status, ethnicity of both the household head and the spouse and the education level of the spouse. For holistic household food and nutrition security approaches, we suggest a shift from a focus on farm production factors to incorporating easily overlooked socio-economic factors shaping dietary quality such as household decision-making power and ethnicity.

*Key words:* dietary diversity score, food consumption score, functional diversity, rural Kenya, species richness

### **5.2 Introduction**

Agricultural biodiversity (agrobiodiversity) remains an under-explored avenue for improving nutrition (Hillocks, 2011; Jones *et al.*, 2014), especially among rural smallholder farming households. Correlating agrobiodiversity with human nutrition remains difficult, partly because poorer smallholder farming households may rely more heavily on farms for diversified diets to compensate for lack of purchasing power while wealthy farmers may have reduced agrobiodiversity but better health because of ability to purchase a more nutritionally diverse diet (DeClerck *et al.*, 2011). Though to some extent households with higher purchasing power can compensate for reduced agrobiodiversity, by for example, purchasing nutrient-rich foods from markets, this is not always the case, as other factors could over-ride a household's wealth status. For instance, the extent to which the person in charge of food preparation has control over food income and if they are involved in decision making may be more important than the amount of a household's income (Jones *et al.*, 2014). Nevertheless, personal

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

incomes managed by women, especially from ownership of small livestock, may result in increased household dietary diversity (Maass *et al.*, 2014). Diversified food intake plays a crucial role especially after harsh conditions such as seasonal food shortages when purchase of foods is necessary to buffer diminishing on-farm food supplies (Savy *et al.*, 2006).

Common to both wealthy and poorer households is the selling of farm produce, especially immediately after harvest seasons for poorer households (Leavy and Poulton, 2007). The accrued incomes can contribute to food purchases which may in turn influence dietary intake, increasing the complexity between agrobiodiversity and dietary diversity (Jones *et al.*, 2014). For poorer households, scarce cash is likely to be prioritised to buying starchy staples to meet basic energy needs while nutrient-dense but more expensive food groups such as fruits remain economically inaccessible (Ruel *et al.*, 2005). Even in cases when nutrient-dense foods are highly available from farms in certain seasons, there could be factors influencing their non-intake. For example, perceptions of locally available indigenous fruits as children's food (Kehlenbeck *et al.*, 2013) or culturally less preferred legumes and indigenous vegetables which are seen in many sub-Saharan African countries as a poor-man's crop (Renzaho, 2004; Keding *et al.*, 2013). Hence, seasonality in food availability may not be as important as socio-economic factors underlying the local food culture, such as local ethnicity that is likely to influence higher dietary diversity among particular ethnic groups in rural Tanzania (Keding *et al.*, 2012), Burkina Faso (Savy *et al.*, 2006) and Malawi (Jones *et al.*, 2014).

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

While the applicability of different dietary diversity scores as indicators of nutritional status has been established (Kennedy *et al.*, 2007; Savy *et al.*, 2007; Arimond *et al.*, 2010; Arsenault *et al.*, 2013), there are only few studies that have explored dietary and farm diversity linkages (Herforth, 2010; Keding *et al.*, 2012; Jones *et al.*, 2014). These studies suggest the existence of knowledge gaps in assessing the exact quantities and usage of all harvested on-farm food produce so as to determine where smallholder farming households lie in the subsistence-commercial gradient (Jones *et al.*, 2014), as well as decision making processes to augment the wealth status data (Keding *et al.*, 2012). Consequently, this study incorporates these factors in examining the associations between dietary diversity and food plant/animal production diversity during two seasons in rural Western Kenya. While the latter is a high potential region endowed with high levels of agrobiodiversity, it faces the double burden of under- and over-nutrition (KNBS and ICF Macro, 2010). In this study, dietary diversity consumed at household level and at individual level with a focus on women, who are mainly in charge of food preparation, was assessed using not only the 1-day Dietary Diversity Scores (DDS) but also the 7-day Food Consumption Scores (FCS). While the 1-day DDS is considered as an accurate indicator of determining nutritional adequacy in rural households (Savy *et al.*, 2007; Keding *et al.*, 2012), this study also factored in the 7-day recall period in order to offer a more complete picture of weekly dietary patterns. This paper examines whether high on-farm agrobiodiversity results in high dietary diversity among smallholder farming households in Western Kenya. Two key research questions guiding this study are:

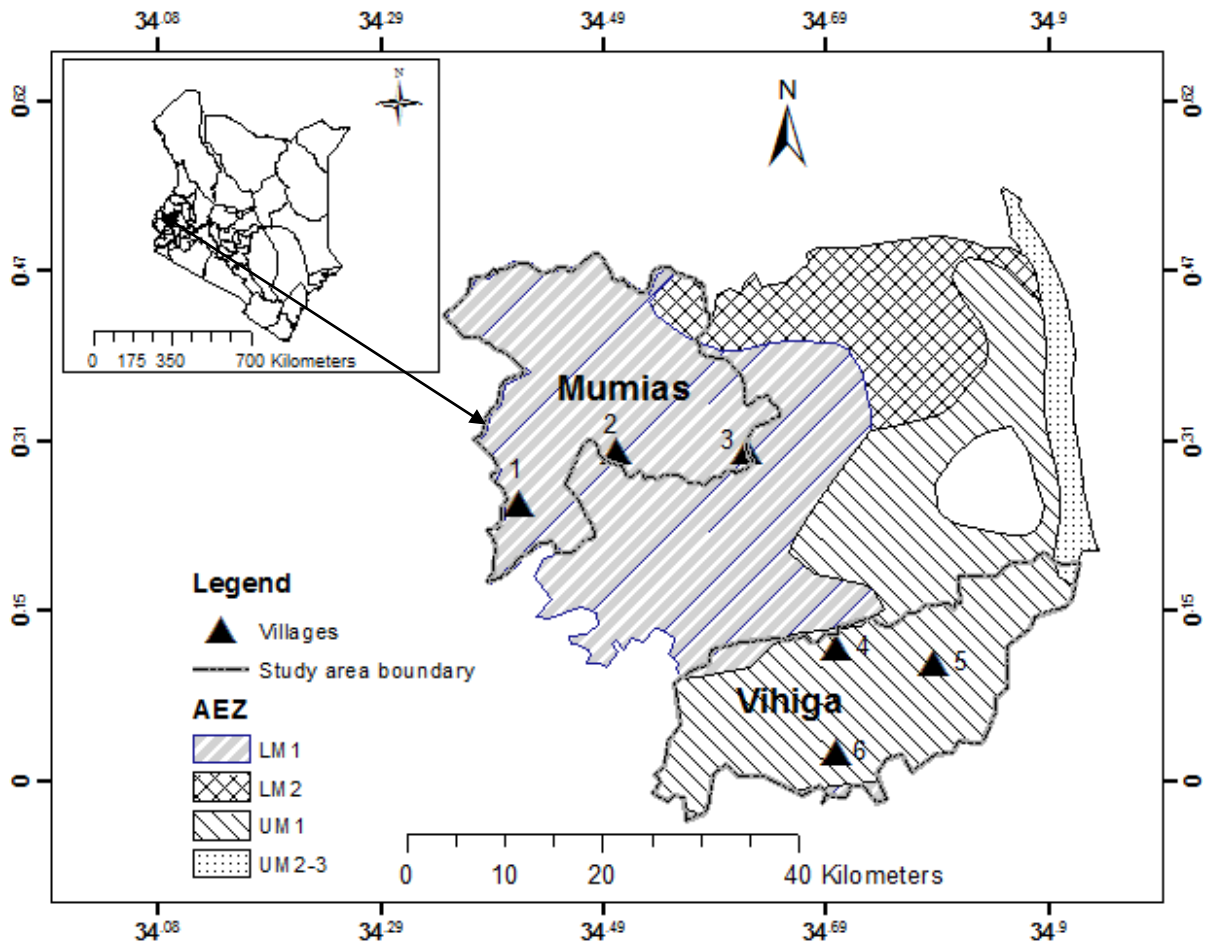
1. How do food scores at household and individual level compare during the two seasons?

2. Is there a relationship between on-farm agrobiodiversity and dietary diversity among smallholder farming households?

### **5.3 Methodology**

#### **5.3.1 Study area and data collection**

The study was conducted in September/October 2012 and July/August 2014 seasons in Mumias and Vihiga districts, Western Kenya. Mumias and Vihiga districts mainly represent the humid Lower Midland (LM1) and Upper Midland (UM1) agro-ecological zones (Jaetzold *et al.*, 2005), respectively (**Figure 5.1**). The selection of Mumias and Vihiga districts as study sites was with an aim to represent different agro-ecological zones, and thus most likely a different level of agrobiodiversity, with an added advantage of geographical closeness to each other.



**Figure 5.1:** Map of the study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga districts mainly categorised as humid Lower Midland (LM 1) and humid Upper Midland (UM 1) agro-ecological zones, respectively. The sampling sites indicating the six villages (triangular symbols) are coded as: 1=Khushipari A, 2= Emahanga, 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo (Source: Ng'endo *et al.* (2015))

**Table 5.1** shows details on geographical, climatic and agricultural characteristics of the two districts. Both September/October 2012 and July/August 2014 time points lie in the short rainy season, with different farming activities characterising them, with planting season during September/October 2012 (PS) and harvesting season in July/August 2014 (HS).

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

**Table 5.1:** Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold *et al.* (2005))

Characteristic	Mumias District	Vihiga District
Main agro-ecological zone	Humid Lower Midland (LM1)	Humid Upper Midland (UM1)
Altitude	1300-1500 m above sea level	1500-1900 m above sea level
Annual mean temperature	21.0- 22.2 °C	18.5- 21.0°C
Total annual rainfall	1650-1850 mm	1800-above 2000 mm
Rainfall pattern	Bimodal with long rains from end of February to end of March and short rains from end of July to November/December	Bimodal with long rains from end of February to end of March and short rains from mid July to November/December
Soil types	Ferrasols	Combination of cambisols and lithosols
Main crops	Cash crops: sugarcane Food crops: sorghum, cassava, sweet potatoes	Cash crops: tea, coffee, sugarcane Food crops: maize, beans, cowpeas

The present study was conducted in tandem with a larger, cross-sectional research project entitled ‘Improving nutrition through local agrobiodiversity’. For the present study, data collection was conducted through farm surveys. The farm survey purposefully selected six villages in order to cover the above mentioned different climatic zones, three villages in Mumias and three in Vihiga districts (**Figure 5.1**), out of 30 villages from the larger study. The latter were sampled according to district village lists with number of households per village applying a ‘probability-proportional-to-size’ approach (Magnani, 1997), with larger villages given a greater chance of selection than smaller villages. A total of 30 households, 15 in Mumias and 15 in Vihiga districts, in the six villages (five households per village) were then randomly selected to represent 10 per cent of the 300 households sampled by the larger study. In both September/October 2012 (PS) and July/August 2014 (HS), the same smallholder farming households were surveyed. On each farm, both the head of the household and the spouse were interviewed by using a semi-structured questionnaire to collect data on:

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

(1) Basic demographic and socio-economic household characteristics, (2) types, amounts and uses of food plant and livestock species/varieties produced on the farm, (3) products of plant and livestock species available and/or consumed by households, (4) the main sources for obtaining food items in the last one year (in the 2014 survey) and during the last five times of consumption, which ranged from the last 24 hours to the last three months (in the 2012 survey), and (4) 1-day and 7-day recalls of food consumption (single food items) consumed at household level and by women only, respectively, during the 2014 survey while only 1-day recalls were obtained from the above mentioned larger study (Kipkorir, 2012). Data on household size, education level, hunger scores (computed according to Ballard *et al.* (2011)) and living conditions of the households (toilet, water and health care facilities) were also collected in the 2014 survey. During the 2012 survey, hunger scores were obtained from the above mentioned larger study (Kipkorir, 2012).

### **5.3.2 Data analysis**

All present on-farm food plant species grown/collected were assigned to one out of the seven major FAO-defined (2011) food plant groups, according to farmers' statements on their main use. Simple descriptive statistics such as means, frequency counts and percentages were computed to characterise farms according to species richness and abundance. To account for the different farm sizes, individual density of food plants was calculated, defined as the number of individuals of a species available in a 1000 m<sup>2</sup> farm area. Three diversity indices, Shannon diversity index, Simpson's index of diversity and Shannon evenness, were computed as measures of species dominance by using Multi-Variate Statistical Package (MVSP), version 3.22 (Kovach Computing

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

Services, 2013). To incorporate both plants and livestock in a single farm diversity measure, a combined crop and livestock count was computed (Jones *et al.*, 2014), by summing up the numbers of different food plant species and livestock that were cultivated/reared by each household. To compare different farms on the basis of the nutrient composition of both food plants and animal source foods (based on the weight of livestock species), relative nutrient functional diversity was computed with R software (R Core Team, 2014) using an R script by Remans *et al.* (2011). For the analysis, two datasets were utilised: (i) a list of species per farm, and (ii) a list of content of seven major nutrients (carbohydrates, proteins, folic acid, iron, zinc, Vitamins A and C) for all the farm food plant and animal species. As it was not possible to get the nutrient contents of all food species from a single food composition table, nine different food composition databases were used (Maundu *et al.*, 1999; Erhardt, 2007; Lukmanji *et al.*, 2008; Purdue University Center for new crops and plant products, 2008; Saxholt, 2009; PROTA, 2010; FAO/INFOODS, 2012a; FAO/INFOODS, 2012b; USDA, 2014). Priority was given to these databases with a focus on the African region so as to enhance regional comparability.

Dietary Diversity Scores (DDS) were computed by summing up the food groups consumed over the past 24 hour recall period by women only and all household members (including women), separately. As women DDS serve as indicator of nutritional adequacy while household DDS is a proxy for a household's economic access to foods, different food groups are required for computation of the two scores (FAO, 2011). Nine food groups were selected for the women DDS and 12 food groups for the household DDS, according to FAO (2011). To categorise the DDS as low,

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

medium or high, the cut-off points were computed using Statistical Package for Social Sciences (SPSS) version 22.0 (IBM Corporation, 2013). The cut-off points used to categorise if household DDS was low (0-7), medium (8) or high (9-12) differed from those categories for the women DDS of low (0-4), medium (5) or high (6-9). Both household and women FCS were computed by multiplying the frequency of consumption of eight food groups in the last seven days by weight assigned to each food group (WFP, 2008), after which three cut-off points determine if food consumption levels are poor (scores between 0 and 28), borderline (scores ranging from 28.5 to 42) or acceptable (score of above 42), according to WFP (2008) .

To determine associations of the food scores with farm diversity indicators, on-farm food production variables and socio-economic factors, both bivariate correlations and multiple regression models were computed. However, the latter results were similar to those of the bivariate analysis and therefore only the correlation relationships are reported. Associations between the variables were tested with Spearman's rank-order coefficient ( $\rho$ ), using SPSS. One of the socio-economic variables, wealth index, was also computed using SPSS, through the standardised Principal Component Analysis method (Filmer and Pritchett, 2001). The 13 variables on living conditions and household assets used in the wealth index calculation were: type of (i) house roof (ii) toilet facility (iii) main source of drinking water , and possession of (iv) electricity/solar (v) radio (vi) mobile phone (vii) watch or clock (viii) television (ix) crop or animal sprayer (x) animal cart (for example, ox or donkey cart for transport purposes) (xi) bicycle (xii) motorcycle (xiii) car or lorry.

## 5.4 Results

### 5.4.1 Household and on-farm agrobiodiversity characteristics

With a mean household size of seven members (**Table 5.2**), each household mainly comprised of a nuclear male-headed family. Most of the household heads (93%) and their spouses (83%) belonged to the Luhya ethnic group while fewer of the wives (53%) as compared to the household heads (70%) had completed primary education (**Table 5.2**). The average household monthly income was 50 USD, with varying levels of shared decision-making on various uses of money for food (**Table 5.2**). Despite having farmed for an average of 11 years on mean farm sizes of 0.36 ha, there were seasonal variations in livelihood sources as relatively few of the households relied on crop farming (17%) as their main income source during the 2014 harvesting season (**Table 5.2**), as compared to close to half (40%) of households that were dependent on crop farming as their main occupation in the 2012 planting season (data not shown).

**Table 5.2:** General characteristics of 30 smallholder farmer households in Mumias and Vihiga districts, Western Kenya during July/August 2014 season

Characteristic	Overall	Mumias	Vihiga
Average household size (no.)	7	8	6
Ethnicity of household head is Luhya (%)	93	100	87
Ethnicity of wife is Luhya (%)	83	73	93
Proportion of household heads having completed primary education (%)	70	67	73
Proportion of wives having completed primary education (%)	53	27	80
Average household monthly income (USD)	50	63	37
Shared decision-making on:			
Money spent on food purchase (%)	70	80	60
Use of harvested plants for home consumption or sale (%)	37	27	47
Use of animal source foods for home consumption or sale (%)	33	40	27
Average farming years at this farm (years)	11	10	12
Average farm size (ha)	0.36	0.53	0.18
Main occupation of household (head) :			
Crop farming (%)	17	20	13

Paper 2: Influence of seasonal on-farm diversity on dietary diversity

Characteristic	Overall	Mumias	Vihiga
Wage employment (%)	17	13	20
Seasonal petty trading eg a non-established small-scale business (%)	43	47	40
Casual labour on other people's farms (%)	10	0	20

A total of 54 and 56 food plant species were identified in the 30 surveyed farms, with an average of 11.2 and 13.4 food plant species in each farm during the 2012 and 2014 surveys, respectively. The mean total abundance of food plants increased from 17,927 to 20,477 individuals per farm by the 2014 survey. During the 2012 planting survey, there was a slightly higher mean food plant Shannon diversity index of 1.02, Shannon evenness of 0.47 and Simpson's index of diversity of 0.52 as compared to the 2014 harvesting survey (with a mean Shannon diversity index of 1.00, Shannon evenness of 0.41 and Simpson's index of diversity of 0.48). In both surveys, the food plant species comprised of seven main food groups: cereals, starchy roots, vegetables, fruits, pulses, spices/condiments and one high-sugar food species, sugarcane.

As compared to the 2012 survey, there was a 10 per cent increase in the proportion of the surveyed households rearing livestock during the 2014 survey (93%). Out of the documented nine livestock species, the most frequent species were indigenous chicken (reared by 87% of the households), followed by cattle (57%), goats (10%), sheep (10%), rabbits (7%), pigs (3%), ducks (3%), fish (3%) and bees (3%). Chicken were mainly reared for their eggs and meat, with at least a third of the eggs (32%) and meat (40%) utilised for home consumption. Cattle were mainly reared for their milk, with close to half (48%) of the milk home consumed, while the remainder was sold and given to extended family members. Varying proportions of other animal source foods were used

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

for both home consumption and for sale, with close to half of bee honey (45%), around a third of pig meat (33%) and fish (30%) consumed by household members. Upon maturity, goats, sheep, rabbits and ducks were all sold for their meat.

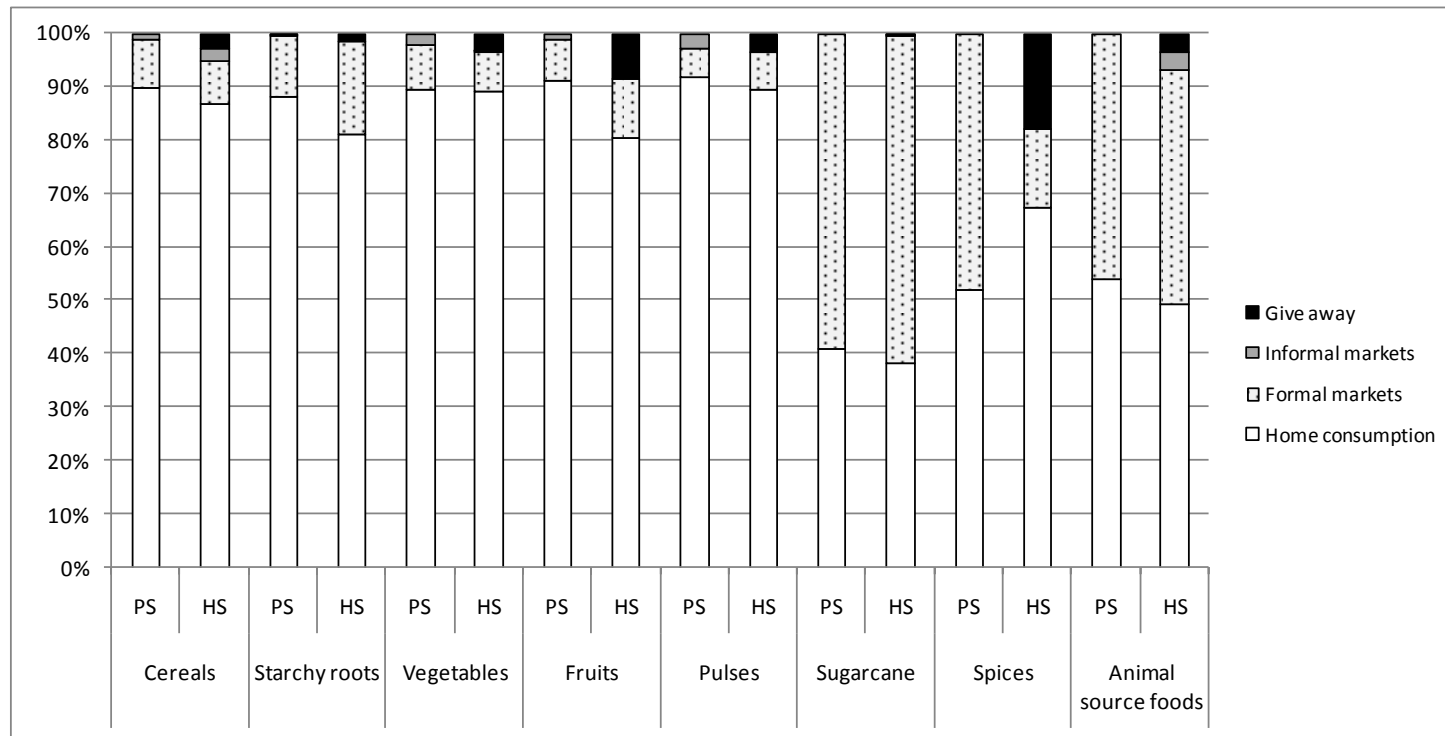
Household hunger scores as an indicator for food security showed that at least half of the households experienced little to no hunger in the last one month of both the 2012 (50%) and 2014 (73%) surveys (**Table 5.3**). During both seasons, most of the food groups were utilised for home consumption, except for more than half (60%) of 'sugarcane' and about one third of the 'animal source foods' (29%) and 'spices' (31%) which were sold in formal markets (**Figure 5.2**). Out of the share of these food groups sold in formal markets during the 2012 planting season, a small share of the 'animal source foods' were both sold in informal markets and given away, with a considerable proportion of the 'spices' (mainly *Capsicum annuum*) given away during the 2014 harvesting season. A small share of 'pulses', 'vegetables' and 'fruits' were also given away in the latter season (**Figure 5.2**). As a mean of the two seasons, two-thirds (75%) of the combined on-farm harvested produce was utilised for home consumption while only 14 per cent was sold in markets. In a similar pattern, half (50%) of the foods consumed during the two seasons were sourced from farms and 26 per cent were sourced from markets (**Table 5.3**).

Paper 2: Influence of seasonal on-farm diversity on dietary diversity

**Table 5.3:** Scores (hunger and food), main food sources and uses among 30 smallholder farming households during two seasons in Mumias and Vihiga districts, Western Kenya

<b>Variable</b>	<b>September/October 2012 planting season</b>	<b>July/August 2014 harvesting season</b>	<b>Overall</b>
<b>Household hunger score (%)</b>			
Severe hunger (4-6)	20	3	12
Moderate hunger (2-3)	30	23	27
Little to no hunger (0-1)	50	73	62
<b>Main food sources (%)</b>			
On-farm production	51	49	50
Markets (formal and informal)	25	27	26
Family and friends	13	10	12
<b>Main on-farm food uses (%)</b>			
Home consumption	71	79	75
Sale in markets (formal and informal)	14	14	14
<b>Dietary diversity score (category)</b>			
Mean household DDS	6 (low)	8 (medium)	7 (low)
Mean women DDS	4 (low)	5 (medium)	4 (low)

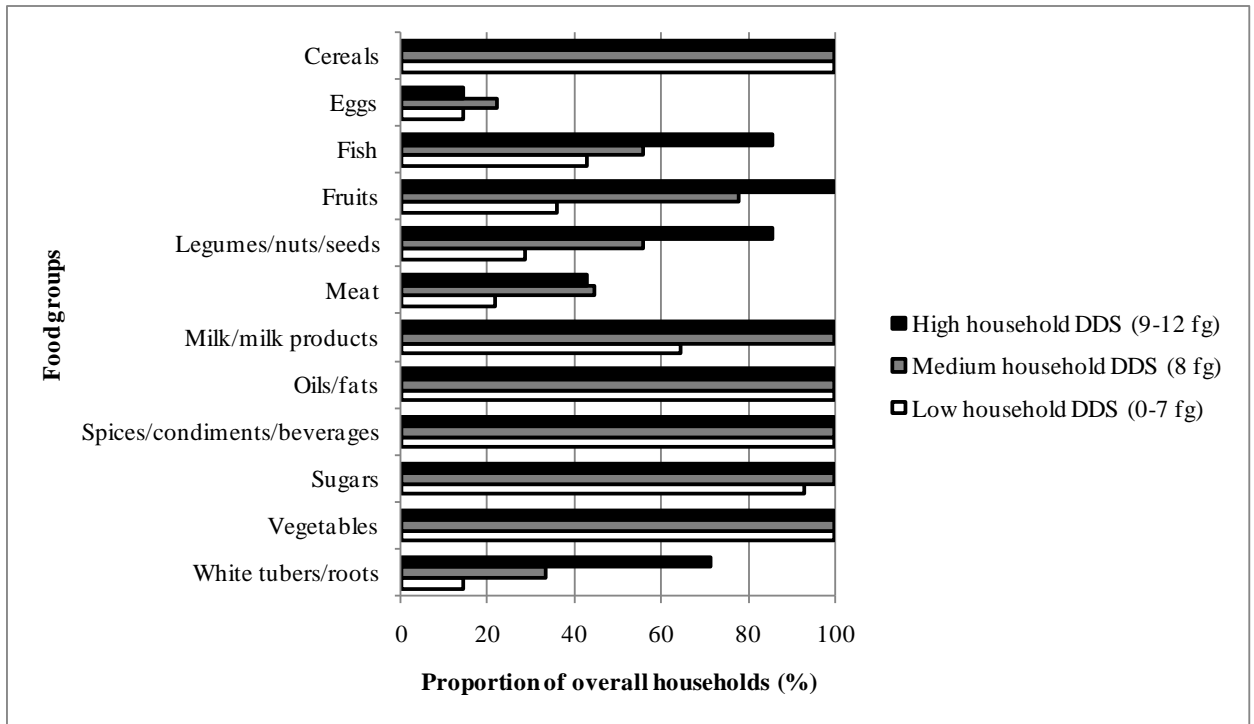
Paper 2: Influence of seasonal on-farm diversity on dietary diversity



**Figure 5.2:** Proportion of main uses of on-farm produce, sorted by the different food groups, during September/October 2012 planting season (PS) and July/August 2014 harvesting season (HS) among smallholder farming households in Mumias and Vihiga districts, Western Kenya

#### **5.4.2 Seasonal comparison of food scores at household and individual level**

The household DDS serves as an indicator of the household's economic access to food. Households consumed between two and nine different food groups on a single day during the 2012 planting season, which increased to between five and 11 during the 2014 harvesting season. During this time, there was an increase in the mean household DDS (from 6 to 8 food groups) but as a mean of the two surveys, the household DDS of 7 was low, implying low household economic access to food. The main food groups consumed by different household members with low, medium or high dietary diversity scores (DDS) differed. While cereals, vegetables, spices and oils/fats were consumed by everyone, and to a large extent sugars, the remaining seven food groups were not consumed by all household members (**Figure 5.3**). Besides the five common food groups, households with a medium DDS additionally consumed milk/milk products and fruits to a great extent. Only 36 per cent of households with a low DDS consumed fruits, in addition to the five common food groups. In the high DDS group, milk/milk products and fruits were consumed by everyone and 86 per cent consumed both legumes and fish. More than half (70%) and close to half (43%) consumed white tubers/roots and meat, respectively while only 14 per cent of the households with high DDS consumed eggs (**Figure 5.3**).

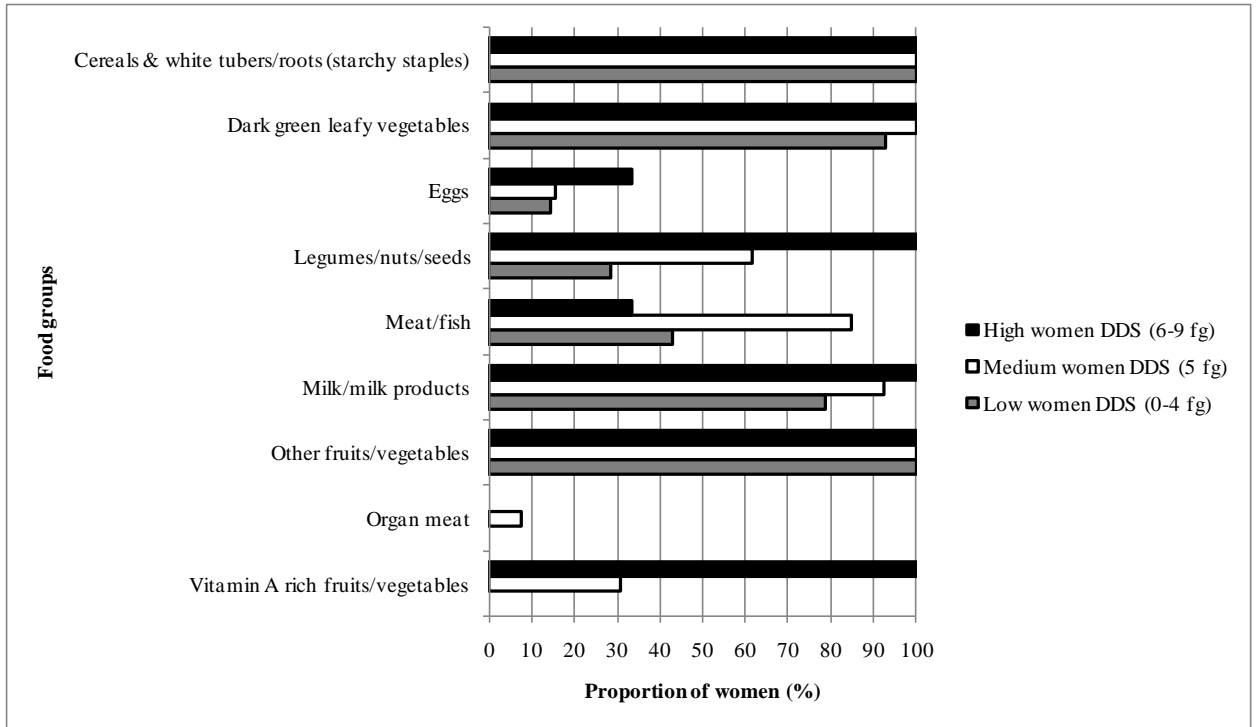


**Figure 5.3:** Proportion of different household members (%) consuming each food group according to the dietary diversity score (DDS) categories, interviewed during two seasons in Mumias and Vihiga districts (n=30). Twelve food groups (fg) are selected for the household DDS according to FAO (2011)

The women DDS is a proxy for dietary quality of women within the household. Overall, women consumed between one and seven different food groups on a single day during the 2012 planting season, with a slight increase of between two and seven during the 2014 harvesting season. Over this time, the mean women DDS also slightly increased (from 4 to 5 food groups). Nonetheless, as a mean of two surveys, the women DDS of 4 was low, implying low women’s dietary quality. All women with either low, medium or high DDS consumed starchy staples (comprising of cereals and white tubers), non-vitamin A fruits/vegetables and nearly all ate dark green leafy vegetables (**Figure 5.4**). Besides the three main food groups, none of the women with low DDS consumed Vitamin A rich fruits/vegetables/tubers and organ meat. In the medium DDS group, not only were these two additional food groups consumed, but also legumes and meat/fish, by 62 and 85 per cent of women, respectively. All women with a high DDS consumed

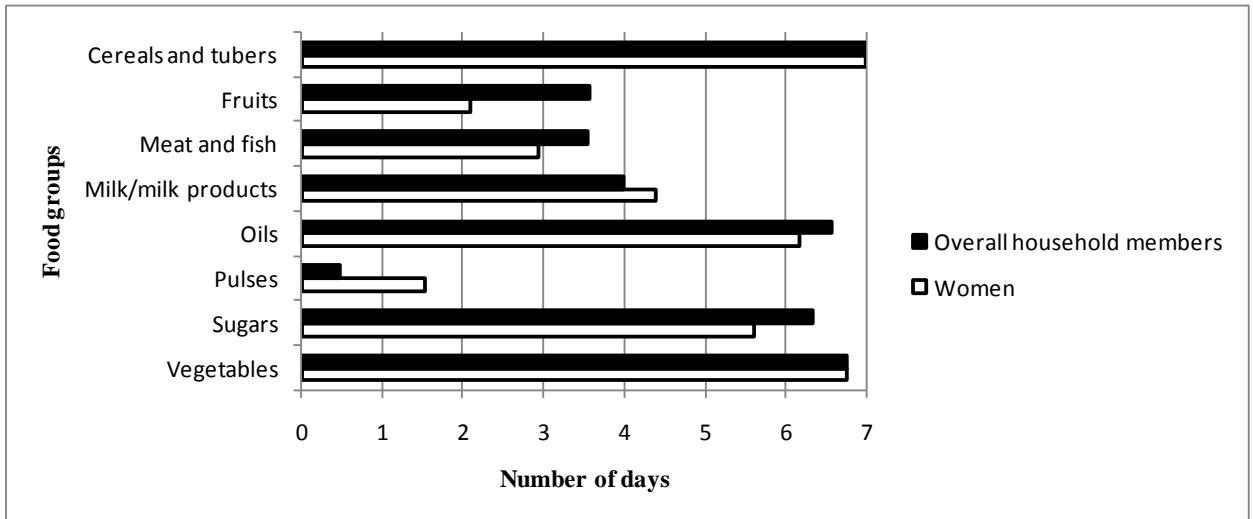
Paper 2: Influence of seasonal on-farm diversity on dietary diversity

starchy staples, legumes, dark green leafy vegetables, Vitamin A rich and other fruits/vegetables while about 30 per cent of women consumed both eggs and meat/fish (Figure 5.4).



**Figure 5.4:** Proportion of women (%) consuming each food group according to the dietary diversity score (DDS) categories, interviewed during two seasons in Mumias and Vihiga districts (n=30). Nine food groups (fg) are selected for the women DDS according to FAO (2011)

The food groups consumed by women over the two surveys greatly coincided with those consumed during seven consecutive days in the 2014 harvesting season (Figure 5.5). Nearly everyone consumed cereals/tubers, vegetables, oils and sugars. While the remaining food groups were not consumed on a daily basis, slightly more women consumed milk/milk products and pulses (Figure 5.5).



**Figure 5.5:** Proportion of overall household members and women (%) consuming each food group in Mumias and Vihiga districts interviewed during July/August 2014 harvesting season in Mumias and Vihiga districts (n=30). Eight food groups are selected according to WFP (2008)

Overall, the majority of women (90%) and different household members (83%) had acceptable levels of food consumption (with a FCS cut-off point ranging from 43 to 92) while about 10 per cent of both groups had borderline levels of food consumption (FCS of between 36 and 42). None of the women and quite a few (3%) of different household members remained at poor food consumption levels (FCS of 26) over the seven-day period.

#### 5.4.3 Associations across indicators of dietary and farm diversity in the two seasons

During both seasons, the seven farm diversity indicators (species richness, Shannon index, Simpson’s index, Shannon evenness, individual density, relative nutrient functional diversity and combined crop and livestock count) were not correlated with any of the four dietary diversity indicators (household and women DDS, household and women FCS). However, relative nutrient functional diversity was slightly positively correlated with women DDS ( $\rho=0.447$ ,  $p<0.05$ ) and household DDS ( $\rho=0.387$ ,

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

$p < 0.05$ ) during the 2012 planting season. During both seasons, there was a trend that women with high DDS belonged in households with biggest farm sizes and of the highest nutrient functional diversity, followed by those with medium and low DDS. All households relied on both farms and markets for sourcing of foods for home consumption but among women with high DDS, there was a trend that the highest proportion of foods consumed was obtained from farms as compared to women with medium DDS and low DDS (over the two seasons, at an average of 57%, 53% and 41%, respectively). Small proportions of on-farm produce were sold in markets in households with women at high, medium and low DDS (at a mean of 9%, 15% and 14% during the two surveys, respectively). The household DDS, as an indicator of household economic access to food, was negatively correlated with the percentage of on-farm consumed foods ( $\rho = -0.465$ ,  $p < 0.001$ ) but slightly positively associated with the proportion of sold on-farm produce ( $\rho = 0.380$ ,  $p < 0.05$ ) during the 2014 harvesting season.

The four food scores (household and women DDS, household and women FCS) were associated with four socio-economic variables. The wife's completion of primary education was positively associated with the household and women DDS during 2012 planting season and with the household and women FCS during the 2014 harvesting season (**Table 5.4**). Completion of primary education by the household heads was associated with lower women DDS during the 2014 harvesting season (**Table 5.4**). During both seasons, the trend was that in households where women had the highest DDS, the majority of the women had completed primary education (67%) while in households with women having the lowest DDS, most of the household heads had completed primary education (93%). While the wealth index was negatively correlated

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

with both household and women DDS during the 2012 planting season, it was positively associated with the household DDS during the 2014 harvesting season (**Table 5.4**). The Luhya ethnicity of the household head and of their spouse was negatively correlated with the women DDS (during the 2012 planting season) and household DDS (during the 2014 harvesting season), respectively (**Table 5.4**). In the 2014 harvesting season, household-only decision making on the use of harvested on-farm crops (for example, if the produce was to be used for home consumption, sale or both purposes) was weakly negatively correlated with household DDS.

Paper 2: Influence of seasonal on-farm diversity on dietary diversity

**Table 5.4:** Correlations between socio-economic factors and food scores among 30 smallholder farming households during two seasons (September/October 2012 planting season (PS) and July/August 2014 harvesting season (HS)) in Mumias and Vihiga districts, Western Kenya

Season	Household head completed primary education (0=no,1=yes)		Wife completed primary education (0=no,1=yes)		Wealth index		Ethnicity of household head is Luhya (0=no, 1=yes)		Ethnicity of wife is Luhya (0=no, 1=yes)		Decision-making on crop use as household head only (0=no,1=yes)	
	Correlation coefficient rho	<i>p</i>	Correlation coefficient rho	<i>p</i>	Correlation coefficient rho	<i>p</i>	Correlation coefficient rho	<i>p</i>	Correlation coefficient rho	<i>p</i>	Correlation coefficient rho	<i>p</i>
<b>Sep/Oct 2012 PS</b>												
Household DDS	na	ns	0.653	<0.001	-0.548	<0.001	na	ns	na	ns	na	ns
Women DDS	na	ns	0.363	<0.05	-0.412	<0.05	-0.407	<0.05	na	ns	na	ns
<b>Jul/Aug 2014 HS</b>												
Household DDS	na	ns	na	ns	0.389	<0.05	na	ns	-0.382	<0.05	-0.377	<0.05
Household FCS	na	ns	0.622	<0.001	na	ns	na	ns	na	ns	na	ns
Women DDS	-0.396	<0.05	na	ns	na	ns	na	ns	na	ns	na	ns
Women FCS	na	ns	0.440	<0.05	na	ns	na	ns	na	ns	na	ns

## 5.5 Discussion

The mean household DDS of 7 and mean women DDS of 4 were low, suggesting an overall low economic access to food at the household level and low women's dietary quality, respectively, over two days (as a mean of the two seasons). Nevertheless, acceptable levels of food consumption were reached (with FCS ranging from 43 to 92) over seven consecutive days during the July/August harvesting season by the majority of different household members (83%) and women (90%). As compared to the two 24-hour recalls, the longer seven-day recall period during the 2014 survey captured not only the food groups consumed on a daily basis (cereals/tubers, vegetables, oils and sugars) but also the less frequently consumed food groups (milk/milk products, pulses, meat/fish and fruits), suggesting that the usual food consumption patterns are more likely reflected over a longer reference period, which is in turn likely to be a stronger basis for assessing the dietary diversity. This is in line with a study comparing 1-day and 3-day recalls among women in rural Burkina Faso which also showed that food consumption had reached its saturation point over the longer 3-day recall period as compared to the 1-day recall which failed to capture three main food groups (vegetables, legumes and fats/oils). They suggest that while the different recall periods reflect different dietary characteristics and the choice over the indicator used depends more on the study objectives, the 1-day recall period is still adequate to predict nutritional status based on dietary quality, especially in rural settings (Savy *et al.*, 2007). In rural Tanzania, women DDS of 6 was considered low (Keding *et al.*, 2012), although 14 food groups were assessed instead of the 12 food groups utilised in this study. So far, there is no international agreement on the number of food groups to consider, nor on the

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

cut-off points for the number of food groups that determine if the household DDS is low, medium or high (Savy *et al.*, 2007). Nevertheless, there has been recent development on the use of five (out of ten) food groups as a cut-off for women's minimum DDS (FAO and FANTA, 2014). However, some of the proposed food groups were not differentiated enough in this study (for example, 'legumes/nuts/seeds' were considered as one food group rather than differentiating 'beans/peas' from 'nuts/seeds' as in the new indicator) hence it was not possible to make use of the new indicator. With the two scores used in the present study (DDS and FCS), it still can be concluded that food consumption in general was adequate for a majority of the study population yet dietary diversity was rather low, which if increased it is likely to result in higher dietary quality.

### **5.5.1 Seasonal food consumption and sources**

There were less distinct differences in food groups consumed over the two seasons by different household members and women. All the surveyed participants consumed vegetables and cereals when analysing all the food scores. In addition, oils/fats and sugars were also consumed by different household members and women with different DDS and FCS during both the planting and harvesting seasons. Cereals and vegetables are considered the most basic diet of rural African households (Keding *et al.*, 2012), with cooked maize flour paste ('ugali') and leafy vegetables as the socially acceptable main hot meals (Ohna *et al.*, 2012). Cooking oil/fat is normally used in cooking the vegetables while sugar is usually added in breakfast tea (Ohna *et al.*, 2012), with or without milk. The energy-dense nutrient-poor foods such as oils and sugars are increasingly being found in rural settings (Keding *et al.*, 2012). Commonly regarded as

‘urban’ foods, probably due to their particular culinary characteristics such as taste (Kayode *et al.*, 2005), their purchase is prioritised over other foods (Noack and Pouw, 2014). During both seasons, around a quarter (26%) of the foods consumed were sourced from markets, while half (50%) was obtained through on-farm production (**Table 5.3**). It is probable that where smallholder farming households rely on multiple sources of food procurement, seasonality in on-farm food availability may not greatly affect food consumption patterns. As in this study, the non-distinct role of seasonality on food groups consumed was also observed among women in rural Tanzania, implying that seasonal changes are less likely to affect foods that are not on-farm sourced but are available for purchase throughout the year (Keding *et al.*, 2012).

There were also minor differences with regard to uses of on-farm produce during both seasons (**Table 5.3**). Most of the on-farm produce (75%, **Table 5.3**) and the individual food groups (**Figure 5.2**) were utilised for home consumption. Only a small proportion (14%) of on-farm produce was sold in markets, mainly ‘sugarcane’, ‘animal source foods’ and ‘spices/condiments’ (**Figure 5.2**). During the 2014 harvest season, slightly more households sold ‘starchy roots’, ‘fruits’ and ‘pulses’, while some of the excess on-farm produce (mainly ‘spices/condiments’ and ‘fruits’) were given away during this harvest season (**Figure 5.2**). Minor engagement with markets, which slightly increases with some food groups during bumper harvest seasons (but does not result in overall increased market participation), is typical of predominantly subsistence-oriented smallholder farming households (Noack and Pouw, 2014). During these periods, they fetch lowest prices as the supply is higher than the demand (Leavy and Poulton, 2007), which is a probable explanation for the food surplus that was given away. Nevertheless,

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

it was also during the harvesting season when fewer households were food insecure which was accompanied by a slight increase in both the household and women DDS, as compared to the 2012 planting season. However, the limitation of the DDS as a simple qualitative measure is that it only considers the types of foods without taking into account food quantities consumed, which is likely to occur during seasonal changes (Keding *et al.*, 2012). While the short (one-month) time scale of food security data collection may also have offered a rather incomplete picture, the repeated survey and calculation of household hunger scores during two seasons yielded comparable results. Nonetheless, there was a trend of a concomitant decrease in hunger scores and increase in DDS at household and individual level during the harvest season. This observation is supported by a study suggesting that for subsistence-oriented farming households, diversity in farm production (such as during increased food availability during the harvest season) is likely to result in an increase in dietary diversity (Jones *et al.*, 2014).

However, increased on-farm production among subsistence-oriented farming households may not necessarily equally improve dietary diversity at both individual and household level. Although a non-significant result in this study, there was a trend that among women with high DDS, the highest proportion of foods consumed was obtained from farms as compared to women with medium DDS and low DDS. However, the household DDS, as an indicator of household economic access to food, was negatively correlated with the proportion of home-consumed foods (but positively associated with the percentage of on-farm harvested produce that was sold), suggesting that increased dietary diversity among smallholder farming households requires more than subsistence-based production. This finding agrees with a rural Malawi study where

there was a negative relationship between proportion of on-farm consumed foods and household DDS (Jones *et al.*, 2014). The need for diversified livelihood sources among smallholder farming households lends support to other rural African studies where in Malawi, smallholder farming households dedicating larger share to market crops had greater household DDS and more diverse farms when using multiple farm diversity indicators (Jones *et al.*, 2014). In Tanzania, women DDS was associated with not only the number of vegetables that the women cultivated/collected, but also if they bought or sold vegetables (Keding *et al.*, 2012).

### **5.5.2 Relationship between on-farm and dietary diversity**

In addition to on-farm production, the surveyed smallholder farming households also obtained food from markets and family/friends. Food procurement from multiple sources is a likely contributor to lack of a linkage between on-farm agrobiodiversity and dietary diversity indicators in this study. This finding disagrees with a Malawian study where a positive relationship was found between farm diversity (measured as species richness, Simpson's index and combined livestock and crop count) and dietary diversity (measured as household DDS and household FCS). While inclusion of the contribution of animal source foods in the diet by use of the combined crop and livestock count is what contributed to this direct relationship in the Malawi study (Jones *et al.*, 2014), inclusion of the indicator did not modify the relationship in this study. Nevertheless, relative nutrient functional diversity (which accounts for total animal source foods available on-farm per weight) resulted in a weak positive association between on-farm agrobiodiversity and dietary diversity in the present study. While nutrient functional diversity was positively associated with species richness (Remans *et al.*, 2011), another

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

Western Kenya study found no association between species richness and adult anaemia levels, but nutrient functional diversity was positively related with adult anaemia (DeClerck *et al.*, 2011), suggesting that the same level of farm diversity when measured in different ways is likely to result in different outcomes (Remans *et al.*, 2011; Jones *et al.*, 2014).

### 5.5.3 Non-farm production factors influencing dietary diversity

Non-farm production factors could also influence dietary diversity of smallholder farming households, further complicating the relationship (Keding *et al.*, 2012; Jones *et al.*, 2014). Socio-economic factors are among the main factors affecting dietary diversity, in some cases remaining the same irrespective of the food consumption recall periods (Savy *et al.*, 2007) but also changing when different seasons are taken into account (Keding *et al.*, 2012). In this study, four main socio-economic factors influenced dietary diversity differently in the two seasons: wealth status, level of shared decision making, education status, and local ethnicity of both the household head and the spouse (**Table 5.4**). Firstly, the negative association of the wealth index with both women and household DDS during both 2012 planting season but positive correlation with household DDS in 2014 harvesting season suggests that the wealth status does not always positively influence dietary diversity at household and individual levels in different seasons. On the one hand, it is likely that the household DDS was positively with wealth index during the harvesting season, a period of food abundance that is likely to not only retain the dietary quality of women through availability of nutrient-diverse foods (hence maintaining the constancy in women's DDS) but also to improve a household's economic access to purchased (and usually energy-dense) foods through

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

increased incomes when some excess farm produce are sold. On the other hand, during the planting season, especially when food reserves from a previous harvest season have run out, on-farm agrobiodiversity is unlikely to serve as a source of food and income. In that case, if increased incomes from other sources are not spent on home consumed foods during this on-farm food shortage planting season, it may result in the reduced ability for a household to purchase the staple food needs (hence negatively affecting a household's economic access to food) as well as a diversity of nutrient-dense foods (thus negatively affecting women's dietary quality). Therefore, it is likely that household wealth may lead to a decline in the dietary diversity during food shortage periods, especially among women, depending on who is in control of cash income or household assets. This is probably because material assets under a household head's control do not guarantee that the wife, who is normally in charge of home food preparation, also has access to the money to purchase diverse nutritious foods. In rural Burkina Faso, women who had higher DDS after a cereal shortage season were those who had personal incomes, represented by animal ownership (Savy *et al.*, 2006). Individual incomes managed by women, especially from ownership of small livestock, may also result in increased household DDS (Maass *et al.*, 2014). Although in this study a household's wealth status is based on wealth index computed from household assets and type of living conditions, the more direct household wealth indicator (measured using household food consumption and expenditure data) in a Malawi study was also not strong enough to modify the positive relationship between dietary diversity and farm production diversity (increased farm diversity is likely to coincide with the harvest season), although the relationship was stronger in wealthier households (Jones *et al.*, 2014). However, household food expenditure does not offer a complete picture when

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

addressing the multiple dimensions of access to nutrition security (Noack and Pouw, 2014). As an illustration, poorer (women-headed) households in rural Tanzania did not exhibit lower DDS, suggesting that material wealth *per se* may not be as important as shared decision making on household food choices and expenditure that ultimately dictate a household's dietary diversity level (Keding *et al.*, 2012).

Secondly, wives of the household heads were the main decision makers on the use of animal source foods and they also contributed to decision making on food types to be purchased as well as the use of harvested on-farm crops in this study. However, when decision making on the use of harvested on-farm crops was left to the household head only (by 33% of the households in this study), it resulted in lower household DDS. These results propose for giving more attention to the issue of decision making power in projects focusing on nutrition and food security. In rural Malawi, although household DDS was greater in households where there was shared-decision making on what to do with income from agricultural activities, the impact of households where this decision was controlled by only the household head was not strong enough to modify the positive relationship between household DDS and farm diversity (Jones *et al.*, 2014).

Thirdly, the wife's completion of primary education was positively correlated with the different food scores at both household and individual levels in the two seasons. However, completion of primary school by the household head was associated with lower women DDS during the 2014 harvesting season (**Table 5.4**). In line with these findings, a nutrition education intervention among women in smallholder farming households in Western Kenya resulted in improved nutrition knowledge scores of the

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

women and the DDS of their children (Waswa *et al.*, 2015). However, a Burkina Faso study found that the women DDS was neither linked to their education level nor to that of the household head (Savy *et al.*, 2007). Despite this, when the study was conducted during a different period, there was a positive association between the education level of the household head (but not that of the spouse) and the DDS of women only at the end of a cereal shortage season, suggesting that the household head's education level may play a protective role only during harsh conditions such as seasonal food shortages (Savy *et al.*, 2006). It is likely that during seasons of food surplus (as the 2014 harvesting season in this study), exposure to better money-generating opportunities as a result of higher education that is in control of household heads, may affect the quality (but not quantity) of household diets. A Central Kenya study among smallholder banana farmers showed that when men were in charge of income from banana sales, the calories consumed remained constant but there was a slight decline in the dietary quality (Fischer and Qaim, 2012). As women are in charge of home food preparation and with the key role of the wives in the decision making process, this study suggests that the education level of the women is a crucial component as they are likely to better contribute in the selection of high quality diets if they are well informed on the importance of diverse diets.

Lastly, local ethnicity may shape food customs that either promote diverse dietary intake (Keding *et al.*, 2012) or result in food preferences that could limit the diversity in diets (Savy *et al.*, 2006; Savy *et al.*, 2007). In this study, the Luhya ethnicity of either the household head or the spouse negatively impacted the DDS due to cultural beliefs associated with certain foods leading to low food intake of these foods. Among some

Luhya sub-tribes, it was considered taboo for lactating women to consume eggs, dry fish, beans, sour milk, insects and cowpea leaves, for different cultural reasons. A striking example was that consumption of eggs soon after delivery was discouraged until the back recovers as otherwise the woman could end up with a curved back as that of a chicken. In addition, eating of cowpea leaves (*Vigna unguiculata*) was associated with loss of milk in a lactating mother. Inherited food taboos are a component of distinguishing sub-ethnic groups (Ohna *et al.*, 2012), which could explain such traditions in differentiating the many sub-tribes (about 26) within the Luhya ethnic group. Although the married women often originate from different communities with diverse food customs, there could be minimal mixing of food cultures in such patriarchal families, with the household food preferences more or less predetermined (Noack and Pouw, 2014). This study suggests in order to better challenge underlying negative food cultural beliefs, local food cultural awareness is a prerequisite for organisations working on nutrition and food security. Otherwise, approaches that are not based on a solid understanding of the local context, and where both women and men are not equally engaged, are less likely to result in long-term solutions (Noack and Pouw, 2014). Therefore, household food and nutrition security interventions may need to shift towards a multi-dimensional strategy while also bringing in easily overlooked socio-economic factors such as household decision-making power and ethnicity into centre stage.

## **5.6 Conclusions**

For a majority of the surveyed smallholder farming households, food consumption over seven consecutive days during the 2014 harvest season was adequate. During both

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

seasons, however, dietary diversity was rather low, which if increased could lead to higher dietary quality. This study also suggests that the lack of a relationship between on-farm agrobiodiversity and dietary diversity in the two seasons could be due to food procurement from multiple sources (farms, markets and family/friends). Furthermore, there was a non-distinct role of seasonality on food groups consumed and the uses of on-farm produce. Socio-economic factors influenced dietary diversity. More important than wealth status, which could have either positive or negative effects, is the role of attainment of basic formal education by women, which is likely to enable them to better contribute towards diverse nutritious diets in their shared decision making role within the household (on the types of food purchased, the use of harvested on-farm crops and animal source foods). The women's education status is also likely to counteract the negative aspects of food cultural beliefs emanating from the local ethnicity of either the household head or the spouse. As a starting point, there is need for local awareness and understanding on existing local food culture to be taken into account before interventions on improving dietary diversity are proposed by agricultural programmes working in rural areas. In addition to this, efforts to enhance nutrition education training among rural communities, especially among households where women have not completed primary education, as well as promoting opportunities for marketing on-farm produce are also likely to be other sustainable strategies that could facilitate strengthening of rural food and nutrition security.

### **5.7 Acknowledgments**

We are grateful to all the farmers, local administration and contact persons who participated in this study. Many thanks to Dr. Patricia Daley (University of Oxford, UK)

## Paper 2: Influence of seasonal on-farm diversity on dietary diversity

for the insightful discussions and invaluable comments on earlier drafts of the manuscript. We would also like to thank Dr. Johannes Herrmann (Giessen University, Germany) for his invaluable explanations and support when conducting the correlation analyses. Our sincere gratitude also goes to the Federal Ministry for Economic Cooperation and Development (BMZ), Germany and the CGIAR Research Program on Agriculture for Nutrition and Health for funding this study, implemented by Bioversity International, Regional Office for sub-Saharan Africa, Nairobi, Kenya. The Rhodes Trust is also acknowledged for covering field travel costs through the David Frederick Research and Travel Grant, as well as funding the tuition fees of the first author to undertake this study in partial fulfillment for the Degree of Doctor of Philosophy at the University of Oxford.

## **6 Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security: A case study of smallholder farming households in Western Kenya**

This chapter is based on the following paper submitted to the journal *Agriculture and Human Values*:

Ng'endo, M., Bhagwat, S. and Keding, G.B. Contribution of nutritional diversity and food perceptions to food and nutrition security: a case study of smallholder farming households in Western Kenya.

Paper 3 further builds up from the previous empirical chapter's finding that rather than farm diversity indicators, other factors, namely, socio-economic and cultural factors (household's wealth status, ethnicity of both the household head and the spouse, and the education level of the wife) are the ones that influenced dietary diversity. The paper provides further evidence on the low dietary diversity of consumed foods (measured in Paper 2), during the same seasons (September/October 2012 and July/August 2014). A major component of this paper is to investigate a different aspect of diversity - that of nutrient diversity (of foods obtained from both on-farm and market sources) by applying a nutrient functional diversity (nFD) score and shows that functionally redundant and unique species that meet all the existing macro-and micro-nutrient needs under investigation are theoretically available during the different seasons. As nutritional diversity is comprised of both nutrient and non-nutrient factors, the paper goes on to

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

show that there is low appreciation for most of the existing on-farm local agrobiodiversity, suggesting that non-nutrient factors and non-farm diversity factors (shown in Paper 2) contribute greatly to an overall low dietary and nutritional diversity. Beyond these parallelisms (with Paper 2), Paper 3 goes further to show that the affordability of some of the preferred foods available in markets vary in the different seasons, thus showing that market food availability does not necessarily equate to its accessibility, a theme that is picked up in more details in the last empirical chapter - Paper 4.

#### **6.1 Abstract**

Sub-Saharan Africa is the only region in the world where hunger prevalence affects over a third of the population, with smallholder farmers, producers of over 80 per cent of Africa's food, and their families facing both calorie and micronutrient deficiencies. With agricultural systems serving as the main source of all nutrients for human consumption, little is known on the extent to which agricultural diversity in different seasons can meet macro-and micro-nutrient needs in rural Africa. A case study in six villages of Mumias and Vihiga districts in Western Kenya was conducted to assess the seasonal nutrient diversity, seasonal nutrient accessibility levels and food perceptions in 30 smallholder farms, seven markets and among 97 focus group discussion participants, respectively. All present plant and animal species grown/collected/reared for food were inventoried and assigned to one of the seven major FAO-defined food groups. Based on two macronutrients (carbohydrates and proteins) and five micronutrients (folic acid, iron, zinc, Vitamins A and C), dendrogram-based nutrient functional diversity metrics were calculated. The survey indicated that during two seasons, on-farm and market food

species offered all the seven macro-and micro-nutrients under investigation, regardless of the seasonal variation in species numbers. While there were varying seasonal accessibility levels for most of the available nutrients in markets, farms were especially effective in readily availing four of the nutrients (proteins, Vitamin A, folic acid and iron) during both seasons. However, the main food shortage months, as perceived by smallholder farming households, coincided only with maize shortage, but a diversity of local foods, deemed to be of low value mainly due to their taste and time-consuming preparation, were available. Raising awareness and nutrition education on the importance of a diversity of local foods in meeting dietary needs, thus stimulating the demand side, can contribute to achieving year-round food and nutrition security among rural households.

*Key words:* food and nutrition security, food perception, functional diversity, seasonal food access, seasonal food availability

## **6.2 Introduction**

Nearly two thirds of the hungry people worldwide are farmers and pastoralists and their families, living in Asia and Africa, the latter of which has been the region of greatest concern (Borlaug, 2007). Ironically, smallholder farming households, producers of around 80 per cent of food supply, make up approximately 60 per cent of this population (FAO, 2012). Sub-Saharan Africa (SSA) still experiences the highest hunger rates (von Grebmer *et al.*, 2014), with more than 90 per cent experiencing constant or recurrent lack of access to sufficient quantity and quality of food (Sanchez and Swaminathan, 2005). Hunger in the form of insufficient calories is only half of the

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

issue, yet a major but often overlooked challenge affecting about three billion people worldwide in both affluent and developing countries is hidden hunger, characterised by micronutrient deficiencies (Welch and Graham, 2005). The most common micronutrient deficiencies are of iron, vitamin A, iodine, zinc and folate (Muthayya *et al.*, 2013), which can co-exist with sufficient or excessive macronutrient intake (von Grebmer *et al.*, 2014). As expected, the majority of these people affected by micronutrient deficiencies live in developing countries, particularly in sub-Saharan Africa (von Grebmer *et al.*, 2014).

Global measures on addressing under-nutrition and nutritional deficiencies among the poor's diets have focused on the three most common micronutrient deficiencies (that of iron, vitamin A and iodine), and often singly, without addressing other essential limiting nutrients, as well as focusing on all these nutrients together (Graham *et al.*, 2007). Diversified diets increase the bioavailability of micronutrients (Diaz *et al.*, 2003) and the main source of all nutrients for human consumption is through agricultural systems (Graham *et al.*, 2007). Thus, African smallholder farming systems that are characterised by a diversity of food crops (Jama and Pizarro, 2008) are crucial change agents. It is suggested that increased agricultural output of micronutrients is likely to be achieved through diversification of cropping systems (Welch and Graham, 2005), characterised by not only the common staples, but also underutilised grains, pulses, fruits, vegetables, starchy roots and tubers (Jaenicke and Virchow, 2013). Although rural smallholder farming systems in developing countries are mainly characterised by high levels of agricultural diversity (Almekinders, 2001), there is a growing trend on increasing agricultural productivity by promoting simplified and intensive cropping systems

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

(Galluzzi *et al.*, 2010), for example, cereal-based cropping systems dominate new African farm production (Graham *et al.*, 2007), despite their limited nutrient contribution, consisting mainly of carbohydrates and small protein amounts but few micronutrients (Welch and Graham, 2005). As a consequence, less diverse agricultural systems will be unable to produce enough micronutrients to meet year-round dietary needs, especially in most of the developing world that relies heavily on agriculture for human nutrition (Welch and Graham, 2005). Still, nutrient-dense indigenous foods are available such as *Corchorus olitorius* (AVRDC, 2009). However, as compared to the major staples, these local foods have only a small share in cropping systems often due to lack of research and development and consequently lack in data on nutrient contents of the different species in the local and global databases (e.g. Kenya and FAO databases), necessitating, for example, several *Corchorus* species (such as *Corchorus acutangulus*, *Corchorus olitorius*, *Corchorus trilocularis* and *Corchorus tridens*) to be grouped together and omission of indigenous fruits with unavailable nutrient composition data (such as *Dovyalis caffra* and *Vitex doniana*).

As a tool in visualising the existing nutrient diversity, nutritional functional diversity metrics enable the assessment of the extent of nutrient diversity of cropping systems. The need for the metrics arise from the understanding that species richness does explain the difference in the identity and number of species, but not necessarily the functional trait differences of the identified species (DeClerck *et al.*, 2011). With its origins in Ecology, the output of functional diversity metrics reflects how different the functional traits in a given area are (DeClerck *et al.*, 2011; Remans *et al.*, 2011). The lower the functional diversity, the higher the similarity in the functional attributes (for example, if

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

only staples are available) and the higher the functional redundancy. While functionally similar crops offer limited nutrient diversity, redundancy in functional traits is not always bad, especially in the face of changing climate where failure of one crop can be replaced by a functionally similar crop (DeClerck *et al.*, 2011). While having sufficient food quantity and quality at the household level is a prerequisite for adequate nutrition, on its own it's insufficient for improved nutrition (Babu and Quinn, 1994). Nutrition security goes beyond food access to food consumption and dietary choices (Committee on World Food Security, 2012; Acharya *et al.*, 2014), coupled with health status determinants, such as access to adequate health services, sanitary environment and maternal care practices (Committee on World Food Security, 2012). Thus, nutrition security is a function of both food and non-food factors (Klennert, 2009).

There are so far few studies that have focused on the nutritional diversity of African smallholder farms (DeClerck *et al.*, 2011; Remans *et al.*, 2011). For these studies, the nutrient data have been based on the presence or absence of on-farm food species (DeClerck *et al.*, 2011; Remans *et al.*, 2011). While recent research using national-level data has enabled incorporation of presence/absence of market food purchases (Lockett *et al.*, 2015) and quantities of foods produced and supplied (Remans *et al.*, 2014), these measurements of nutritional diversity are yet to integrate the important dimension of food utilisation, which is best captured using household-level data (Remans *et al.*, 2014). Extending the data used to crop abundance, livestock diversity and number, and income ranges, this paper aims to contribute to a comprehensive understanding of the linkages between agricultural and nutritional diversity in smallholder farming households, by way of a case study of smallholder farmers in Western Kenya. This

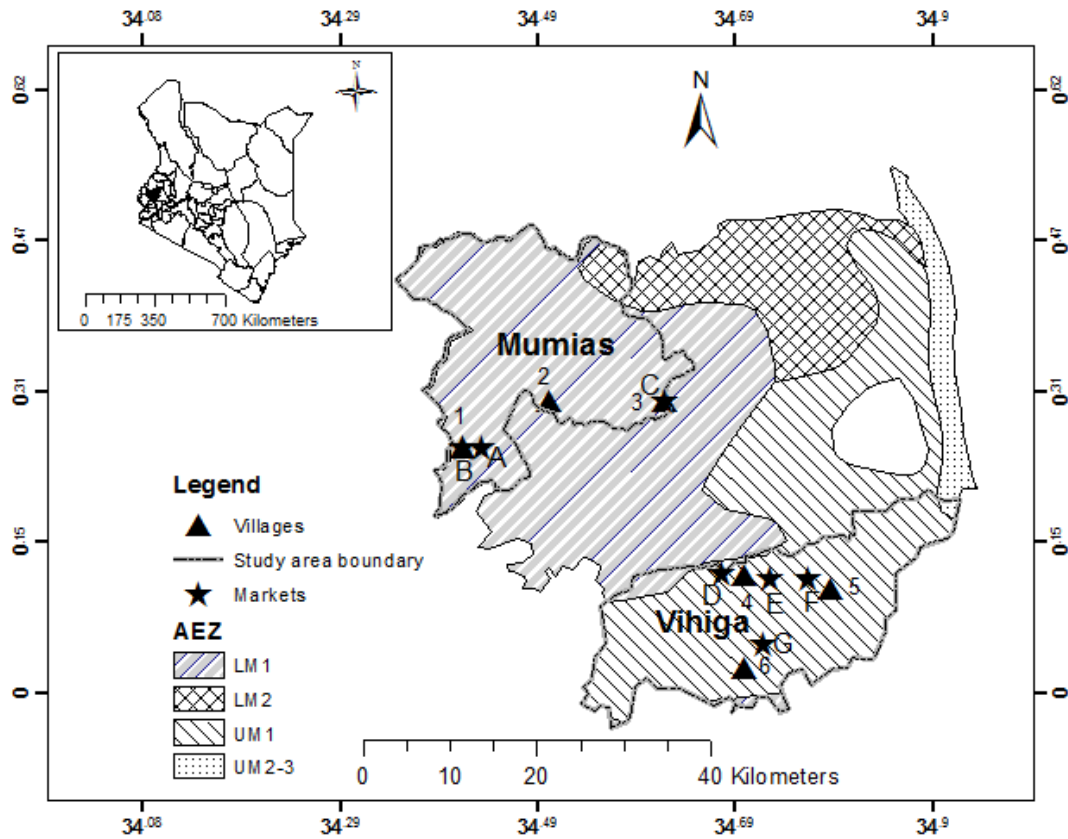
paper examines whether there are linkages between food plant species and nutritional diversity in smallholder farms. To do this, the study seeks to answer the following two research questions:

1. What nutrients are available for smallholder farmers to meet a balanced diet?
2. How does seasonal food accessibility compare to income levels in the study sites?

### **6.3 Methodology**

#### **6.3.1 Study area and data collection**

The study was conducted in September/October 2012 and July/August 2014 seasons in Mumias and Vihiga districts, Western Kenya. Mumias and Vihiga districts mainly represent the humid Lower Midland (LM1) and Upper Midland (UM1) agro-ecological zones (Jaetzold *et al.*, 2005), respectively (**Figure 6.1**). The selection of Mumias and Vihiga districts as study sites was with an aim to represent different agro-ecological zones, and thus most likely a different level of agrobiodiversity, with an added advantage of geographical closeness to each other. **Table 6.1** shows details on geographical, climatic and agricultural characteristics of the two districts.



**Figure 6.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kilingili, E=Mudete , F= Chavakali, G= Majengo

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

**Table 6.1:** Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold et al. (2005))

Characteristic	Mumias District	Vihiga District
Main agro-ecological zone	Humid Lower Midland (LM1)	Humid Upper Midland (UM1)
Altitude	1300-1500 m above sea level	1500-1900 m above sea level
Annual mean temperature	21.0- 22.2 °C	18.5- 21.0°C
Total annual rainfall	1650-1850 mm	1800-above 2000 mm
Rainfall pattern	Bimodal with long rains from end of February to end of March and short rains from end of July to November/December.	Bimodal with long rains from end of February to end of March and short rains from mid July to November/December
Soil types	Ferrasols	Combination of cambisols and lithosols
Main crops	Cash crops: sugarcane Food crops: sorghum, cassava, sweet potatoes	Cash crops: tea, coffee, sugarcane Food crops: maize, beans, cowpeas

The present study was conducted in tandem with a larger, cross-sectional research project entitled ‘Improving nutrition through local agrobiodiversity’. For the present study, data collection was conducted through farm surveys, Focus Group Discussions (FGDs) and market surveys. The farm survey purposefully selected six villages in order to cover the above mentioned different climatic zones, three villages in Mumias and three in Vihiga districts (**Figure 6.1**), out of 30 villages from the larger study. The latter were sampled according to district village lists with number of households per village applying a ‘probability-proportional-to-size’ approach (Magnani, 1997), with larger villages given a greater chance of selection than smaller villages. A total of 30 households, 15 in Mumias and 15 in Vihiga districts, in the six villages (five households per village) were then randomly selected to represent 10 per cent of the 300 households sampled by the larger study. In both September/October 2012 and July/August 2014, the same smallholder farming households were surveyed. On each farm the head of the household and/or the spouse were interviewed by using a semi-structured questionnaire

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

to collect data on: (1) basic demographic and socio-economic household characteristics, (2) names, production data and uses of food plant and livestock species/varieties produced on the farm, and (3) products of plant and livestock species available and/or consumed by households. Data on living conditions of the households (toilet, water and health care facilities), nutritional knowledge of the interviewed mothers and child feeding practices and anthropometric measurements of the women and their children aged between six and 23 months were obtained from the above mentioned larger study (Kipkorir, 2012).

The Body Mass Index (BMI) for women (n=29) were calculated from their weight and height measurements (weight in kg/ height in m<sup>2</sup>) to estimate their nutritional status, according to WHO (2006). One woman was excluded from the BMI analysis due to pregnancy. The nutritional status of the children aged 6-23 months was assessed based on their anthropometric measurements and expressed as Z-scores for each of the three indicators of under-nutrition: stunting, wasting and underweight (WHO, 1995). The feeding practices of the 6-23 month children were assessed based on one of the WHO (2010) infant and young child feeding indicators. Minimum Dietary Diversity (MDD) is defined as the percentage of 6-23 month children who receive food from four or more food groups per day (WHO, 2010).

In September/October 2012, purposive sampling was utilised in assembling Focus Group Discussion (FGD) participants (Basch, 1987) who were smallholder farmers. The FGDs were conducted in the six villages where the farm surveys were conducted, where on the chosen day two gender-disaggregated FGDs (Satzinger *et al.*, 2009) were held.

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

This is because it was deemed men and women may offer different views on the same set of questions and they talk more openly when separately grouped. With an aim of enhancing the discussions (Wong, 2008), a range of varying age groups were selected in each FGD session so as to stimulate diverse views during each session. While aiming for between eight and 12 participants (Basch, 1987; Wong, 2008) in each of the FGD participant recruitments from different areas of each village, the actual turnout ranged from six to 11 members, with a total of 97 participants in the 12 FGDs. In consultation with the local contact person in each village, the FGD sessions were held at a central venue in the village. A semi-structured checklist was used to guide the discussion and collect data on (1) incentives and disincentives of diversified and specialised farming systems (2) seasonal calendar of locally available foods belonging to six of the major FAO-defined (2011) food groups, according to FGD participant statements on their main use: (i) cereals (ii) starchy roots/tubers/green bananas (iii) vegetables (iv) fruits (v) pulses/nuts/seeds (vi) animal source foods. In each village, the set of two specific food groups to be discussed by participants in one FGD session were randomly selected. To document the differences in gender views on similar food groups, the second FGD session in each village focused on the same set of two food groups.

Smallholder farming households in both the farm survey and FGDs participated in the selection of the seven major local markets near the surveyed villages in Mumias and Vihiga districts (**Figure 6.1**). During both September/October 2012 and July/August 2014 seasons, the same seven markets were surveyed, with a total of 65 and 66 market traders interviewed in the two seasons, respectively. Simple random sampling was adopted to select the market traders (Abukutsa-Onyango, 2002) representing the

different market stands with an aim of sampling the whole market. With this, at least 10 per cent of market stands representing each food group were randomly sampled for market trader interviews. In cases where the market trader randomly selected was unavailable to answer the questions, a different market trader representing the same stand was purposefully sampled (Abukutsa-Onyango and Onyango, 2005). A semi-structured questionnaire was utilised to collect market data on: (1) edible food plant and animal species available (2) sources of produce, and (3) selling prices of different foods.

### **6.3.2 Data analysis**

To determine the extent that availability of different food species (in both farms and markets) improves nutrition, the contents of seven major nutrients: two macronutrients (carbohydrates and proteins), three vitamins (folic acid, Vitamins A and C) and two minerals (iron and zinc) for the different food species were compiled. The selection of these nutrients not only enabled comparability of data with a similar study (DeClerck *et al.*, 2011), but they also represent the first four out of the five micronutrients (folic acid, Vitamin A, iron, zinc and iodine) that are deficient in Kenya, according to the Ministry of public health and sanitation's (2012) report. To compile the nutrient contents of the different food species, nine different food composition databases were used (Maundu *et al.*, 1999; Erhardt, 2007; Lukmanji *et al.*, 2008; Purdue University Center for new crops and plant products, 2008; Saxholt, 2009; PROTA, 2010; FAO/INFOODS, 2012a; FAO/INFOODS, 2012b; USDA, 2014) as it was not possible to get the nutrient contents of all food species from a single food composition table. Priority was given to databases with a focus on the African region so as to enhance regional comparability.

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

Detailed nutrient composition data were missing for some closely related species, hence they were grouped together and the nutrient data for any of them were applied to the rest of the group members. This was the case for: (i) *Amaranthus cruentus subspecies hybridus* and *Amaranthus hybridus complex* (collectively classified as *Amaranthus* species) (ii) *Cleome hirta* and *Cleome gynandra* (collectively classified as *Cleome* species) (iii) *Corchorus acutangulus*, *Corchorus olitorius*, *Corchorus trilocularis* and *Corchorus tridens* (collectively classified as *Corchorus* species) (iii) leaves of *Cucurbita maxima* and *Cucurbita moschata* (classified as leaves of *Cucurbita* species) (iv) fruits of *Cucurbita maxima* and *Cucurbita moschata* (classified as fruits of *Cucurbita* species). The nutrient contents of some local foods were completely missing from the different food databases, necessitating their exclusion from the nutrient food list. The omitted food species were (i) *Vitex doniana*, (ii) *Syzygium cuminii*, and (iii) *Solanum betaceum*. Two of the spices/condiments, tea (*Camellia sinensis*) and coffee (*Coffea arabica*), were also omitted. Their exclusion from the final analysis is mainly because their anti-nutritive effects could be of more importance (Baye *et al.*, 2012) and as they were exclusively cash crops, their home consumption was also negligible.

To identify different food clusters on the basis of their nutrient composition, functional diversity analysis was conducted with R software (R Core Team, 2014) using an R script by Remans *et al.* (2011). For the analysis, two datasets were utilised: (i) a list of the seven nutrients for all the farm or market species (nutrient\*species matrix), and (ii) a list of species per site, in this case either farm or market (species\*site matrix). Firstly, the nutrient\*species matrix was used to calculate multivariate distances between food species, based on the uniqueness in nutrient composition and content, which resulted in

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

clustering food species into a dendrogram. The branch lengths of the dendrogram were then summed up from the number of species per site in the species\*site matrix (Remans *et al.*, 2011). To capture the different parts of a single food species, different food parts consumed from each species were analysed separately (for example, leaves and fruits of *Cucurbita* species). Secondly, the species\*site matrix utilised different approaches to generate market and farm abundance data. For the species\*farm site matrix, the on-farm food species abundance data were obtained by counting individuals of each food species that produced yields for the respective year, after which the harvested amounts were converted to 100 grams of its annual yield. For the species\*market site matrix, the abundance data on market food species were directly related to access, where it comprised of the use of both average smallholder farming household income per month and market selling price data, as a way to compare accessibility of diversity in markets (Remans, 2014. pers. comm.). The analysis was done in three steps: (i) the market selling price data were converted to price per 100 grams of market food species, after which, (ii) the price data were then converted to the percentage of average smallholder household monthly income, and, (iii) the resulting percentage was then used as the market abundance data. The larger the abundance data, the larger the access of the smallholder farming household is in terms of price compared to income (Remans, 2014. pers. comm.). To categorise the market food species by three levels of food access (low, medium or high), the cut-off points for three equal groups in the market abundance data was carried out using Statistical Package for Social Sciences (SPSS) version 22.0 (IBM Corporation, 2013). The cut-off points used to categorise if market accessibility in 2012 was low (1.3-4.5), medium (4.6-12.3) or high (above 12.3) differed from those

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

categories for low (1.5-5.3), medium (5.4-10.3) or high (above 10.3) market accessibility in 2014.

For both matrices (nutrient\* species and species\*site), the nutrient composition was listed per 100 grams of food species: carbohydrates (g/100g), proteins (g/100g), total folic acid ( $\mu\text{g}/100\text{g}$ ), Vitamin A ( $\mu\text{g}/100\text{g}$ ), Vitamin C ( $\mu\text{g}/100\text{g}$ ), iron (mg/100g) and zinc (mg/100g). The nutrient values for uncooked food species were used, as the nutrient contents vary greatly depending on the cooking method. The resulting raw nutritional values were then standardised by dividing them by the average dietary reference intake values of the corresponding nutrient for both women and men aged 19-50 years (Institute of Medicine of the National Academies, 2014). The resulting value represented the recommended daily intake value of a nutrient that the food species provides.

To determine the seasonal availability of different food species, a combination of views from both female and male FGD participants was compiled. To calculate the percentage of the 30 surveyed smallholder farming households perceiving food hunger across the different months, hunger months (computed according to standard questions by Ballard *et al.* (2011)) were obtained from the above mentioned larger study (Kipkorir, 2012).

## **6.4 Results**

### **6.4.1 Characteristics of surveyed smallholder farming households**

Each household mainly comprised of a nuclear family with the majority of households (93%) as male-headed. The mean age of the household head and of the spouse was 40

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

and 35 years, respectively. Seventy per cent of the household heads and 53 per cent of their wives had completed primary school. The total household income (from both on- and off-farm activities) was at an average of 50 USD per month, although this average masks the considerable difference in average income between the two districts, as shown in **Table 6.2**. There were also varying levels of shared decision-making on various uses of money for food (**Table 6.2**). With regard to the environment and hygiene conditions, less than half of the respondents had access to safe toilet facilities (43%), such as pit latrines and protected drinking water facilities (27%) such as piped water or rain water collection. The nearest health facility and local market were within close proximity (up to 30 minutes walking distance) for 40 and 70 per cent of the respondents, respectively. While none of the women were underweight, more than half (72%) had normal BMI, 17 per cent were overweight and 10 per cent were obese. Few of the children were underweight (7%) and wasted (3%) while the prevalence of stunting was slightly higher (at 23%). More than half (57%) of the children received Minimum Dietary Diversity (MDD). Regarding nutritional knowledge of the caregivers, more than half of the mothers had heard about iron, Vitamins A and C, but less than 20 per cent could name at least one food rich in any of the three nutrients (**Table 6.2**).

**Table 6.2:** General characteristics of 30 smallholder farming households in Mumias and Vihiga districts, Western Kenya

Characteristic	Overall	Mumias	Vihiga
Average age of household head (years)	40	40	40
Average age of wives (years)	35	31	40
Proportion of household heads having completed primary education (%)	70	67	73
Proportion of wives having completed primary education (%)	53	27	80
Average household monthly income, from both on-and off-farm sources (USD)	50	63	37

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

Characteristic	Overall	Mumias	Vihiga
Shared decision-making on:			
money spent on food purchase (%)	70	80	60
use of harvested plants for home consumption or sale (%)	37	27	47
use of animal source foods for home consumption or sale (%)	33	40	27
<b>Environment and hygiene conditions</b>			
Access to safe toilet facilities (%)	43	20	67
Access to protected drinking water facilities (%)	27	47	7
Walking distance to nearest health facility ≤ 30 minutes (%)	40	33	47
Walking distance to nearest local market ≤ 30 minutes (%)	70	67	73
<b>Anthropometrics</b>			
Proportion of women with normal Body Mass Index, BMI (%)	72	80	60
Proportion of overweight women (%)	17	13	20
Proportion of obese women (%)	10	0	20
Proportion of underweight children (%)	7	13	0
Proportion of wasted children (%)	3	7	0
Proportion of stunted children (%)	23	27	20
<b>Child feeding practices and mother's nutritional knowledge</b>			
Proportion of children receiving Minimum Dietary Diversity, MDD (%)	57	53	60
Proportion of mothers who had heard about iron (%)	53	27	80
Proportion of mothers able to name at least one iron food source (%)	7	0	13
Proportion of mothers who had heard about Vitamin A (%)	80	67	93
Proportion of mothers able to name at least one Vitamin A food source (%)	17	7	27
Proportion of mothers who had heard about Vitamin C (%)	57	40	73
Proportion of mothers able to name at least one Vitamin C food source (%)	7	7	7

#### 6.4.2 Species and nutrient diversity through on-farm and market food species

There was a slight increase in on-farm food plant and animal species from September/October 2012 (49 species) to July/August 2014 (52 species) (Appendix I, Species List 6.1). A similar trend was observed in the markets, with 45 and 48 food items available during the 2012 and 2014 seasons (Appendix I, Species List 6.1), respectively. Seasonal increase in on-farm species richness was accompanied by a rise

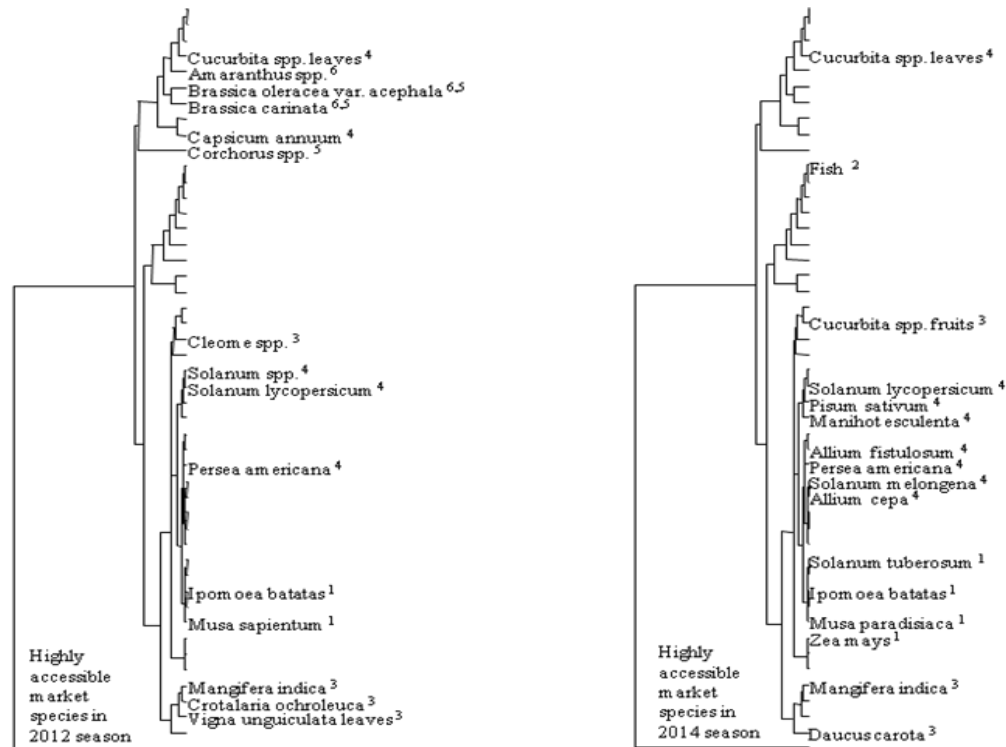
### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

in on-farm functional diversity, from 8.86 to 9.55, in the 2012 and 2014 seasons, respectively (**Figure 6.2**). The functional diversity dendrograms also clustered food species with similar nutrient characteristics together, highlighting three main patterns in the grouping of food species: (i) one nutrient is provided by multiple species in different food use groups (Appendix I, Species List 6.1) (ii) some food species provide more than one nutrient, (iii) while others are excellent sources of one main nutrient, hence remaining ungrouped in the dendrogram, for example folic-acid rich *Corchorus* species (Figure 6.2). During both seasons, regardless of the change in species numbers, all the seven macro- and micro-nutrients under investigation were available, either through availability of the same food species or by replacement of some food species with others in both farms (Figure 6.2) and markets (Appendix I, Species List 6.1).

While the dendrograms show the potential of farms and markets in providing all the seven nutrients, accessibility of both on-farm and market food species differed. In the markets, the accessibility of the same food species varied per season. During both seasons, there was low accessibility of food species rich in zinc (**Figure 6.3**). The two main available food sources rich in Zinc were pulses/nuts/seeds (such as *Vigna radiata*, *Phaseolus vulgaris*, *Arachis hypogaea*, *Sesamum indicum*) and animal source foods (beef).



**Figure 6.2:** Functional diversity dendrograms comparing on-farm food species richness and average functional diversity (FD) during the 2012 and 2014 seasons in 30 smallholder farms of Mumias and Vihiga districts, Western Kenya. The dendrogram species are clustered based on their content of seven nutrients under investigation, coded as: 1=Carbohydrates, 2= Proteins, 3= Vitamin A , 4= Vitamin C, 5= Folic acid, 6= Iron, 7=Zinc. Missing species in either dendrogram indicate those unavailable in that particular season, but present in the other season. Species in bold indicate those that are unique to that season



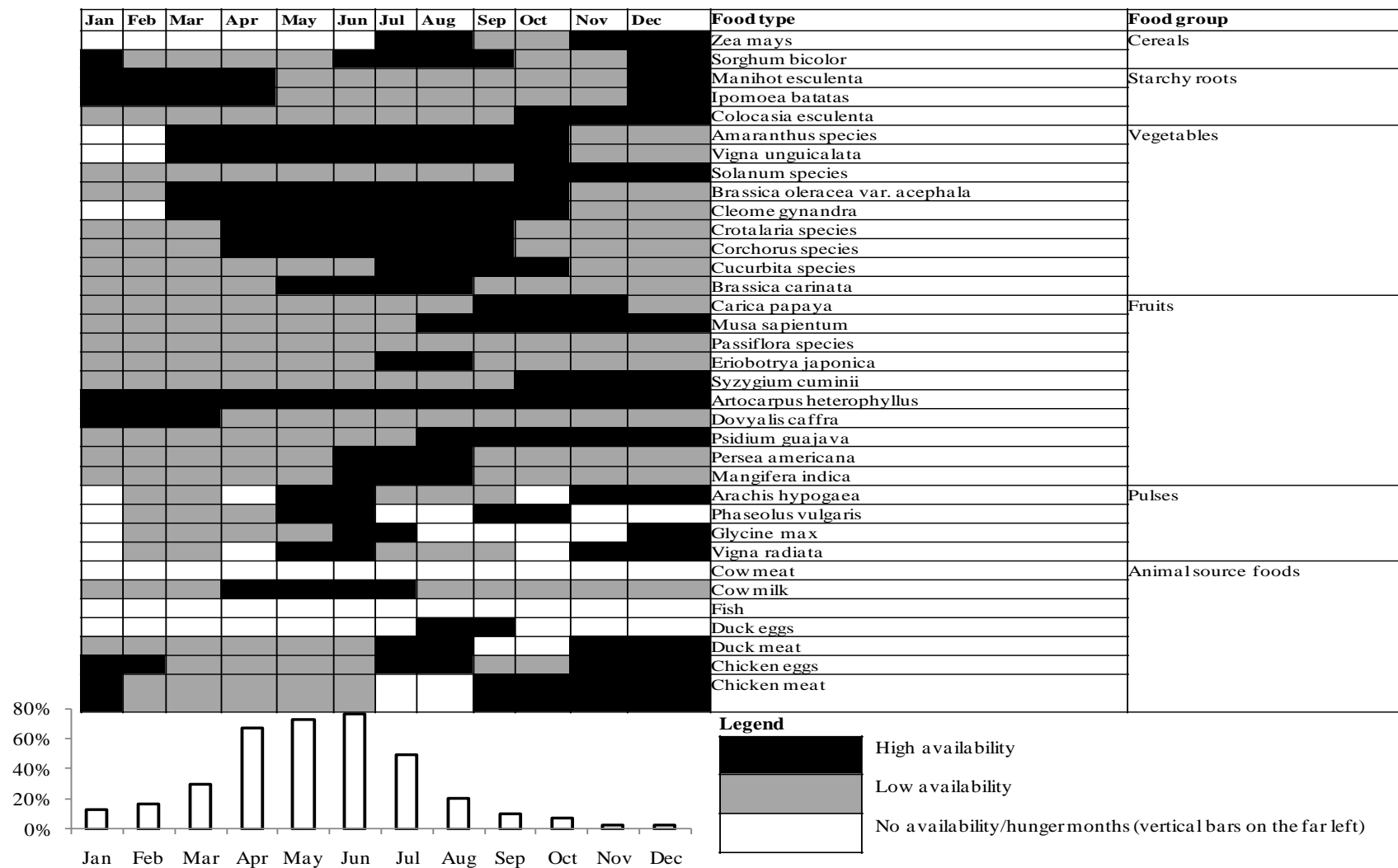
**Figure 6.3:** Functional diversity dendrograms comparing highly accessible food species during the 2012 and 2014 seasons in seven markets of Mumias and Vihiga districts, Western Kenya. With the exception of zinc, these market species are rich in the remaining six nutrients under investigation, coded as: 1=Carbohydrates, 2= Proteins, 3= Vitamin A , 4= Vitamin C, 5= Folic acid, 6= Iron. Missing species in each dendrogram indicate those that are not highly accessible in that particular season, though in most cases they may still be available but accessible at low or medium levels

In addition to zinc, protein-rich foods in the 2012 season and those high in both folic acid and iron in the 2014 season had low to medium accessibility levels (Appendix I, Species List 6.1). In the farms, meat from chicken, pigs, goats, rabbits, sheep and cattle in the 2012 season, and meat from the latter four in the 2014 season were not used for home consumption by varying proportions of households.

#### **6.4.3 On-farm food shortage months and cultural perceptions of foods**

The majority of the smallholder farming households perceived the main food shortage months to fall between April and June (**Figure 6.4**). These hunger months coincided with the months that maize (*Zea mays*), the main staple food in the study area, was unavailable. However, during the same period, a diversity of alternative local foods was readily available on-farm, as reported by a broader group of Focus Group Discussion (FGD) participants in the same villages. Most of the alternative local foods available during the hunger months were perceived to be of lower value, as reported through discussions on whether the foods could be offered to visitors. The alternative cereal food plant, sorghum (*Sorghum bicolor*), was highly available in June, which was also the highest hunger month as reported by 77 per cent of the respondents (**Figure 6.4**).

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security



**Figure 6.4:** On-farm seasonal availability of major food groups as perceived by focus group discussion participants (n=97) with corresponding hunger months as perceived by smallholder farming households in Mumias and Vihiga districts in 2012 (n=30)

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

The FGD participants considered sorghum as a traditional food that was mainly consumed by those who are accustomed to it. Further, it was not perceived to be good for visitors as it takes too long to cook (about two hours), it's bitter during the hot and dry season hence one needs to add local seasoning to it, and it takes long to chew it. Consequently, even when its availability is high, farming households can survive without it and buy maize instead.

Among the vegetables, pumpkin leaves (*Cucurbita* species) were highly regarded by both male and female FGD participants, mainly due to their soft texture when cooked. However, they are available in high amounts only after the peak hunger season (**Figure 6.4**) while alternative local vegetables available during the hunger season are less preferred for various reasons. According to women FGD participants, cowpea leaves (*Vigna unguiculata*) take a long time to cook (about two hours). In addition to this, men FGD participants reported that since cowpea leaves have both dry and wet season varieties, the hot season varieties have a bitter taste hence requiring addition of a local seasoning to improve the taste. One also has to keep on chewing incessantly and this could lead to social embarrassment. *Corchorus* species could also lead to social embarrassment as it's slippery and one cannot hold it well as the leaves are quite long. *Crotalaria* species were also considered to have a poor taste and requiring a long process to cook them, where one needs to add milk and keep the soaked leaves overnight before cooking them. Similar opinions on taste and time-consuming preparation were reported for the *Solanum* species, with women FGD participants stating that '*although mnavu [Solanum villosum] can be given to visitors, one needs to know how to cook it as it can be very bitter. With the modern and improved mnavu*

Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

*[Solanum scabrum], it is not as bitter and it can be given to visitors, but only when cooked well, that is, mixed with milk when cooking so as to reduce the bitterness. If this is not done, it will be very bitter as well.* It was also considered time-consuming to prepare *Amaranthus* species, as it has to be mixed with other vegetables.

Jack fruits (*Artocarpus heterophyllus*) were highly available year-round while avocados (*Persea americana*) and mangoes (*Mangifera indica*) were the highly available fruits in June, the peak hunger month (**Figure 6.4**). Nonetheless, none of the listed fruits were completely unavailable throughout the year (Figure 6.4). Even when in low availability, respondents reported that they don't buy guavas (*Psidium guajava*) as they are considered as fruits for children, not for adults, and eating too much of them could result in stomach problems. In addition, women FGD participants stated that *'When highly available, it is not easy to sell guavas as there is no market for them since they are considered as fruits for everyone. Even when they are stolen on farms, we don't worry as we regard them as 'free fruits' which don't belong to anyone.'*

Different types of common beans (*Phaseolus vulgaris*) were perceived differently by the respondents. For one of the common beans highly available between May and July, men FGD participants were of the opinion that *'although it is a high yielding type, 'ndombolo' common bean type has a low market demand for two reasons: firstly, its black colour makes rice dishes turn from white to black. Secondly, it causes stomach upsets'*. Yet another high-yielding common bean type highly available in May and June was poorly perceived, with women FGD participants stating that *'even if 'bucas' is a high-yielding common bean type, it is tasteless'*. Conversely, two other common bean

types ('okuodo' and 'rosebella') were considered to have a sweet taste while a third type ('wairimu') was perceived by women FGD participants as *'good for health as it increases blood flow and it is also used in preparing flour for use by children'*. Despite soy beans (*Glycine max*) being highly available in June, women FGD participants suggested that they were less liked as they are tough to chew.

Among animal source foods, all the respondents reported that fish and cow meat were unavailable on-farm and instead sourced from markets year-round, when required. When highly available, chicken meat was considered more valuable than beef, mainly because it was also used for traditional purposes, such as payment of bride price. Despite that duck meat could serve as an alternative meat source, men FGD participants reported that *'although ducks reproduce at a faster rate and they have good meat, traditionally they are considered as dirty animals, as they mostly feed on left-overs and in turn also spoil our farm crops'*.

#### **6.4.4 Preferences for different farming systems**

An understanding of the various incentives and disincentives for maintaining different farming systems was sought during the Focus Group Discussions (FGDs) and in the farm survey. Although 97 per cent of the surveyed smallholder farming preferred to have had diversified farms, the two main reasons for their farms not being as diversified were the high cost of inputs (67%) and land scarcity (53%). The high cost of inputs was also the main disincentive for maintaining agrobiodiverse farms for both men and women FGD participants. The main motivation factors for agrobiodiverse farms were that it served as a source of household food security and income, among women and

men FGD participants, respectively. With regard to specialised farms, men FGD participants perceived that such farms required less labour and management. In addition to this, they generally preferred growing cash crops but the prevailing poor market prices for crops would be their main disincentive for maintaining specialised farms. Among women FGD participants, inasmuch as specialised farms would serve as a source of income, maintaining a low diversity of crops was likely to result in household food insecurity, as well as the temporary use of lump sum money associated with sale of cash crops.

## **6.5 Discussion**

### **6.5.1 Availability and accessibility of nutrients in different seasons**

In this study, increase in seasonal on-farm species richness was accompanied by a rise in functional diversity, a similar trend observed in other studies on Western Kenya smallholder farms (DeClerck *et al.*, 2011; Remans *et al.*, 2011), suggesting that species richness and functional diversity are interconnected (Cadotte *et al.*, 2011). Despite the seasonal variation in species numbers in both the farms and markets, availability of the seven nutrients remained constant. The constant nutrient functional diversity could be because sites, for example, farms, with low species numbers can still have high functional diversity if the crops are diverse enough to cover the different nutrient traits (DeClerck *et al.*, 2011; Remans *et al.*, 2011), and the converse is also true. During different seasons, the dendrograms also show that multiple foods offer one nutrient, implying that food species missing during one season can be replaced by other foods offering similar nutrients in a different season. While simply adding more species may have little effect on adding functional traits to the community due to functional

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

redundancy (Jackson *et al.*, 2007), these additional species are likely to replace those affected by the changing climate, maintaining functional diversity and resilience of farming systems (DeClerck *et al.*, 2011).

While seasonal nutrient availability remained constant, farms were especially effective in readily availing four of the nutrients (proteins, Vitamin A, folic acid and iron) during both seasons, as the market accessibility of these four nutrients varied. Farms were also essential in provision of zinc, a micronutrient with low accessibility in the markets during both seasons. With the main zinc sources in this study as some of the legumes and animal source foods, zinc from both sources was least accessible during both seasons in the markets. In the farms, there was low consumption of animal source foods, as the available domestic animals were either sold or kept as assets. Similar findings on non-home consumption of animal source foods have also been reported in other low-income countries (Allen, 2006; Dror and Allen, 2011). Despite the non-home consumption of animal source foods, some of the readily available legumes provided an alternative zinc-rich food source for home consumption. Markets were good at provision of a selection of food species rich in carbohydrates and Vitamin C, with medium to high levels of accessibility during both seasons. However, these nutrients were also available in farms. Hence, both farms and markets could play overlapping roles in maintaining accessibility of all the nutrients during the different seasons. Though some food species offer more than one nutrient, there is no food species that offers all the seven nutrients in sufficient quantities, suggesting the need for a diverse diet to meet the nutrient needs in the different seasons. Several studies support that a

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

diverse diet, that is preferably based on locally available foods, is needed to meet nutritional needs in low-income settings (Frison *et al.*, 2006; Fanzo *et al.*, 2011).

While even more than these seven nutrients are needed for a balanced diet, the amounts of these nutrients are highly important (Darmon *et al.*, 2005), with adequacy likely to be reached with increased dietary diversity (Foote *et al.*, 2004) based on increased agricultural diversity, especially for low-income countries (Remans *et al.*, 2014). Beyond nutrients, there are also other numerous health-promoting bioactive substances, which make a diverse diet even more important (Kris-Etherton *et al.*, 2004; Biesalski *et al.*, 2009). As an agrobiodiversity indicator, the functional diversity approach remains a robust explanatory tool (Cadotte *et al.*, 2011) in visualising nutrient availability trends, not only in farms but also in markets. For the latter, we have demonstrated its application for use as an indicator of market food affordability (Herforth *et al.*, 2014) by bringing into focus food price and income levels in determining access levels (Remans *et al.*, 2014). Integration of both seasonal farm and market agrobiodiversity is a step towards making holistic and clear agriculture-nutrition linkages, especially as there still is limited evidence on how agriculture contributes to nutrition (Remans *et al.*, 2014).

#### **6.5.2 Food shortage months coincide with low preference for a diversity of local foods**

Factors not directly related to nutrients may have contributed to poor consumption of a diversity of local foods. The coinciding of hunger months with a lack of maize in Western Kenya was also reported by Djurfeldt (2012). As in most of Africa, maize is considered the most important crop in Kenya (Djurfeldt and Wambugu, 2011) and is the

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

most common food crop grown by the rural poor households (Mwololo, 2010) since its transition to a staple crop during World War 1 (Smale *et al.*, 2006), replacing traditional millet and sorghum varieties (Collier, 2010). With small farm sizes coupled with living in densely-populated areas, a majority of the smallholder farming households are unable to achieve year-round maize self-sufficiency and hence they are bound to be net maize buyers (Kirimi *et al.*, 2011). In this study, the hunger months start to peak between April and June. These three months are also part of the cropping season, with farmers mainly planting and pruning their crops. April is a difficult month for the majority of smallholder farming households as schools have closed and there are extra people to feed (Djurfeldt, 2012). The dwindling of maize supplies further coincides with annual peak maize prices in May and June (Kirimi *et al.*, 2011). During these months, it is likely that smallholder farmers with diminishing on-farm maize supplies are also most likely unable to purchase maize at their highest price. With over 90 per cent of the Kenyan population depending on maize as the staple crop (Mwololo, 2010), it is likely that households equate these months, characterised by low maize on-farm availability and market accessibility, to hunger months.

During these maize shortage months, a diversity of other local foods is available in variable amounts but the low preference for these alternative foods accounts for their under-consumption. This finding is backed up by a study in Ethiopia characterised by year-round availability and accessibility of wild fruits, which further overlaps with times of acute food and nutrition insecurity. Despite this, there is low fruit utilisation as a result of the peoples' cereal-based dietary habits and their cultural perception (Fentahun and Hager, 2009). Similarly, in south-west Uganda, only in times of food

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

scarcity are some indigenous vegetables used, and their use is limited to a relish (Musinguzi *et al.*, 2006). Maize dominant production systems have also led to a shift from the more diverse pre-colonial farming systems characterised by a diversity of traditional foods which are better adapted to the local conditions (Collier, 2010), enabling food and nutrition security to be achieved in the face of changing climate. This recent change in farming systems also suggests that diets do evolve over time and they can also further change towards more diversity.

In addition to poor perceptions of locally available foods, other probable factors for low appreciation of a diversity of local foods in this study could include poor knowledge of the importance of the different nutrients, coupled with low education levels of the mothers, who were the main caregivers. In this study, although the mothers provided their infants with the minimum dietary diversity, this could be because they are considered as fragile hence the need to take keen care of their dietary needs during the pre-weaning stage (0-5 months) (Matanda *et al.*, 2014), but this does not necessarily happen thereafter when early weaning introduces children to nutrient-poor cereal-based foods, mainly porridge devoid of milk and bulky solid foods which are difficult for the child's developing gut to digest (Bwibo and Neumann, 2003; Matanda *et al.*, 2014). The education level and nutritional knowledge may in turn influence the main decision maker on the use of the different foods. In this study, most of the decisions regarding foods (those purchased, the use of harvested plants and animal source foods) are shared. The main decision maker on the use of animal source foods, one of the main sources of zinc, was the household head's spouse and probably with knowledge of the importance of the nutrient, they would be more empowered to make better food decisions.

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

However, increased knowledge of caregivers in isolation does not necessarily translate to nutrition behaviour change (Waswa *et al.*, 2015). Even if better nutritional knowledge may not result in better informed dietary choices, it may still be helpful in benefitting from the unappreciated alternative foods, if there could be possibilities for smallholder farming households to sell them and the money generated used to purchase staple foods (such as maize) as well as to improve their overall livelihoods.

One approach that is likely to increase the existing on-farm diversity is to tackle disincentives for maintaining diversified farms. As the extent of on-farm diversity is ultimately determined by farmers' decisions, it's necessary to understand their motivations and demotivations. This study suggests that there needs to be a balanced understanding of motivations for both women and men farmers, as this study shows that use of harvested foods is either a shared or household-head only decision making process. Views of both men and women smallholder farmers in this study suggest the main avenues for increased high on-farm agrobiodiversity to be provision of opportunities for agrobiodiversity to serve as a source of food security and income, as well as measures tailored to meet high input costs. While the relative cost of basic inputs such as water may be comparable in both diversified and monoculture systems, the cost of fertilisers and insecticides is likely to be lower in diversified farms (Jackson *et al.*, 2007), with such farms likely to concomitantly reduce the impacts of pests and diseases while increasing soil fertility (Frison *et al.*, 2011). In a case study in rural Thailand, farmers with diversified farms spent less money on fertilisers and pesticides as compared to those with monoculture farms, who required stronger incentives to practise agrobiodiversity (Maneevitak, 2007). In this study, a lingering but less

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

explicitly expressed concern during the FGDs was that diversified farming systems are likely to reduce allocated space for the main crop, as well as possible negative inter-crop interactions, where both could lead to lower crop yields. While diversified systems are more likely to reduce crop damaging effects than simplified production systems, increased diversity also does reduce densities of the main crop, which may in turn affect quantities of harvested produce (Letourneau *et al.*, 2011). The likely interference with existing crop yields is likely to hinder risk-averse smallholder farmers from diversifying their farms. Furthermore, farmers are more likely to adopt agrobiodiversity practices if their adoption offers them personal, rather than societal, benefits (Jackson *et al.*, 2007).

There are various categories of motivations, ranging from direct incentives (that reduce investment costs, such as lowering input costs, providing cost-sharing and price guarantee arrangements) to indirect enabling incentives (that influence a farmer's decision to adopt agrobiodiversity, such as market development, producer support services, accessibility and availability of basic inputs) (Enters *et al.*, 2004). Different forms of direct incentives that have been implemented have had limited to no impact on increased on-farm agrobiodiversity, especially among the most vulnerable smallholder farmers. Although market price guarantees of maize for smallholder farmers in Zambia has not interfered with overall crop diversity (but it has led to a decrease in the share of land dedicated to these crops), the incentive has benefitted wealthier smallholder farmers rather than poorer ones (Mason *et al.*, 2015). While the farm input subsidy programme in central and southern Malawi led to increased production of maize and tobacco, the two crops for which fertiliser, seed and pesticide costs are subsidised, it also resulted in simplified farming systems (Chibwana *et al.*, 2012). Implementation of

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

these programmes have proved unsuccessful in multiple ways in other African countries (Jayne and Rashid, 2013; Ricker-Gilbert *et al.*, 2013), recommending that a shift to supporting indirect enabling incentives, for example, infrastructure and research and development, could yield higher returns on the financial investments (Jayne and Rashid, 2013). There was a preference for indirect enabling incentives (such as market development and provision of extension services) if diverse farming systems of vegetable-agroforestry in Vietnam (Catacutan and Duque-Pinon, 2009) and conservation agriculture with trees in Eastern Kenya (Ng'endo *et al.*, 2013) were to be adopted by these smallholder farmers. Therefore, selection of indirect enabling incentives is likely to catalyse adoption of agrobiodiversity to serve as both a food security and income source among poor smallholder farmers.

#### **6.6 Conclusions**

This study shows that locally available on-farm and market food species meet existing macro-and micro-nutrients needs in different seasons, suggesting a link between agricultural and nutrient diversity. In the markets, there are varying seasonal accessibility levels for most of the available food species, which may influence households to strive for on-farm food sufficiency when market food prices are high. Despite the rich diversity of foods offering diverse nutrients on-farm, there is a general low appreciation for most of this diversity, as food shortage months coincided with a lack of maize, the main cereal in the study area, yet during this same period other starchy foods were available that could replace the maize while in addition a diversity of other food groups were present to contribute to a diverse diet. The low food perception and nutritional knowledge suggest that, in order to achieve sustainable food and

### Paper 3: Contribution of nutritional diversity and food perceptions to food and nutrition security

nutrition security, agricultural interventions need to also take into consideration such factors that are not directly related to nutrients. It is likely that increased awareness creation and nutritional education on the importance of the local foods in meeting dietary needs may increase value for these local foods so that even if they are not necessarily preferred by households, they could be bought by consumers in rural or urban areas who are informed on their nutritional benefits. Hence, by also creating opportunities for smallholder farmers to sell their produce in markets, the incomes raised could contribute to meeting high input costs, as well as having extra money to buy other produce in markets that is available year-round but at different accessibility levels. This, in turn, is likely to contribute to year-round food and nutrition security among smallholder farmers in Western Kenya and beyond.

#### **6.7 Acknowledgments**

We are grateful to all the farmers, local administration and contact persons who participated in this study. Many thanks to Dr. Patricia Daley (University of Oxford, UK) for the insightful discussions and invaluable comments on earlier drafts of the manuscript. We would also like to thank Dr. Roseline Remans (Bioversity International - Ethiopia) for providing the R Script utilised in the functional diversity analyses, and to Balqis Mohamed Rehan, Julia Wagemann and Takeshi Inagawa for assistance with debugging, running and explaining the R script. Our sincere gratitude also goes to the Federal Ministry for Economic Cooperation and Development (BMZ), Germany for funding this study, implemented by Bioversity International, Regional Office for sub-Saharan Africa, Nairobi, Kenya.

## **7 Paper 4: Challenges and opportunities for market integration to improve food security: A case study of smallholder farming households in Western Kenya**

This chapter is based on the following paper submitted to the *Journal of Rural Studies*:

Ng'endo, M., Bhagwat, S. and Keding, G.B. Challenges and opportunities for market integration to improve food security: a case study of smallholder farming households in Western Kenya.

This chapter picks up from Paper 3 and shows that the preferred food groups purchased from markets are cereals, animal source foods and fruits, during September/October 2012 and November/December 2012 time-points. Economic access to these preferred foods can be enhanced by (i) selling diverse local foods of high nutritional value but low desirability (as shown in Paper 3) (ii) selling products uniquely available through on-farm production but missing in local markets thus filling in the market gaps, and (iii) improving smallholder farmers' access to formal markets in general and to market traders in particular by organising smallholder farmers to fill in these local market gaps and to add value to surplus perishable produce. However, there still remains a need to stimulate the demand of most of these local produce, so that even if these foods are not necessarily preferred by rural households in one locality, they could still be sold in other rural and urban markets. As the last empirical chapter of the thesis, this paper also connects back to Paper 1 by showing that smallholder farming households utilise not

only markets, but also working social networks and on-farm production for continuous food supply.

### **7.1 Abstract**

African smallholder farmers produce food both for home consumption and commercial purposes, but these farmers are often net food buyers in local markets. To what extent do markets play a role in making food available and accessible throughout the year? This study assessed: (1) the role of markets in access to food at household level, and (2) the extent of smallholder farmers' involvement in market trading networks. All plant and animal species grown or reared for food were inventoried on 30 smallholder farms in six villages of Mumias and Vihiga districts, Western Kenya. A survey of available food products was conducted in three markets in Mumias and four markets in Vihiga near the surveyed farms. The market was the main source for cereals in both districts, while in Mumias district, fruits and animal source foods were also mainly sourced from markets. Regarding market trading systems, 15 per cent of the 48 food products were sold by the farmers, 10 per cent were sold by small scale traders, while 75 per cent were sold by large scale traders. The study shows that local markets are mainly utilised by market traders who bring produce from outside the study areas. To increase incomes to enable access to diversified foods, organised smallholder farmers can be integrated better in the local market system, in two key ways: (1) by tapping into increasing market demand for 'niche' products uniquely available through on-farm production; and (2) by value addition of farm produce lost at post-harvest to increase year-round availability of diversified foods.

*Key words:* food security, market, market integration, rural Kenya, smallholder farmer

## **7.2 Introduction**

Unlike in the developed countries where close to 15 per cent of total income is devoted to food (Regmi and Meade, 2013), spending on food represents 50 to 80 per cent of developing country consumers' budgets (Smale *et al.*, 2009). The population of Eastern and Southern Africa is predominantly rural (Barrett, 2008), with 60 to 80 per cent of the rural households, including a large proportion of smallholder farmers growing food crops, as net food buyers of the same crops they grow (Barrett, 2008; Mehra and Rojas, 2008; Smale *et al.*, 2009). This is mainly because they are unable to meet the subsistence needs of their families through their own production and must purchase the remainder, usually at higher prices (Smale *et al.*, 2009; Smale *et al.*, 2012). Due to dependence of rural households on market purchase for food supply, in some cases making up to 90 per cent of all the food consumed (Baiphethi and Jacobs, 2009), markets play a crucial role in achievement of household food security. With the scarce cash directed towards meeting staple food needs first in rural markets (Smale *et al.*, 2009; Thorne-Lyman *et al.*, 2009), household food transfers (Baiphethi and Jacobs, 2009) and subsistence production (Aliber and Hart, 2009; Baiphethi and Jacobs, 2009) enhance accessibility to affordable foods.

While the majority of smallholder farmers prioritise subsistence production as a household food security strategy, agricultural production that raises household incomes is critical to guarantee longer-term food security and improve their well-being (Mehra and Rojas, 2008). To guarantee both household food consumption needs and market

demand, surplus agricultural output needs to be generated (Omiti *et al.*, 2009). Surplus smallholder farmers comprise of 20 to 30 per cent of rural households while an additional 10 to 15 per cent of rural households are net deficit producers who nevertheless sell a proportion of their crop soon after harvest (Poulton *et al.*, 2006b), when prices are at their lowest. Crop sales by poor households occur straight after harvest because they are desperate for cash, hence these ‘distress sales’ are driven by short term survival needs (Leavy and Poulton, 2007) rather than a longer term focus on farming as a business enterprise.

For smallholder farmers selling their produce in formal markets, there are many steps in the value chain to take the product from producer to consumer (KIT and IIRR, 2008). Smallholder farmers who are unable to supply directly to wholesale or retail markets sell their produce to spot market traders (Rao and Qaim, 2010; Wiggins, 2012), who act as market intermediaries. Travelling traders, who include many part-time traders who spend most of their time farming, meet the farmer at his farm to collect and pay for the produce in cash. Until the trader sells the produce to someone else, he must bear all costs and any unpredictable losses that may occur while the produce is under his ownership (KIT and IIRR, 2008). Although traders specialise in marketing the produce (Collier and Dercon, 2014), the majority of smallholder farmers regard them as ‘middlemen’ who gain profits for themselves along the value chain, while paying farmers poor prices for their produce (Wiggins, 2012). With this suspicion, co-operation between smallholder farmers and traders is relatively under-developed and this could be closely related to lack of market access for smallholder farmers (KIT and IIRR, 2008). Lack of formal market access is also associated with poor infrastructure together with

long distances to markets and poor access to information on prevailing market produce prices (Delgado, 1999; Leavy and Poulton, 2007; Alene *et al.*, 2008). These poor conditions translate to high exchange costs which are usually too high for smallholder farmers to enable many transactions to take place (Delgado, 1999; Alene *et al.*, 2008). Households have different abilities to mitigate these market transaction costs, resulting in differential market participation among smallholder farmers (Alene *et al.*, 2008), with a majority of the farmers in low-income rural areas opting out of markets (Barrett, 2008) as market product sellers.

Though it is acknowledged that in cases when smallholders engage in markets, they only trade in small volumes, there exists a knowledge gap on the extent of smallholder farmer involvement in market trading networks, especially in regions with good market access. Secondly, although on-farm food production is insufficient to meet smallholder farming household food needs and markets are important for sourcing foods mainly staple food grains (Jayne *et al.*, 2006), there exists a knowledge gap on the diversity and amounts of other food groups sourced from markets, in addition to other food channels. To address these two knowledge gaps, this study addresses two research questions:

1. What is the role of markets in access to food at household level among smallholder farmers?
2. To what extent are smallholder farmers integrated into the market trading networks for selling their produce in regions with good market access?

## 7.3 Methodology

### 7.3.1 Study area and data collection

Primary market data were collected in September and October 2012, while farm data were collected both between September/October 2012 and November/December 2012 in Mumias and Vihiga districts in Western Kenya. Mumias and Vihiga districts mainly represent the humid Lower Midland (LM1) and Upper Midland (UM1) agro-ecological zones, respectively (Jaetzold *et al.*, 2005). The selection of Mumias and Vihiga districts as study sites was with an aim to represent different agro-ecological zones, and thus most likely a different level of agrobiodiversity, with an added advantage of geographical closeness to each other and both regions being close to local markets.

**Table 7.1** shows details on geographical, climatic and agricultural characteristics of the two districts.

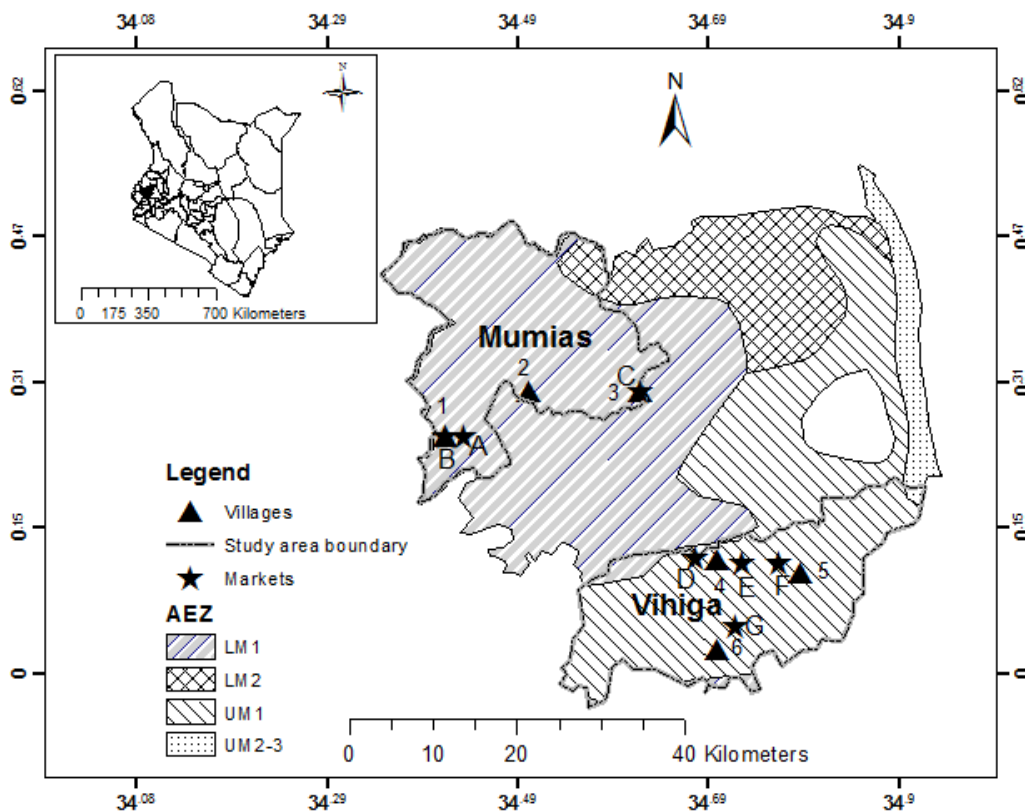
**Table 7.1:** Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya (Source : Jaetzold *et al.* (2005))

Characteristic	Mumias District	Vihiga District
AEZ	Lower Midland (LM1)	Upper Midland (UM1)
Altitude	1300- 1500 metres above sea level	1500-1900 metres above sea level
Annual mean temperature	21.0- 22.2 °C	18.5- 21.0°C
Total annual rainfall	1650-1850 mm	1800-above 2000 mm
Rainfall pattern	bimodal with long rains from end of February to end of March and short rains from end of July to November/December.	bimodal with long rains from end of February to end of March and short rains from mid July to November/December
Soil types	Ferrasols	combination of cambisols and lithosols
Main crops	Cash crops: sugarcane Food crops: sorghum, cassava, sweet potatoes	Cash crops: tea, coffee, sugarcane Food crops: maize, beans, cowpeas

The present study was conducted in tandem with a larger, cross-sectional research project entitled ‘Improving nutrition through local agrobiodiversity’. The present study

purposefully selected six villages in order to cover the above mentioned different climatic zones, three villages in Mumias and three in Vihiga districts, out of 30 villages from the larger study. The latter were sampled according to district village lists with number of households per village applying a 'probability-proportional-to-size' approach (Magnani, 1997), with larger villages given a greater chance of selection than smaller villages. A total of 30 households, 15 in Mumias and 15 in Vihiga districts, in the six villages (five households per village) were then randomly selected to represent 10 per cent of the 300 households sampled by the larger study. In both September/October 2012 and November/December 2012, the same smallholder farming households were surveyed.

Smallholder farmers participated in the selection of major local markets near the surveyed farms in Mumias and Vihiga districts. Seven major local open-air markets, three in Mumias and four in Vihiga districts, were surveyed on seven non-consecutive market days. Simple random sampling was adopted to select market traders to be interviewed (Abukutsa-Onyango, 2002) in all the different market stands with an aim of sampling the whole market. With this, at least 10 per cent of market stands representing each food group were randomly sampled for the market trader interviews. In cases where the market trader randomly selected was unavailable to answer the questions, a different market trader representing the same stand was purposefully sampled (Abukutsa-Onyango and Onyango, 2005). A total of 65 market traders representing 65 different stands were interviewed. **Figure 7.1** shows a map of the two study areas, indicating the six villages and seven markets where the survey was carried out.



**Figure 7.1:** Map of study area in Western Kenya (dark shade in the inserted map), with Mumias and Vihiga district categorised as humid Lower Midland (LM1) and humid Upper Midland (UM1) agro-ecological zones, respectively. The village (triangle symbols) codes are: 1=Khushipari A, 2= Emahanga , 3= Busokho, 4= Hombala, 5= Wambenge, 6= Lodondo. The market (star symbols) codes are: A= Buhuru, B= Mumias, C= Makunga, D= Kilingili, E=Mudete , F= Chavakali, G= Majengo

All present food plant and livestock species were inventoried per farm by recording species names and counting individuals of each species. On each farm, the household head or his/her representative was interviewed using a semi-structured questionnaire to collect data on: (1) basic demographic and socio-economic household characteristics, (2) names, production, and uses of food plant and livestock species produced on the farm, (3) products of plant and livestock species consumed by households. In addition, during November/ December 2012, respondents reported the source of the foods that they consumed within the household for the last five times. This time span ranged from

the last 24 hours to the last few months, depending on the food items. During the November/December 2012 survey, farmers also reported specific walking distance approximations to the nearest market and the frequency of nearest market visits in a month. The market survey was utilised to capture market food biodiversity available for purchase by smallholder farmers and sources of the market produce. A semi-structured questionnaire was utilised to collect market data, in September and October 2012, on: (1) edible food species available (2) sources of produce (3) prices of different foods, and (4) seasonal availability of these foods.

### **7.3.2 Data analysis**

All present on-farm and market food plant species were assigned to one out of the seven major FAO-defined (2011) food plant groups, according to statements on their main use. Simple descriptive statistics such as means, frequency counts and percentages were computed to characterise farms and markets according to species richness and abundance, as well as the proportions of market produce sold by different types of market traders.

There were species identification challenges in the local markets when identifying leaves of the following local vegetables: (1) *Amaranthus cruentus subspecies hybridus* and *Amaranthus hybridus complex* (collectively classified as *Amaranthus* species) (2) *Corchorus acutangulus*, *Corchorus olitorius*, *Corchorus trilocularis* and *Corchorus tridens* (collectively classified as *Corchorus* species) (3) *Cucurbita maxima* and *Cucurbita moschata* (collectively classified as *Cucurbita* species) (4) *Solanum villosum*, *Solanum scabrum* and *Solanum americanum* (collectively classified as *Solanum*

species) (5) *Crotalaria ochroleuca* (classified as *Crotalaria* species). Although it was possible to obtain specimens of some unidentified plants for proper identification, plant identification at the species level was in some cases still challenging, especially with the different *Amaranthus* species. In most cases, however, it was possible to identify species while conducting the farm survey, where higher diversity among these species was documented (Maundu *et al.*, 1999). For the sake of consistency and comparability of market and farm species, all the above mentioned species were taxonomically classified in one of the five respective groups.

## **7.4 Results**

### **7.4.1 Profile of the local markets and market traders**

The seven open-air markets have at least one market trading day. There are two daily markets (Makunga and Majengo markets), one biweekly market (Mumias market) and four weekly markets (Buhuru, Mudete, Kilingili and Chavakali markets). Four of the seven markets (Chavakali, Majengo and Mudete markets in Vihiga district and Mumias market in Mumias district) are municipal council markets, centrally located in rural town centres where local administrative offices are based while the others are rural markets (**Table 7.2**). Trading in all the seven local markets is subject to daily market trading fees and taxes, ranging from USD 0.3 to USD 1, mainly depending on the quantity of produce to be traded. Buhuru rural market in Mumias district had the highest number of different produce (30) mainly because it is a mixed market trading in live animals, animal source foods and a variety of farm produce (**Table 7.2**).

Paper 4: Challenges and opportunities for market integration to improve food security

**Table 7.2:** Frequency of products in seven markets in Mumias and Vihiga districts, Western Kenya, in September/ October 2012

Food group	Frequency of food products in Mumias markets						Frequency of food products in Vihiga markets								Overall frequencies
	Buhuru Rural		Mumias Municipal		Makunga Rural		Mudete Municipal		Majengo Municipal		Kilingili Rural		Chavakali Municipal		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%
Animal source foods	7	23	1	4	3	13	3	11	3	11	3	12	3	11	12
Cereals	3	10	0	0	3	13	3	11	2	7	4	15	2	7	9
Fruits	3	10	6	25	3	13	3	11	2	7	3	12	6	22	14
Pulses/nuts/seeds	5	17	1	4	5	21	2	7	2	7	3	12	2	7	11
Starchy roots/ tubers/green bananas	2	7	1	4	2	8	2	7	2	7	3	12	2	7	8
Vegetables	10	33	15	63	8	33	12	44	14	50	7	27	10	37	41
Spices/ condiments	0	0	0	0	0	0	2	7	3	11	3	12	2	7	5
Total produce	30	100	24	100	24	100	27	100	28	100	26	100	27	100	100

#### Paper 4: Challenges and opportunities for market integration to improve food security

All the seven markets in the two districts are readily accessible by tarmac roads, except Buhuru rural market which is accessible by gravel road. This makes it inaccessible during wet weather due to the slippery nature of the road, yet it had the highest number of different types of produce out of the seven markets surveyed. In Mumias district, the average walking distance to the nearest market is 37 minutes, with an average of ten market visits per month for each household. In Vihiga district, it takes an average of 32 minutes to walk to the nearest market, with an average of eight market visits per month per household.

Out of the 65 market traders interviewed, 40 per cent and 60 per cent were male and female traders, respectively. A majority (97%) of the female traders, with an average age of 39 years, were owners of the stands while 62 per cent of the male traders, with an average age of 32 years, owned the stands. Both female and male traders had been in the market trading business for an average of at least ten years. Slightly more than half of the female traders (51%) and 31 per cent of male traders sold a diversity of different produce on one stand, ranging from two to seven different food groups. Vegetables, followed by fruits, were the most popular combinations in the mixed market stands. The rest of the market traders specialised in particular market products, mainly selling animal source foods. Among female traders, chicken-only and fish-only stands were most popular while among male traders, cattle-only stands were the most popular. Sixty different plant and animal species were documented on the surveyed farms (Appendix I, Species List 7.1) while 48 different food products were available in the local markets (Appendix I, Species List 7.1).

Paper 4: Challenges and opportunities for market integration to improve food security

There was an overlap of 58 per cent of on-farm products that were also available in the markets (**Table 7.3**). ‘Niche’ products unavailable in the local markets but uniquely available through on-farm production comprised of one animal source food, 12 fruits, three pulses/nuts/seeds, three starchy roots/tubers/green bananas and three vegetables (**Table 7.3**).

**Table 7.3:** Overlaps and gaps in products available in seven markets and on 30 farms in Western Kenya, between September and October 2012

Food group	Overlaps in products available in markets and farms	Products available only in markets or farms	
		Market-only products	Farm-only ('niche') products
<b>Animal source foods</b>			
	Cattle	Fish	Rabbit
	Chicken		
	Goat		
	Sheep		
	Pig		
<b>Cereals</b>			
	<i>Sorghum bicolor</i>	<i>Eleusine coracana</i>	
	<i>Zea mays</i>	<i>Oryza sativa</i>	
		<i>Triticum aestivum</i>	
<b>Fruits</b>			
	<i>Ananas comosus</i>	<i>Citrullus lanatus</i>	<i>Annona muricata</i>
	<i>Citrus limon</i>	<i>Citrullus sinensis</i>	<i>Carica papaya</i>
	<i>Mangifera indica</i>		<i>Dovyalis caffra</i>
	<i>Musa sapientum</i>		<i>Eriobotrya japonica</i>
	<i>Persea americana</i>		<i>Morus alba</i>
			<i>Passiflora</i> species
			<i>Passiflora edulis</i>
			<i>Physalis peruviana</i>
			<i>Psidium guajava</i>
			<i>Solanum betaceum</i>
			<i>Syzygium cuminii</i>
			<i>Vitex doniana</i>
<b>Pulses/nuts/seeds</b>			
	<i>Arachis hypogaea</i>		<i>Cajanus cajan</i>
	<i>Glycine max</i>		<i>Lens culinaris</i>
	<i>Phaseolus vulgaris</i>		<i>Vigna subterranea</i>
	<i>Sesamum indicum</i>		
	<i>Vigna radiata</i>		
<b>Spices/condiments</b>			
	<i>Capsicum annum</i>	<i>Allium sativum</i>	<i>Camellia sinensis</i> (sold in other markets)
		<i>Coriandrum sativum</i>	<i>Coffea arabica</i> (sold in other markets)
		<i>Zinziger officinale</i>	

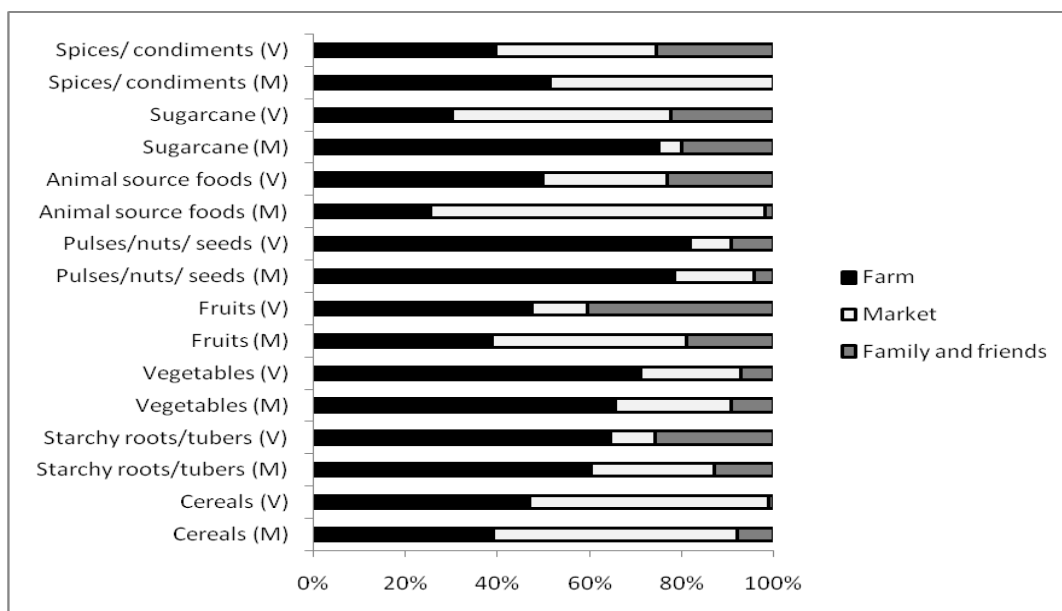
Food group	Overlaps in products available in markets and farms	Products available only in markets or farms	
		Market-only products	Farm-only ('niche') products
<b>Starchy roots/tubers/green bananas</b>			
	<i>Ipomoea batatas</i>		<i>Colocasia esculenta</i>
	<i>Manihot esculenta</i>		<i>Dioscorea bulbifera</i>
	<i>Solanum tuberosum</i>		<i>Musa paradisiaca</i>
<b>Vegetables</b>			
	<i>Allium cepa</i>	<i>Brassica oleracea</i> <i>var. capitata</i>	<i>Cleome hirta</i>
	<i>Allium fistulosum</i>	<i>Spinacia oleracea</i>	<i>Basella alba</i>
	<i>Amaranthus</i> species		<i>Erythrococca bongensis</i>
	<i>Brassica carinata</i>		
	<i>Brassica oleracea var. acephala</i>		
	<i>Cleome gynandra</i>		
	<i>Corchorus</i> species		
	<i>Crotalaria</i> species		
	<i>Cucurbita</i> species		
	<i>Daucus carota</i>		
	<i>Solanum lycopersicum</i>		
	<i>Solanum melongena</i>		
	<i>Solanum</i> species		
	<i>Vigna unguiculata</i>		
<b>High-sugar foods</b>			
			<i>Saccharum officinarum</i> (sold in other markets)

#### 7.4.2 Main foods available in markets and for household food consumption

The different food types available in all the markets and farms were grouped into eight of the major FAO-defined (2011) food groups, namely (i) cereals (ii) fruits (iii) pulses/nuts/seeds (iv) starchy roots/tubers/green bananas (v) vegetables (vi) spices/condiments (vii) animal source foods, and (viii) high-sugar foods. In the context of this study, the high-sugar food refers to sugarcane (*Saccharum officinarum*), found on farms but not in the local markets surveyed. During September/ October 2012 market survey, vegetables had the highest availability in all the markets, with a frequency of 41 per cent, followed by fruits (14%), animal source foods (12%), pulses/nuts/seeds (11%), cereals (9%), starchy roots/tubers/green bananas (8%), and spices/condiments (5%), respectively (**Table 7.2**). The vegetable food products available in all the markets were bulb onions (*Allium cepa*), white cabbages (*Brassica oleracea var. capitata*), African

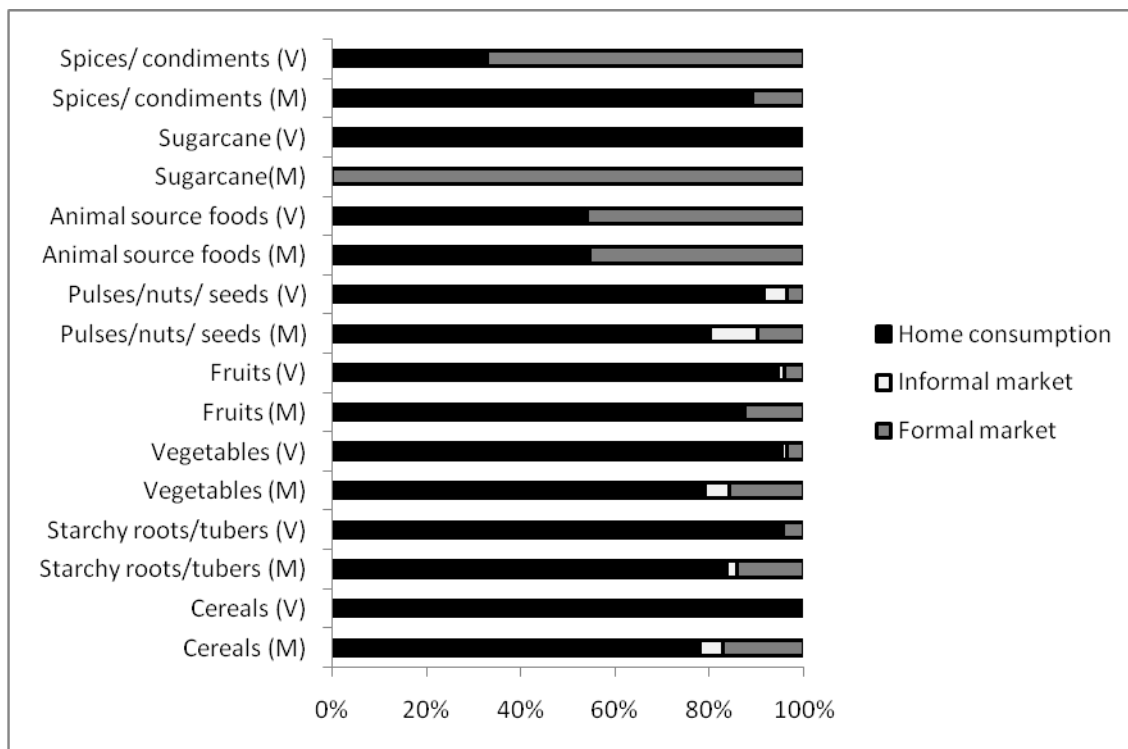
kale (*Brassica oleracea var. acephala*) and tomatoes (*Solanum lycopersicum*). *Amaranthus* species, *Solanum* species and cowpea leaves (*Vigna unguiculata*) were available in six out of the seven markets.

Markets also play a role in contributing to household food consumption of smallholder farmers throughout the year. During the last five times a certain food group had been consumed at the household level, the market was the main food source for cereals in both Mumias and Vihiga districts while in Mumias district, fruits and animal source foods were also mainly sourced from markets. In Vihiga district, a considerable proportion of fruits, animal source foods, starchy roots/tubers/green bananas and spices/condiments were sourced from family and friends. In both districts, the four key main food groups sourced from farms were vegetables, spices/condiments, pulses/nuts/seeds, and starchy roots/tubers/green bananas (**Figure 7.2**).



**Figure 7.2:** Food sources for the different food groups given as the last five consumptions among households in Mumias (M) and Vihiga (V) districts between November and December 2012, N=30 (15 per district)

On-farm food production by smallholder farmers is mainly for home consumption, though some proportion is also utilised for commercial purposes. This is through both formal and informal market channels (**Figure 7.3**), with the latter mainly through in-kind exchange within the community. Formal market channels are mainly utilised for selling cash crops, mainly tea (*Camellia sinensis*) in Vihiga district and sugarcane (*Saccharum officinarum*) in Mumias district, classified as spices/condiments and a high-sugar food, respectively. The proportion of pulses/nuts/seeds that are sold through in-kind exchange is equal or higher, as compared to those sold through formal market channels in Mumias and Vihiga districts, respectively (**Figure 7.3**).



**Figure 7.3:** Main food uses of on-farm products among households in Mumias (M) and Vihiga (V) districts between September and October 2012, N=30 (15 per district)

### 7.4.3 Pre- and post-harvest losses

Some of the on-farm produce for either home consumption or for selling in both formal and informal markets is lost through pre-and post-harvest losses. Between January and December 2012, 10 and 37 per cent of the smallholder farmers had experienced pre- and post-harvest food losses, respectively. Although negatively affecting a small proportion of smallholder farmers, these farmers mentioned that ‘hailstones’ are mainly responsible for pre-harvest food losses of a diversity of on-farm crops in Vihiga district, a more humid region. In both Vihiga and Mumias districts, post-harvest food losses are mainly due to poor markets for surplus fruits and vegetables, followed by poor storage conditions of cereals.

Between January and December 2012, the main foods lost were fruits and vegetables but also pulses and cereals. The key fruits affected were guavas (*Psidium guajava*), avocados (*Persea americana*) and mangoes (*Mangifera indica*). During high harvest seasons, the quantity of fruits is too much for household food consumption and they would sometimes be left to rot and birds would also eat and spoil the ripe fruits. This post-harvest loss is mainly because there is low market demand for seasonal fruits in high supply. One farmer reported that when fruits are available in high quantities, the market price for a 50-kilogram bag of avocados can be as low as USD 0.4. Within one month of high vegetable harvest, a different farmer experienced losses of cowpea leaves (*Vigna unguiculata*), African kale (*Brassica oleracea var. acephala*), Jew’s mallow (*Corchorus* species) and slender leaf (*Crotalaria* species), due to poor market prices as they were too much for both household and livestock consumption. The main cereal affected by post-harvest loss is maize, due to aflatoxin contamination as a result of

storage of the cereal in damp conditions. According to the farmers, a main cause of pre-harvest food loss in Vihiga district is excessively cold conditions that result in ‘hailstones’ that destroy on-farm crops. For example, between September and November 2012, a diversity of on-farm crops, including cowpea leaves (*Vigna unguiculata*), fruit bananas (*Musa sapientum*), avocados (*Persea americana*) and guavas (*Psidium guajava*), had been destroyed.

#### **7.4.4 Participation in local market trading system**

While the geographical and socio-cultural setting in formal markets is that of trading between smallholder farmers and interested buyers (whether known or unknown) in open-air markets, informal markets are characterised by in-kind exchange of farm produce by smallholder farming households (mainly to known buyers, such as family and friends) away from designated market places. Although smallholder farmers have surplus on-farm produce and engage mainly in informal market channels, their involvement in formal market channels is minimal. The only market produce smallholder farmers were directly selling were milk, *Amaranthus* species, African kale (*Brassica oleracea* var. *acephala*), sweet potatoes (*Ipomoea batatas*), avocados (*Persea americana*), groundnuts (*Arachis hypogaea*) and common beans (*Phaseolus vulgaris*), the latter three being a produce from only one smallholder farmer (who was selling his on-farm produce at the market). Fifteen per cent of the 48 food products were sold by smallholder farmers (who were also part-time market traders) and 10 per cent were sold by small scale/travelling traders (who directly sourced their products from local smallholder farmers), while 75 per cent of the products were sold by large scale traders/wholesalers, who did not directly source their products from smallholder farmers

Paper 4: Challenges and opportunities for market integration to improve food security

but rather sourced their products from small scale traders, large scale farmers from within the district, other districts and from neighbouring countries. The food groups ‘fruits’, ‘pulses/nuts/seeds’ and ‘starchy roots/tubers’ were mainly sourced from neighbouring countries such as Uganda (**Table 7.4**).

**Table 7.4:** Types of market traders and origin of products in the seven markets in Mumias and Vihiga districts, in September/October 2012

Food group	Type of market trader	Origin
Animal source foods	A,B	A Market trader’s farm
		B Within district, Other districts (Kakamega, Kisumu, Busia, Luanda, Lodwar, Nandi)
Cereals	B,C	B Within district, Other districts (Busia ,Kitale, Nandi, Eldoret, Busia, Kapsabet, Kisumu)
		C Someone’s farm
Fats and oils	B	B Within district
Fruits	A,B,C	A Mumias
		B Other districts (Kakamega, Kisumu, Bungoma, Siaya, Machakos and Kitui, Marakwet, Mombasa), neighbouring countries (Uganda, Tanzania)
		C Chavakali (Someone’s farm), Mumias (Someone’s farm)
Pulses/nuts/seeds	A,B	A Buhuru
		B Other districts (Busia, Kakamega, Kisumu, Luanda, Nairobi), neighbouring countries: Uganda
Spices/ condiments	B	B Within district (Mumias, Majengo), Other districts (Bungoma, Kakamega, Kisumu, Mombasa, Nairobi)
Starchy roots/tubers/green bananas	A,B	A Kisumu, Mumias
		B Within district (Chavakali, Majengo), Other districts (Busia, Bungoma, Kakamega, Mount Elgon area, Kiambu, Marakwet, Nairobi, South Nyanza, Timboroa), neighbouring country (Uganda)
Vegetables	A,B,C	A Mumias (market trader’s farm)
		B Within district (Mumias, Majengo, Makunga), Other districts (Kakamega, Kapsabet, Nandi, Mount Elgon area, Kisumu, Kitale, Luanda)

Food group	Type of market trader	Origin
		Mwea, Nairobi, Narok)
	C	Makunga (someone's farm), Kilingili (someone's farm)

A-smallholder farmer, B-large scale trader/wholesaler, C- small scale trader/travelling trader

## 7.5 Discussion

### 7.5.1 Smallholder farming households rely on multiple food sources

This study shows that smallholder farmers rely on farms, markets and existing social networks such as family and friends in meeting household food consumption needs. This finding corroborates with a study in Amhara region of Ethiopia where the three most common ways of food acquisition among rural households are on-farm production, purchase from markets and gifts, respectively (Negatu, 2004). There is a general consensus that rural households mainly access food through subsistence production, markets and household transfers (Baiphethi and Jacobs, 2009), yet, never through only one source.

### 7.5.2 On-farm production as a food source

In the study sites, smallholder farms are essential in meeting household food needs for a number of food groups which are also highly available in markets. While reducing reliance on markets for most household food consumption needs, these foods also affordably provide diverse nutritional value. The main strategy employed by the smallholder farmers to reduce unnecessary market visits is by consumption of alternative foods available through on-farm production, such as seasonally available fruits and starchy roots/tubers/green bananas. In this study, though oranges (*Citrus*

*sinensis*) were the most highly available fruits at the local markets, fruits that were highly consumed by smallholder farming households were guavas (*Psidium guajava*), mangoes (*Mangifera indica*), avocados (*Persea americana*) and fruit bananas (*Musa sapientum*). With regard to starchy roots/tubers/green bananas, though irish potatoes (*Solanum tuberosum*) were widely available in local markets, they were not consumed by smallholder farming households. In the two study sites, smallholder farmers plant and consume more than one variety of cassava (*Manihot esculenta*) and sweet potatoes (*Ipomoea batatas*). The popularity of sweet potatoes and cassava (*Manihot esculenta*) for home consumption could be a survival strategy to acquire a cheap source of starchy roots and tubers. This finding on the popularity of the three cassava varieties, ‘Migyera’ (MM95/0183), ‘SS4’ and MM96/1872 types, for on-farm production corroborates with a study conducted among a cassava consuming community in Nambale, Western Kenya, reiterating the popularity of ‘SS4’ and ‘Migyera’, with the latter as the most preferred variety for cooking (Nungo *et al.*, 2012).

Although vegetables were the most frequent in the local markets, smallholder farmers in both districts mainly relied on vegetables sourced from their farms during the November/December short rainy season. The high availability of vegetables in markets could be explained by a Western Kenya market study suggesting that market availability of a particular kind of vegetable is associated with its high demand (Ekesa *et al.*, 2009). Although smallholder farmers endeavoured to increase their vegetable self-sufficiency through farm production, adequate vegetable yields depend on many factors, including seasonality, implying that markets remain essential for year-round vegetable supply. At the same time, it is common to cook different vegetables together in one meal in

Western Kenya, for example cowpea leaves (*Vigna unguiculata*) are mostly cooked together with Jew's mallow (*Corchorus* species) (Ekesa *et al.*, 2009). Despite high farm harvests of a local favourite vegetable during one season, crop losses may deplete a household's vegetable reserve. For example, one smallholder farmer growing Jew's mallow lost the entire crop within one month post-harvest, which could necessitate sourcing the vegetable elsewhere when desired for home consumption. Farmers may also not always grow all the different types of vegetables they consume in a meal, necessitating them to access the other vegetables from alternative sources, including markets.

### **7.5.3 Markets and social networks as a food source**

While farms are more important for sourcing a diversity of nutrient-rich food groups, markets play an important role in provision of foods inadequately available through on-farm production, especially cereals. The importance of cereals is backed up by a study suggesting that staples are one of the main ingredients of most of the food that is consumed by rural households, and they rely on such staples for a large share of their daily calories (Smale *et al.*, 2009). In Mumias and Vihiga districts, as in the rest of Western Kenya, dry maize grain is milled to produce a fine maize flour, which is used to make a cooked paste known as 'ugali' (Mwololo, 2010), considered a staple and a delicacy among the Luhya community, the predominant community in the two study sites.

The importance of working social networks for food access is exemplified by sourcing of starchy roots/tubers/green bananas and fruits from family and friends in Vihiga

district, though the percentages exchanged and consumed are lower than those sourced from on-farm production. Family and friends, who in most cases were also farmers, shared their produce with the smallholder farmers, whether the family and friends' produce was in surplus or not. Seasonally available fruits which were in high supply for smallholder farming households' consumption, but in low demand at the local markets, were also shared among family and friends. A study conducted among smallholder farmers in Embu District of Eastern Kenya found that most (76%) of the farmers grow crops for home consumption rather than for the market, due to poor market prices (Stocking *et al.*, 2003). This could be the case with green bananas (*Musa paradisiaca*), which were readily available through on-farm production and for smallholder farming household consumption, but were unavailable in local markets.

#### **7.5.4 Smallholder farming households rarely sell their surplus on-farm produce in the formal markets**

Smallholder farmers produce on-farm produce for both home consumption and for commercial purposes. With the exception of sugarcane and spices/condiments, the highest proportion of a majority of the food groups were utilised for home consumption, with the remainder sold. Apart from sugarcane in Mumias and tea in Vihiga districts, animal source foods are also sold in formal markets in addition to their utilisation for home consumption. Animal source foods sold in formal markets are mainly cattle but also goats, sheep, rabbits and pigs, while chicken are reared by smallholder farming households mainly for their eggs. Though it's suggested that poor smallholder farming households tend to sell rather than consume the animal source foods they produce (Allen, 2003; Dror and Allen, 2011; Smith *et al.*, 2013), this mainly applies to large

livestock, such as cattle, where their sale could also contribute to household food security by providing income that can be used to purchase staple foods (Smith *et al.*, 2013) or pay for non-food items such as school fees, household goods and repairs, among other uses.

Though studies suggest that poor infrastructure leads to high transaction costs that limit the extent of smallholder farmer engagement in formal market exchanges (Omamo, 1998; Nagarajan *et al.*, 2007; Dury *et al.*, 2011), physical access to formal markets is not necessarily a limiting factor in this study. This is because both study sites are well connected to local markets mainly by tarmac roads, with the nearest local urban or rural market relatively close to the smallholder farming households. However, the smallholder farmers in this study still do not participate in formal market trading network as sellers, suggesting that it takes more than good infrastructure for rural households to engage and participate in formal markets (Omiti *et al.*, 2009). While trading smallholder farm produce between households and relatives strengthens family relationships (Maroyi, 2009), informal market channels in this study were probably selected depending more on the type of market information a farmer has access to and the need to reduce market transaction costs. As in this study, though formal sources of market information such as newspapers and mobile phones are available in the rural areas, they are inaccessible to the majority of smallholder farmers who do not purchase or read newspapers on a regular basis (Omiti *et al.*, 2009). While all smallholder farmers in this study either own or have access to a mobile phone, these phones are mainly for socialising but less frequently for communicating with potential buyers and discovering market prices (Mutabazi *et al.*, 2013). Though travelling traders could serve

#### Paper 4: Challenges and opportunities for market integration to improve food security

as more accessible contacts on prevailing market prices, limited repeated transactions with these traders hamper long-lasting business relationship that facilitate insightful market information dialogues. Therefore, optimal use of the existing mobile phone technology could facilitate the building of relationships with market traders so as to improve smallholders' market access. However, the under-developed co-operation between market traders and smallholder farmers could also be because market traders seem more interested in having regular and consistently high quality supplies (KIT and IIRR, 2008) whereas smallholder farmers mostly trade in small volumes of variable quality (Hazell, 2005).

Secondly, informal markets are characterised by lower transaction costs, as all trading of food crops and livestock in formal rural markets attracts fees and taxes (Ellis and Bahiigwa, 2003; Ellis and Mdoe, 2003). In addition to this, surplus pulses/nuts/seeds, a less perishable produce, was sold in both formal and informal markets in this study, with a preference for informal markets due to the flexibility of products and services that the produce could be traded for. For example, a farmer exchanged surplus soya beans (*Glycine max*) and groundnuts (*Arachis hypogaea*) for payment of her children's school fees. Informal selling of surplus on-farm produce, while offering flexibility in the mode of payment, also incurs little or no transaction costs as compared to transporting and selling produce in formal markets. Barrett *et al.* (2000) suggest that when smallholder farmers participate in markets, they are engaged in low-return market activities, such as petty trading at weekly rural markets mainly because they have little financial choice, which also applied to the situation in Western Kenya.

### **7.5.5 Market traders mainly source produce from distant areas**

This study shows that the majority of the market produce is not sourced from within the region, which is confirmed by a Western Kenya showing that most market products come from neighbouring districts, not from within the same area (Abukutsa-Onyango, 2002). This is partly because some produce, such as lemons (*Citrus limon*), oranges (*Citrus sinensis*) and animal source foods such as fish, are not produced in the local area, necessitating market traders to purchase such produce from neighbouring areas.

For locally available produce, three main observations explain why traders least source their market produce from local smallholder farmers, based on informal discussions with market traders. They concern quantity, price and quality: firstly, while smallholder farmers are unable to consistently supply market traders with high quantities of produce, traders acquire sufficient quantities of plant produce from other readily accessible sources, which saves both time and money. Among smallholder farmers, surplus on-farm produce for selling is highly available immediately (one to two weeks) after the harvest season, after which the remaining quantities are reserved for home consumption. It could also be that as a result of many traders in search of the (same) produce, smallholder farmers run out of surplus stock for selling soon after harvesting. With high quantities unavailable for selling, traders in search of market produce would be required to search for produce from many different farmers to get desired quantities, which is time consuming. The same applies for animal source foods, where one trader remarked that in most cases, a trader can only get five chicken from five different local smallholder farmers while in other neighbouring districts where chicken rearing is common (such as Nandi district), one can get a hundred chicken from one source.

Secondly, in cases where the produce is available in high quantities for a longer time span, for example sweet pepper (*Capsicum annuum*), few of the smallholder farmers will have the produce, and most likely having incurred high production costs, the produce can be quite expensive for traders to buy. In such cases, it is more profitable for market traders to buy such produce in places of high availability, even if in different districts or even countries. Thirdly, where the produce is highly availability and affordable, the produce may be unsuitable for local markets. For example, many smallholder farmers harvest maize when it is too young, which is good for selling as roasted or boiled maize, but not suitable for selling as grain, as it is not preferred for grinding into maize flour. The low sourcing of produce from smallholder farmers further agrees with studies suggesting that smallholder farmers are rarely integrated in local markets (Rietbergen *et al.*, 2002; Kruijssen *et al.*, 2009) generally due to variability in the quantity and quality of their produce.

While smallholder farmers dealing in food crops and livestock in this study have poor access to markets, smallholder farmers growing the two main cash crops, sugarcane and tea, are well connected to domestic and regional markets. In Mumias, sugarcane smallholder farmers are offered institutional support through out-grower schemes, with farmers accessing a ready market, among other benefits (Govereh *et al.*, 1999). Similar producer support is mirrored by smallholder tea farmers in Vihiga district. In this study, though the smallholder farmers dealing in food crops and livestock lack formal institutional support, they also rarely organise themselves (formally or informally) to market existing produce or develop better markets for their produce. Organised farmers have the potential to enhance the quantity and quality of their produce which in turn

facilitates better co-operation with market traders, with traders offering higher prices and a loyal business relationship lasting years (KIT and IIRR, 2008).

#### **7.5.6 Organised smallholder farmers stand to benefit by filling in market gaps**

Despite their current minor involvement as sellers in local market trading networks, smallholder farmers who get organised in the study sites could potentially benefit from better market integration, in two key ways: by filling in the local market gaps and by local product value addition. In the first instance, smallholder farmers have the capacity to fill in the market gaps by diversifying their on-farm produce to match produce available and in demand in the local markets. In this study, smallholder farmers do not currently produce locally available products uniquely available in local markets such as spices/condiments (*Allium sativum*, *Coriandrum sativum* and *Zinzigar officinale*) and animal source foods, which are in demand in the local markets. With changing tastes increasing rural and urban demand for some food products such as indigenous vegetables (Gotor and Irungu, 2010; Muhanji *et al.*, 2011; Chege *et al.*, 2015), organised smallholder farmers can also tap into these markets by introducing ‘niche’ products unavailable in markets but uniquely available through on-farm production, for example rabbits (**Table 7.3**). While rabbit keeping was not practised commercially in the Western Kenya study sites during the survey period, smallholder farmers in some other parts of the country have established market linkages based on this niche product. While many Kenyans are unaware that rabbit meat can adequately substitute other protein sources (Borter and Mwanza, 2011), in 2009, a smallholder-run organisation based in Central Kenya, the Rabbit Breeders Association of Kenya (RABAK), started their enterprise by addressing the misconceptions around rabbit meat consumption.

They did so by educating community members on the nutritional and economic value of rabbit meat through extensive campaigns in annual national agricultural fairs, monthly local farmers' meetings and ad hoc media coverage. RABAK received a boost from one of the leading regional supermarket chains, supplying them with about two tonnes of rabbit meat every month to date, thus substantially increasing the farmers' market share. RABAK has also partnered with about six other collaborators offering many forms of support, including procurement of RABAK's rabbit fur, thus establishing the smallholder farmers' rabbit market niche (RABAK, 2014). Thus, while there is a need for various stakeholders to stimulate education on nutrition to help build market integration for smallholders based on their niche products, it is also likely that when organised smallholder farmers initiate such ventures, other interested stakeholders eventually partner with them, thus resulting in sustainable support schemes. In addition, some of these food groups, including small ruminants and starchy roots, are subject to relatively few transaction costs (Delgado, 1999). Moreover, with diversification between early maturing and late maturing produce, some of these niche products unavailable on every farm around the same time could be sold for a good price and the profits utilised to meet household food needs. Further, when vegetables, fruits and livestock products become more plentiful and cheaper, they could improve households' nutritional status (Poulton *et al.*, 2006).

In the second instance, preservation and value addition of surplus perishable products is a strategic market entry point for organised smallholder farmers, not only to increase farmers' incomes, but also as a strategy to bridge hunger gaps during out-of-season periods. In this study, surplus fruits, vegetables and cereals are mainly lost through post-

harvest losses. This is because production is done by most smallholder farmers at the same time, resulting in high seasonal supply and low demand (Omiti *et al.*, 2009). In this study, though few farmers (37%) are affected by post-harvest food losses, the surplus seasonal produce that eventually makes it to the market fetches low prices. The poor market prices result from the limited ability of producers to store surplus produce as a way of coping with price fluctuations (Weinberger and Lumpkin, 2007), especially in seasons of high availability. The issue may be more complex than limited storage facilities, as farmers often have little choice but to sell their produce immediately so as to meet their short term cash needs (Godfray *et al.*, 2010). However, through pooling of resources, seasonal surplus supply can be processed at different levels (factory, village, household, individual) and to different degrees (minimal, culinary, “ultra-processing”) (Monteiro and Cannon, 2010) into higher value produce with a longer shelf life, such as dried fruits and vegetables, which can fetch higher prices and meet food demands during food deficit seasons. For example, organised smallholder farmers in Mgeta region in Tanzania market local goat milk yoghurt through a semi-formal local goat cooperative, which has a greater impact on improving their livelihoods than selling highly perishable surplus milk (Lie *et al.*, 2012). Thus, reduction of food waste by value addition could contribute to increased food availability (Kader, 2003; Sagar and Kumar, 2010) as well as to rural development and poverty reduction by improving agribusiness livelihoods (Hodges *et al.*, 2011).

Although this study is limited by identification of morphologically similar local vegetables in the local markets as well as by market and farm species identification down to variety level, the findings provide insights to addressing the challenges that

smallholder farmers face in market participation, with an aim of increasing market integration for improved household food security.

## **7.6 Conclusions**

Smallholder farmers with different farm and environmental settings utilise multiple channels of continuous food supply. Markets are more important for sourcing cereals, a staple food inadequately available through on-farm production, while their own farms are more important for sourcing a diversity of nutrient-rich food groups, with working social networks playing a supporting role. Although surplus on-farm produce for selling are seasonally available, smallholder farmers prefer to sell such produce in informal markets as they are associated with lower transaction costs. At the same time, market traders in formal markets mainly source their produce from distant areas, including other countries, due to the small and inconsistent volumes that smallholder farmers trade in. As a consequence, smallholder farmers are least integrated in formal markets. Improving smallholder farmer access to formal markets in general and to market traders in particular goes hand in hand with efforts in organising smallholder farmers to fill in the local market gaps and to add value to surplus perishable products. This in turn holds the potential to increase food incomes and close out-of-season food and nutrition gaps. The increased incomes could enable access to diversified foods and reduce the need for food self-sufficiency, with an overall impact on improving household food security.

## **7.7 Acknowledgments**

We are grateful to all the farmers, market traders, local administration and contact persons who participated in this study. We also thank Dr. Patricia Daley (University of

#### Paper 4: Challenges and opportunities for market integration to improve food security

Oxford, UK) for the insightful discussions and invaluable comments on earlier drafts of the manuscript. Our sincere gratitude also goes to the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, for funding this study, implemented by Bioversity International, Regional Office for sub-Saharan Africa, Nairobi, Kenya.

## **8 Overall conclusions**

This chapter serves five purposes. The first is to recapitulate the research questions answered in the empirical chapters (Papers 1 to 4). Secondly, it discusses the four case study findings in the context of larger trends around land use, nutrition, climate change and urbanisation. It then expounds how the four empirical chapters map onto the conceptual framework and what new knowledge they contribute together that each individual empirical chapter does not on its own. Next, recommendations resonating with the study findings are proposed. Lastly, the limitations of the study offering opportunities for future research are discussed.

### **8.1 Summary of research questions addressed**

This study has examined the extent to which local agrobiodiversity contributes to food and nutrition security of smallholder farming households in a high potential agricultural region. Taking into account the multi-dimensional nature of food and nutrition security, the study has employed the food system concept as a useful frame for examining the availability, utilisation and linkages between agricultural, nutritional and dietary diversity among smallholder farmers in Western Kenya. The study had four specific objectives: to assess on-farm crop diversity and its underlying factors, the relationship between agricultural and dietary diversity, and that of agricultural and nutritional diversity and then finally to investigate market food accessibility levels and the extent of local market integration among smallholder farming households. The aforementioned specific objectives have been addressed by answering nine research questions (RQ 1.1 to 1.9) in four articles (Papers 1 to 4), as discussed below.

## Chapter 8: Overall conclusions

In Paper 1, ‘Variability of on-farm food plant diversity and its contribution to food security: A case study of smallholder farming households in Western Kenya’, three research questions were answered. The first is that food plant diversity was generally high and most of the food groups dominant in the two study sites differed, with the exception of cereals, the main staple crop. Secondly, on-farm agrobiodiversity was influenced less by biophysical factors and more by socio-economic factors such as wealth status and age of household head. Next, there was no significant relationship between on-farm agrobiodiversity and household food security during the survey period, as in addition to on-farm food production, markets and working social networks contributed significantly to the food security of the smallholder farming households.

Paper 2, ‘Influence of seasonal on-farm diversity on dietary diversity: A case study of smallholder farming households in Western Kenya’, covered the next two research questions. Firstly, during both 2012 planting and 2014 harvest seasons, the average household and women 1-day dietary diversity scores were low, implying low household economic access to food and low women’s dietary quality, respectively. Nevertheless, the 7-day food consumption scores during the 2014 harvest season showed that acceptable levels of food consumption were realised by the majority of households (83%) and women (90%). Secondly, there was no strong association between dietary diversity (measured using 1-day dietary diversity scores and 7-day food consumption scores at household and individual levels) and on-farm agrobiodiversity (measured using seven farm diversity indicators). Instead, dietary diversity was influenced by socio-economic factors, namely, the household’s wealth status, ethnicity of both the household head and the wife, and the education level of the wife.

## Chapter 8: Overall conclusions

Paper 3, ‘Contribution of nutritional diversity and food perceptions to food and nutrition security: A case study of smallholder farming households in Western Kenya’, also addressed two research questions. The first point is that locally available on-farm and market food species during both 2012 planting and 2014 harvesting seasons contributed towards a balanced diet by offering all the five micronutrients (folic acid, iron, zinc, Vitamins A and C) and two macronutrients (carbohydrates and proteins) under investigation, suggesting a link between agricultural and nutrient diversity. Secondly, there were varying seasonal accessibility levels for most of the food species available in markets, which may have influenced households to strive for on-farm food sufficiency during high market food prices. Nevertheless, farms were especially effective in readily availing four of the nutrients (proteins, Vitamin A, folic acid and iron) during both seasons. Despite the rich diversity of foods offering diverse nutrients on-farm, there was a general low appreciation for most of this diversity, as food shortage months coincided with a lack of maize, the main cereal in the study area. During this same period, however, a diversity of local foods, deemed to be of low value mainly due to their taste and time-consuming preparation, were available to not only replace the maize but also contribute to a diverse diet.

Paper 4, ‘Challenges and opportunities for market integration to improve household food security: A case study of smallholder farming households in Western Kenya’, was designed to answer the last two questions. The first is that markets were more important for sourcing maize, a staple food inadequately available through on-farm production, while on-farm production was more important for sourcing a diversity of nutrient-rich food groups, with working social networks playing a supporting role. The second point

is that although surplus on-farm produce for selling were seasonally available, smallholder farmers preferred selling such produce in informal markets as they were associated with lower transaction costs. At the same time, market traders in formal markets mainly sourced their produce from distant places, including other countries, due to the small and inconsistent volumes that smallholder farmers traded in. As a consequence, smallholder farmers were least integrated in formal markets.

### **8.2 Individual study findings**

By way of four case studies, this research has offered insights into smallholder producers' food and nutrition security challenges and opportunities, with the overall aim of contributing to the knowledge on the availability, utilisation and linkages between agricultural, nutritional and dietary diversity.

With regards to land use, this research has concluded that subsistence-oriented agricultural production systems harboured low food plant diversity (as shown in the 'cereal farm' cluster) and did not make smallholder farming households more food secure than those with market-oriented production systems, as in the 'large sugarcane farm' cluster. This finding corroborates with studies in various African countries that have shown that subsistence-oriented farming households are more food-insecure than market-oriented ones (Negatu, 2004; De Weerd, 2009; Tittonell *et al.*, 2010; Chirwa and Matita, 2012). Building on other studies that show that commercialisation could in fact go hand in hand with diversification (Bernholt *et al.*, 2009; Mutabazi *et al.*, 2013; Wiehle *et al.*, 2014), this research demonstrates that integration of commercial crops such as sugarcane, as shown in the 'long-standing cereal-sweet potato farm' and 'large

## Chapter 8: Overall conclusions

sugarcane farm' clusters, resulted in slightly higher species richness and diversity indices and a more balanced proportion of functional food groups. At the same time, higher species richness and diversity (mainly found in farms managed by wealthier households and older household heads) had no direct influence on household food security, as shown by the non-significant relationship between food security and agrobiodiversity. The non-significant relationship was because farms were not relied upon entirely for household food consumption, with markets and working social networks contributing significantly. Nevertheless, higher on-farm agrobiodiversity by mixing subsistence and cash food crops can translate to higher household food security and more resilient food systems by increasing incomes and the ability to buy food during low on-farm production periods. The need for smallholder farmers to step up into higher-value agricultural activities, such as crop-livestock diversification (Maass *et al.*, 2014; Thornton and Herrero, 2014) and cultivation of multi-purpose non-industrial cash crops such as fruit trees (Baul *et al.*, 2015), has already been acknowledged. This land use diversification may not only increase household incomes but also improve supply of nutrient-dense foods at local markets, an important source of food for rural communities.

Pertaining to nutrition, dietary diversity is not only influenced by availability and affordability of foods (Herforth and Ahmed, 2015), calling for an understanding of other factors that could still limit consumption of nutritious foods (McDermott *et al.*, 2015). This thesis contributes by bringing into focus socio-economic factors influencing dietary diversity in different seasons. While at the same time there was a non-existent linkage between on-farm agrobiodiversity and dietary diversity, as well as a non-distinct

## Chapter 8: Overall conclusions

role of on-farm production seasonality on food groups consumed, dietary diversity was influenced by a household's wealth status, ethnicity and education level of the wife. The influence of dietary diversity on wealth status was either positive or negative in the two seasons. Women's completion of primary education had consistently positive associations with dietary diversity, which is likely to enable women to better contribute towards choices for nutritious diverse foods in their shared decision making role within the household (on the types of foods purchased, the use of harvested on-farm crops and animal source foods). Moreover, women's attainment of basic primary education also enhances their ability to challenge negative aspects of local food culture attached to either their or the household head's ethnicity. The strong influence of the aforementioned socio-economic factors on food consumption patterns suggests their important role in ultimately shaping the extent of food and nutrition security at a household level in the study area. It has been suggested that if agricultural interventions at the grassroots are to effectively tackle food and nutrition insecurity over the long-term, an appreciation of the existing local food culture is a prerequisite (Noack and Pouw, 2014).

While cultural practices, such as food taboos, may inhibit resilience of rural communities to the unpredictability of the food system as a result of the changing climate (Thornton *et al.*, 2014), low appreciation of existing local food diversity may also contribute to food and nutrition insecurity in areas endowed with high agrobiodiversity levels. Traditional agricultural production systems, with their high levels of functional redundant and unique species (Bihn *et al.*, 2010; Gallagher *et al.*, 2013), are better suited to local conditions, providing most nutrients despite the

## Chapter 8: Overall conclusions

changing climate (DeClerck *et al.*, 2011). Previous studies have also shown local agrobiodiversity's potential to meet macro-and micro-nutrient requirements not only in rural Africa (DeClerck *et al.*, 2011; Remans *et al.*, 2011) but also in other low- and middle-income countries accounting for close to half of the world's population (DeFries *et al.*, 2015). The role of markets as an important food source for smallholder farming households has also been acknowledged (Remans *et al.*, 2011; Remans *et al.*, 2014; Luckett *et al.*, 2015), with the possibility of it contributing more to rural households' nutritional diversity than on-farm produced foods acknowledged (Luckett *et al.*, 2015). A major component of Paper 3 in the assessment of nutritional diversity (comprising of nutrient and non-nutrient factors) was to investigate the nutrient diversity (of foods obtained from both on-farm and market sources) by applying a nutrient functional diversity score, which showed that functionally redundant and unique species that met all the existing macro-and micro-nutrient needs under investigation were theoretically available during different seasons. While a recent study among households in rural Malawi also shows the nutritional diversity of both on-farm and market species (Luckett *et al.*, 2015), this thesis went a step further to investigate affordability levels of market purchased foods in the different seasons. It showed that there were varying seasonal accessibility levels of foods purchased from markets, which may influence households to strive for on-farm food self-sufficiency when market food prices are high. While farms were especially effective in readily availing four nutrients (proteins, vitamin A, folic acid and iron) during both seasons, there was a low appreciation for most of this diversity. By incorporating an overlooked dimension of household food and nutrition security, food utilisation, this research revealed that the main food shortage months, as perceived by smallholder farming households, coincided only with maize shortage, the

## Chapter 8: Overall conclusions

staple food in the study area, but a diversity of local foods, deemed to be of low value mainly due to their taste and time-consuming preparation, were available to contribute to a diverse diet. Thus, Paper 3 provided further evidence that the high nutrient diversity of on-farm and market foods (measured in Paper 3) but low dietary diversity of consumed foods (measured in Paper 2) during the same seasons (September/October 2012 and July/August 2014) were due to non-farm production diversity indicators (including nutrient diversity).

While there were parallelisms between Papers 2 and 3, the subtle but important distinction between the two papers lies in the definition of the terms shaping the two papers – food/dietary intake (in Paper 2) and nutrients (in Paper 3), which are assessed and interpreted differently, using either food consumption data (Paper 2) or nutrient composition data (in Paper 3). In Paper 2, food consumption data were used to generate dietary diversity scores, a multi-proxy indicator that reflects the economic access to food (for households) and dietary quality (for women). In Paper 3, nutrient composition data were used to compute nutrient diversity metrics in form of nutrient functional diversity score, a farm diversity indicator, that showed the theoretically available macro-and micro-nutrients during different seasons. Paper 3 went further to show that the affordability of some of the preferred foods available in markets varied in the different seasons, thus showing that market food availability did not necessarily equate to its accessibility.

While low desirability of the diversity of local foods available to the smallholder farming households may persist, these foods could still be sold to consumers in rural or

## Chapter 8: Overall conclusions

urban areas who are already informed on their nutritional benefits. In turn, increased incomes could enable access to preferred foods purchased from markets, especially of cereals, animal source foods and fruits, the main food groups that were sourced from markets in the study area. Economic access to preferred foods can also reduce the need for food self-sufficiency, especially of maize, the main cereal consumed, as staple food production on very small farms is unlikely to meet a household's food and nutrition requirements. While farm sizes may gradually increase with increased migration of people to urban areas (Regmi and Meade, 2013), it is more likely that the increasing population size in rural areas is leading to declining farm sizes that are not viable for year-round food and income security (Waithaka *et al.*, 2006). Western Kenya, one of the most densely populated areas in the country (Jaetzold *et al.*, 2005), will be no exception. Conversely, the increasing population size means that there will be more people to feed (Regmi and Meade, 2013) and demand for nutrient-dense foods may concomitantly increase (Ngugi *et al.*, 2007). This research contributes by highlighting the unique products that were available through on-farm production. It further showed that although surplus on-farm produce for selling were seasonally available, smallholder farmers preferred to sell such produce in informal markets as they were associated with lower transaction costs. Consequently, their integration in formal local markets was low. During the survey period, only 15 per cent of the market produce was sold by smallholder farmers, while about two-thirds was sold by large scale traders sourcing produce from distant areas, including other countries, rather than from smallholder farmers, as they traded in small and inconsistent volumes. Improving smallholder access to formal markets in general and to market traders in particular goes hand in hand with efforts in organising smallholder farmers to tap into the increasing market demand for

the niche products uniquely available through on-farm production. In turn, the existing local agrobiodiversity provides opportunities to not only improve food security but also offer employment to smallholder farmers in both agricultural and non-agricultural activities, thus enabling them to step up and out of agriculture (Harris and Orr, 2014; Maass *et al.*, 2014; Thornton and Herrero, 2014). These options have been acknowledged as possible strategies for poor smallholder farmers to get out of the poverty trap (De Weerd, 2009; IFPRI, 2015).

### **8.3 Combined study findings**

While the findings of the four papers (Papers 1 to 4) are sufficient to stand alone, bringing the four case studies together allows a clearer representation of the multi-dimensional nature of the local food system existing among smallholder farming households in the two districts in Western Kenya. As opposed to examining a few of the food system elements in isolation, a detailed understanding of the interconnected nature of food system components is necessary if agricultural research is to lead to holistic food and nutrition security (Noack and Pouw, 2014; McDermott *et al.*, 2015). This research contributes by bringing into focus the inter-linkages across production, accessibility and utilisation of local agrobiodiversity by adapting the food systems concept by Ericksen *et al.* (2010). The conceptual framework described in Section 2.7.3 provides a visual aid on inter-connectedness across the four empirical chapters (Papers 1 to 4) and how they map onto the conceptual framework in a cyclical fashion, eventually closing the ‘local agrobiodiversity circle’. The complex relationship between the ‘food system activities’ and ‘food security outcomes’ is depicted by two-way arrows that show interdependence of the food security components. While agrobiodiversity is the

## Chapter 8: Overall conclusions

central plank of the food system conceptual framework, it is important to note that agrobiodiversity is just one of the many food security strategies, and it has its limitations and a political dimension. Thus, the thesis as a whole offers a critical perspective on limited agrobiodiversity thinking, while also advocating greater attention for agrobiodiversity. Insights resulting from this multi-dimensional view offer both a strong agricultural perspective, as well as one that moves beyond the agricultural production dimension and takes on a food system view.

Together, the study findings contribute by examining the linkages between agricultural, dietary and nutritional diversity, for which the current empirical evidence is insufficient (Fanzo *et al.*, 2011). The non-significant relationship between on-farm agrobiodiversity and food security, in Paper 1, and with dietary diversity, in Paper 2, is the thread that starts to weave the tapestry together. In Paper 3, there is a suggested link between agricultural and nutrient diversity because on-farm and market food species met existing macro-and micro-nutrient needs in two seasons. However, the low value attached to readily available nutrient diversity proposes that non-nutrient factors contributed greatly to an overall low nutritional diversity. This explanation is confirmed by the low dietary diversity of consumed foods measured during the same two seasons, in Paper 2. Moreover, the low average women and household dietary diversity scores imply low women's dietary quality and low household economic access to food, respectively. Investigating the role of markets in access to food at household level, in Paper 4, revealed that smallholder farmers utilised markets for sourcing cereals, mainly maize, as its on-farm production on small farms did not meet households' staple food needs. In addition, markets were also important for obtaining animal source foods and fruits in

## Chapter 8: Overall conclusions

one of the two districts. On-farm production, however, was more important for sourcing a diversity of nutrient-rich food groups, with working social networks playing a supporting role. This finding builds on other studies that have highlighted that smallholder farmers obtain foods from multiple sources (Negatu, 2004; Baiphethi and Jacobs, 2009), and markets may actually be playing a bigger role in food procurement (Luckett *et al.*, 2015). However, market food availability does not necessarily equate to its accessibility, and this study makes this connection by showing that affordability of foods available in markets varied in different seasons (in Paper 3), offering an evidence-based explanation on a probable reason for smallholder farmers' dependence on on-farm production, especially when market food prices are high. Nevertheless, rather than focusing on only on-farm production, there is a need to factor in multiple food sources in the food and nutrition security equation. Multiple food procurement is a theme that cuts across the four papers in different perspectives, reinforcing that smallholder farming households utilise multiple channels of continuous food supply, as well as offering an explanation for the non-linkages between agricultural, dietary and nutritional diversity.

Multiple food procurement further builds another layer to the tapestry, that of connecting agrobiodiversity with household food security outcomes. For availability and access to the amount, type and quality of food required (Ericksen *et al.*, 2010), this research shows that smallholder farming households relied on on-farm production, markets and working social networks. Even if macro-and micro-nutrient rich foods were available and accessible, this did not necessarily translate to their ultimate consumption, leading to a third critical connection to food availability and accessibility- its utilisation.

## Chapter 8: Overall conclusions

While the nutrient value of food is one of the factors determining the extent of obtaining food benefits (Ericksen *et al.*, 2010; Ingram, 2011), this research highlights the urgency in taking into account socio-economic and cultural factors with equal weight to ecological factors, from different angles, thus completing the tapestry analogy. While a rich diversity of on-farm foods were readily available in different seasons and were especially effective in readily availing four of the seven nutrients under investigation, there was low appreciation for most of this diversity. Most of these foods were considered to be of low value due to their taste and time-consuming preparation, and their low consumption was further reflected by virtue that food shortage months, as perceived by the smallholder farming households, coincided only with maize shortage while nutrient-dense local foods were highly available and accessible on-farm. In addition, dietary diversity was neither influenced by the level of agrobiodiversity nor by seasonality in the on-farm food production, but rather by the household's wealth status, ethnicity and education level of the wife. Connecting back to food availability, even the level of on-farm food production was influenced more by socio-economic factors rather than by biophysical factors, where higher food plant species were found in farms managed by wealthier households and older household heads. Thus, food security outcomes-agrobiodiversity connections in this study are explained through both multiple food procurement and socio-economic and cultural factors, themes embroidered in the four papers from different angles, together enabling them to better illuminate the extent of food and nutrition security of the surveyed households from multiple perspectives.

## Chapter 8: Overall conclusions

The thesis as a whole makes a contribution to the literature on agrobiodiversity and food security by showing that the multi-dimensional perspectives on agrobiodiversity need to build not only on to the food system concept but also by taking the food system conceptual framework down to the local level and grounding it with empirical household data. The benefit of focusing on the local level was that it allowed me to effectively address the key gap identified in literature about the present global food system (Chapter 1), namely that there is a disconnect between the global understanding and the local potential (Cash *et al.*, 2006) of attaining food and nutrition security. The empirical data collected factored in different scales (Cash *et al.*, 2006): one spatial (local level), two jurisdictional (Mumias and Vihiga districts), several temporal (2012 planting /2014 harvesting seasons and one-day/seven-day food consumption recall durations) and two network (family/household and kin/sub-tribes). This data collection enabled the assessment of seasonal dietary diversity, on-farm and market agrobiodiversity in two districts. Socio-economic and cultural factors limiting food utilisation at different network levels were identified (with food customs limiting the consumption of diverse foods among some, but not all, sub-tribes in the households), thus showing that there are varying hindrances to food system components. While the thesis addressed important local level barriers to unlocking agrobiodiversity's potential, limiting the analysis to one spatial scale may have restricted an understanding of the equally important interactions between local and regional levels (Cash *et al.*, 2006), notwithstanding the fact that the collection of data at these levels within the confines of a doctorate study may have posed further challenges in timely completion of the study.

#### **8.4 Study recommendations**

Overall, this study proposed that in order to make smallholder farmers more food secure and resilient to the ups and downs of the global food system, they need to be better supported by various stakeholders to not only diversify their on-farm production and dietary intake but also to value the nutrient diversity offered by locally available agrobiodiversity, which can provide a unique entry point for them to engage in formal markets by selling these nutrient-dense products with increasing market demand. Four recommendations for organisations and policy makers that emerge from the study's findings are discussed below:

1. Organisations working on conservation of agrobiodiversity and plant genetic resources at the local level need to support smallholder farmers to concurrently diversify production into both high-value nutrient-dense crops as well as livestock species, as mentioned in Paper 1. One of the main forms of support needed by farmers as they transition into this high-risk venture is a regular contact point for advice and information tailored to smallholder-farmer needs and constraints. The mainstream service providers, agricultural extension officers, belong in a rural development sector facing perennial budgetary constraints in many developing countries (Fanzo *et al.*, 2015). In Kenya, underfunded extension operations results in their limited reach, and smallholder farmers who are poor, with small farm sizes and living in remote areas, are often excluded (Muyanga and Jayne, 2006). Despite this, alternative agents are emerging, such as private agricultural extension officers (Muyanga and Jayne, 2006), agriculture-trained community members and nutrition-trained community health workers from the public sector, community based organisations or Non-

Governmental Organisations (NGOs) (Fanzo *et al.*, 2015). These service providers could be the determining change agents in moving the food and nutrition security agenda forward.

2. A possible strategy for organisations to integrate smallholder farmers better into the food system is by ensuring discussions on food and nutrition security happen more at the local level. As was shown in Paper 2, socio-cultural and socio-economic factors shaping food consumption patterns may be more important in dictating a household's dietary quality than prescribing pre-determined portfolios of nutrient diverse food crop and animal species for farmers to incorporate in their farming systems. Among the service providers, community-based personnel possess various attributes that have enabled them to contribute positively to the food and nutrition security agenda. In addition to (sometimes) volunteering their services, they often have gained extensive cultural awareness, community trust and local reach (Fanzo *et al.*, 2015), providing a vital skill set that organisations can tap into. So far, successful nutrition education interventions spearheaded by community health workers have resulted in increased nutritional knowledge among mothers and consumption of diversified foods by their children in various rural areas, including western Kenya (Waswa *et al.*, 2015), western Uganda (Kabahenda *et al.*, 2011) and southern Malawi (Hotz and Gibson, 2005). Farmer-led agricultural initiatives in various countries in Africa, Asia and Latin America have also been found to be taken up by community members (Waters-Bayer *et al.*, 2015). To increase the efficiency of these personnel, there is the need for organisations working with community service providers to target not only women but also men (Fanzo *et al.*, 2015) and

extended family members, such as grandparents (Waswa *et al.*, 2015). These social networks are likely to provide supportive environments that catalyse sustained behaviour change, a crucial ingredient needed if interventions are to translate from knowledge transfer to long-term consumption of diversified foods (Waswa *et al.*, 2015). Besides the need for balanced household targeting, there is an urgent need for these organisations to offer training that goes beyond technical and soft skills to an integrated training that enables the agriculture and health personnel to better understand each others' disciplinary approaches and 'speak a common language' (Fanzo *et al.*, 2015; Lachat *et al.*, 2015). This interdisciplinary understanding is likely to foster their advisory capacity and reduce duplication in their operations so that they can further extend their reach.

3. Policy makers need to create enabling incentives to encourage longer-term commitments by institutions organising smallholder farmers to fill in the local market gaps and to add value to their surplus perishable products, as suggested in Paper 4. The primary organisations championing this cause are the private sector and other development agencies, and efforts to stimulate their business activities as they support smallholder farmers could be a strategic win-win mechanism. While the institutional and policy environment for natural resource management in Kenya is generally encouraging (Yatich *et al.*, 2007), in most cases the policies are either poorly implemented or not targeted to smallholder farmers (Ng'endo *et al.*, 2013). Section 2.6.1 also offered more discussion on this issue. When policies are explicitly designed to benefit smallholder farmers, they often remain poorly enforced, such as the initiative by the Kenyan government and the private sector to standardise irish potato packaging that did

not result in tangible benefits for smallholder farmers (Kaguongo *et al.*, 2014). Besides poor targeting, implementation and enforcement, another major drawback in the existing policies identified by FARM-Africa, a development agency linking smallholder farmers to profitable markets in Kenya, Uganda and Tanzania, is multiple taxations at different government administrative levels (Nyang *et al.*, 2010). As in Kenya, the local taxation regime in rural Uganda and Tanzania is such that trading of crops and livestock attracts taxes and fees by public agencies at different levels (Ellis and Bahiigwa, 2003; Ellis and Mdoe, 2003). Some examples of daily market charges incurred by sellers in the study area were mentioned in Paper 4. The likelihood of multiple and incremental costs in a single transaction further discourages smallholder farmers from selling food crops and livestock in formal markets (Ellis and Bahiigwa, 2003). However, organised and trained smallholder farmer groups may have better capacity to influence government policies. For example, a coffee farmer association in Tanzania, initiated by FARM-Africa, is actively lobbying with central and local government to harmonise coffee tax and cess (Nyang *et al.*, 2010).

4. With the proliferation of private and NGO initiatives offering support to rural smallholder farmers, sometimes with contrasting interests and power dynamics, the strength of government in designing and implementing protective policies that improve transparency and capacity in contractual agreements and entrepreneurial support could enable risk-averse smallholder farmers to negotiate profitable commercialised production systems (Kilelu *et al.*, 2013). Integrating smallholder farmers into value chains for non-traditional cash crops

such as fruits and vegetables will not only increase household incomes, but also contribute to an improved supply of these nutrient-dense foods at local markets, which are an important food procurement source for rural households.

5. There still remains a need to stimulate high demand for diverse local foods of high nutritional value (see Paper 3) so that even if they are not necessarily desirable by rural households in a locality, they could still be sold in other rural and urban markets. Nutrition education may lead to a better understanding of nutritional value of locally available foods, especially niche on-farm products (identified in Paper 4), which could in turn lead to better use of agrobiodiversity, and potentially to better markets as well. Nutrition education could be initiated by formal and semi-formal organised smallholder farmers interested in promoting specific niche products, and it is likely that once they start the nutrition education and marketing process from the local level, other interested stakeholders are more likely to support in building market integration for smallholders based on their niche products (as was shown by organised rabbit smallholder farmers in Paper 4). The media is also a potential support system for the wide-spread dissemination of nutrition education and they may be more willing to assist proactive smallholder farmers. In Kenya, the media is increasingly supportive of both group and individual smallholder farmers in a range of ways, from featuring stories of smallholder farmers who have succeeded as entrepreneurs based on their niche products (Chao, 2015) to airing weekly episodes of smallholder farmer visits that have improved the farmers' production, value-addition and marketing potential (Shamba Shape Up, 2015).

6. There still remains a high risk of building markets for diverse niche products. This has been the case for Kenyan farmers rearing quails, small domestic birds considered to have more nutrient-dense eggs as compared to chicken eggs. As the awareness of their nutritional benefits rapidly spread across the country, the small-sized quail eggs retailed at several times higher than the larger-sized chicken eggs. Subsequently, quail farming sharply picked up in early 2014 as more farmers engaged in the lucrative business (Xinhua, 2014), only for the prices to plummet soon afterwards as the quail market saturated (Murumba, 2014). While this was a part of the normal business cycle governed by the supply and demand principles, the sharp price fall left many start-up farmers with immense financial losses (Outdoors Africa, 2014). Needless to say, the repercussions must have been worse for smallholder farmers with no back-up financial strategies. Thus, while better markets for nutritious products may be created, compensation mechanisms need to be put in place for farmers to buffer the imminent market shocks. An example of a market price guarantee agricultural insurance scheme for smallholder farmers that has been successfully implemented by the Brazilian government is the Family Farming Price Guarantee Programme (FAO, 2015). However, in sub-Saharan Africa, agricultural insurance is rare (FAO, 2015), thus posing an immense challenge to the use of diverse local agrobiodiversity for better markets in the long-term. There are also other high risks that apply to local products that have already penetrated different markets. For example, despite the high market demand for indigenous vegetables in Kenya (Gotor and Irungu, 2010; Muhanji *et al.*, 2011; Chege *et al.*, 2015), these vegetable smallholder farmers still face exploitation

by middlemen and lack access to centralised market information (Muhanji *et al.*, 2011), issues that could be best tackled by not only the creation of the financially-challenging compensation schemes but also by implementation and enforcement of existing government policies. Hence, by creating an enabling environment for smallholder farmers to take up opportunities to sell their produce in markets, the incomes raised could contribute to meeting high input costs as well as having extra money to buy other produce in markets that is available year-round but at different accessibility levels (as shown in Paper 3), contributing to enhanced food and nutrition security, income generation and to more sustainable and resilient food systems.

### **8.5 Study limitations and areas of future research**

This study has shown that food and nutrition security among the surveyed households depends less on purely on-farm food production but more on food access from markets and working social networks as well as non-nutrient food consumption factors that determine utilisation of food to ensure dietary quality is achieved. There are several limitations to the study that offer opportunities for future research.

Firstly, the small sample size of the households (n=30) and local markets (n=7) surveyed has implications on the statistical power and generalisation of the results at population level. Rather than provide sample representativeness, the study aimed to gain insights into possible food and nutrition security inter-linkages using multi-method approaches - the reason behind the case study design. In addition, focus group discussion participants (n=97) drawn from the same localities enriched the generalisation of some of the results at the district level. However, the two study sites

## Chapter 8: Overall conclusions

also represented high potential areas, limiting its comparability to lower potential areas that may have wider differences in levels of agrobiodiversity. To increase the utilitarian value of the multi-method approach, future studies need to increase the number of farmers and markets surveyed in geographically distant areas so as not to only achieve sample representativeness but also to make broader within-country generalisations on the extent to which agrobiodiversity contributes to food and nutrition security. In addition, there is a need to assess agrobiodiversity at different levels of the spatial scale (for example at local and regional levels) so as to expand the understanding on linkages across agricultural, nutritional and dietary diversity.

Secondly, the one-month time frame of data collection of the household hunger score, utilised as a food security indicator, may not necessarily offer a complete picture of the food security situation of the household. In this study, the hunger score provided a useful approximation of current household-level food security applicable for comparisons within the same groups of households. While different results may have been reached if the hunger scores were measured at a different time of year or in a different year, this research offered a dimension in seasonal household food security, where the 2012 and 2014 hunger scores still yielded roughly similar results. However, the use of household hunger categories in the currently available tool (Ballard *et al.*, 2011) may not differentiate enough the different forms of hunger. A future study measuring household hunger scores using a global standard tool still under development, the food insecurity experience scale (Ballard *et al.*, 2013), could be useful in better capturing different food security situations.

## Chapter 8: Overall conclusions

The third limitation is that while the dietary diversity analysis was based on both one-day and seven-day recall food consumption data, the latter were only collected during the 2014 survey for its added value in capturing usual food consumption patterns. Their measurement during only time point limited comparability of seven-day food consumption patterns during both the 2012 and 2014 surveys. Similarly, anthropometric measurements were taken only during the 2012 survey but not in the 2014 survey. In addition, the new Women Dietary Diversity cut-off points (FAO and FANTA, 2014) were published after completion of the second survey, and as the tool required different food group differentiations at the data collection stage, its use would have rendered the 2012 and 2014 data incomparable. Future dietary diversity studies could benefit more from use of the newly developed cut-off points so as to better assess women's dietary quality. Although one-day recall food consumption data have been found to be adequate predictors of economic access to food (for households) and dietary quality (for women), this study found that use of the seven-day recall food consumption data provided a more typical consumption pattern as compared to the snapshot one-day recall periods. Therefore, consistent use of both recall periods for all household members and inclusion of anthropometric measurements could provide more robust indicators on their nutritional status.

Lastly, the exclusion of intra-specific diversity in the analysis omitted an equally useful dimension of agrobiodiversity. While data on the local variety names of both animal and plant species were collected, there were high inconsistencies in their local nomenclature by the interviewed farmers. For livestock, skin colour was the basis in their local naming by both interviewed farmers and market traders. Moreover, correct

## Chapter 8: Overall conclusions

identification by triangulation with existing literature and consultations with a taxonomist was not always possible, especially for morphologically similar varieties, hence the decision to utilise species level as the taxonomic level of all the analyses in this study. Future studies can improve on plant identification challenges by factoring in additional time and money to enable them to access the available laboratory facilities.

Despite these limitations, this thesis has offered insights on the multiple food procurement channels, the socio-economic and cultural factors shaping food consumption and the level of market integration among smallholder farming households. As a result, this thesis offers evidence-based knowledge on the crucial inter-linkages between food availability, accessibility and utilisation that when addressed with equal weight, could be instrumental in unlocking local agrobiodiversity's potential as a path to household food and nutrition security and in so doing, enabling the nutrition-sensitive agriculture agenda to gain increased momentum.

## 9 Appendices

### 9.1 Appendix I: Species Lists

#### 9.1.1 Species List 4.1

List of food plant species (sorted by food use groups), their scientific and common names, number of varieties as well as frequencies and abundances in 30 farms surveyed in Mumias and Vihiga districts, Western Kenya, in November/December 2012

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
<b>Cereals</b>										
1	<i>Zea mays</i>	Poaceae	Maize	Mahindi	Exotic	7	93	161, 099	87	68, 335
2	<i>Sorghum bicolor</i>	Poaceae	Sorghum	Mawele	Exotic	5	40	38, 451	20	402
<b>Fruits</b>										
3	<i>Ananas comosus</i>	Bromeliaceae	Pineapple	Nanasi	Exotic	1	40	120	27	12
4*	<i>Annona muricata</i>	Annonaceae	Soursop	Mtomoko	Exotic	1	0	0	7	2
5	<i>Carica papaya</i>	Caricaceae	Papaya	Paipai	Exotic	1	13	6	13	6
6*	<i>Citrus limon</i>	Rutaceae	Lemon	Ndimu	Exotic	1	7	1	0	0
7*	<i>Dovyalis caffra</i>	Salicaceae	Kei apple	-	Exotic	1	7	3	0	0
8*	<i>Eriobotrya</i>	Rosaceae	Loquat	Zabibu	Exotic	1	20	4	13	5

Appendix I: Species Lists

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
	<i>japonica</i>									
9*	<i>Mangifera indica</i>	Anacardiaceae	Mango	Embe	Exotic	4	47	22	47	11
10*	<i>Morus alba</i>	Moraceae	White mulberry	Mfurusadi	Exotic	1	7	1	0	0
11	<i>Musa sapientum</i>	Musaceae	Dessert banana	Ndizi ya kuivisha	Exotic	7	73	164	53	84
12*	<i>Passiflora species</i>	Passifloraceae	Granadilla	-	Exotic	1	0	0	7	1
13*	<i>Passiflora edulis</i>	Passifloraceae	Passion fruit	Marakucha	Exotic	1	7	3	0	0
14*	<i>Persea americana</i>	Lauraceae	Avocado	Parachichi	Exotic	6	53	26	80	26
15	<i>Physalis peruviana</i>	Solanaceae	Cape gooseberry	-	Exotic	1	7	1	0	0
16*	<i>Psidium guajava</i>	Myrtaceae	Guava	Pera	Exotic	3	47	31	67	27
17*	<i>Solanum betaceum</i>	Solanaceae	Tree tomato	Gogwe	Exotic	1	7	1	0	0
18*	<i>Syzygium cuminii</i>	Myrtaceae	Java plum	Zambarau	Exotic	1	27	5	7	1
19*	<i>Vitex doniana</i>	Verbenaceae	Black plum	Fudu	Indigenous	1	7	3	0	0
<b>Pulses/nuts/seeds</b>										
20	<i>Arachis hypogaea</i>	Fabaceae	Groundnut	Njugu karanga	Exotic	2	47	11, 753	7	30
21	<i>Cajanus</i>	Fabaceae	Pigeon pea	Mbaazi	Exotic	1	40	856	7	47

Appendix I: Species Lists

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
	<i>cajan</i>									
22	<i>Glycine max</i>	Fabaceae	Soy bean	Soya	Exotic	1	33	4,646	20	3,143
23	<i>Lens culinaris</i>	Fabaceae	Lentil	Kamande	Exotic	1	0	0	7	2
24	<i>Phaseolus vulgaris</i>	Fabaceae	Common bean	Maharagwe	Exotic	9	20	28, 155	7	1
25	<i>Vigna radiata</i>	Fabaceae	Mung bean/greengram	Ndengu	Exotic	1	7	280	0	0
26	<i>Vigna subterranea</i>	Fabaceae	Bambara nut	Njugu mawe	Exotic	1	7	1220	0	0
<b>Spices/condiments</b>										
27	<i>Camellia sinensis</i>	Theaceae	Tea	Chai	Exotic	1	0	0	13	2,198
28	<i>Capsicum annum</i>	Solanaceae	Sweet pepper	Pilipili hoho	Exotic	1	20	5	20	7
29	<i>Coffea arabica</i>	Rubiaceae	Arabica coffee	Kahawa	Exotic	1	7	5	13	13
<b>Starchy roots/tubers/ green bananas</b>										
30	<i>Colocasia esculenta</i>	Araceae	Taro	Nduma	Exotic	2	53	3,792	67	395
31	<i>Ipomoea batatas</i>	Convolvulaceae	Sweet potato	Kiazi kitamu	Exotic	6	60	14, 821	67	7,069
32	<i>Manihot esculenta</i>	Euphorbiaceae	Cassava	Mhogo	Exotic	5	80	12, 109	40	92

Appendix I: Species Lists

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
33	<i>Musa paradisiaca</i>	Musaceae	Cooking banana	Ndizi ya kupika	Exotic	3	40	20	80	178
34	<i>Solanum tuberosum</i>	Solanaceae	Irish potato	Kiazi	Exotic	1	0	0	7	3
<b>Vegetables</b>										
35	<i>Allium cepa</i>	Alliaceae	Bulb onion	Kitunguu	Exotic	1	0	0	7	300
36	<i>Allium fistulosum</i>	Alliaceae	Spring onion	Kitunguu cha kijiti	Exotic	1	20	68	47	65
37	<i>Amaranthus cruentus subspecies hybridus</i>	Amaranthaceae	Amaranth	Mchicha	Indigenous	1	33	185	67	233
38	<i>Amaranthus hybridus complex</i>	Amaranthaceae	Amaranth	Mchicha	Indigenous	1	13	11	27	353
39	<i>Basella alba</i>	Basellaceae	Indian spinach	Nderema	Exotic	1	0	0	27	10
40	<i>Brassica carinata</i>	Brassicaceae	Ethiopian cabbage	Kanzira	Indigenous	1	0	0	7	93
41	<i>Brassica oleracea var. acephala</i>	Brassicaceae	African kale	Sukuma wiki	Exotic	2	53	2,447	80	6,533
42	<i>Cleome gynandra</i>	Capparaceae	Spider plant	Mkabili	Indigenous	1	7	10	27	36
43	<i>Cleome hirta</i>	Capparaceae	Spider plant	Mkabili	Indigenous	1	7	22	0	0
44	<i>Commelina species</i>	Commelinaceae	Dayflower	Linyolonyolo	Indigenous	1	7	19, 575	0	0

Appendix I: Species Lists

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
45	<i>Corchorus acutangulus</i>	Tiliaceae	Jew's mallow	Mlenda	Indigenous	1	7	19	13	292
46	<i>Corchorus olitorius</i>	Tiliaceae	Jew's mallow	Mlenda	Indigenous	1	7	37	20	285
47	<i>Corchorus trilocularis</i>	Tiliaceae	Jew's mallow	Mlenda	Indigenous	1	0	0	20	162
48	<i>Corchorus tridens</i>	Tiliaceae	Jew's mallow	Mlenda	Indigenous	1	13	52	60	2,289
49	<i>Crotalaria ochroleuca</i>	Fabaceae	Slender leaf	Mito	Indigenous	1	33	1,917	53	9,706
50	<i>Cucurbita maxima</i>	Cucurbitaceae	Pumpkin	Malenge	Exotic	1	27	20	33	10
51	<i>Cucurbita moschata</i>	Cucurbitaceae	Pumpkin	Malenge	Exotic	1	40	32	60	31
52	<i>Erythrococca bongensis</i>	Euphorbiaceae	-	Shirieto	Indigenous	1	7	1	0	0
53	<i>Solanum lycopersicum</i>	Solanaceae	Tomato	Nyanya	Exotic	1	13	6	40	15
54	<i>Solanum melongena</i>	Solanaceae	Egg plant	Biringanya	Exotic	1	0	0	7	2
55	<i>Solanum americanum</i>	Solanaceae	Black nightshade	Mnavu	Indigenous	1	27	3,604	53	438
56	<i>Solanum scabrum</i>	Solanaceae	Black nightshade	Mnavu	Indigenous	1	13	206	7	1,162
57	<i>Solanum villosum</i>	Solanaceae	Black nightshade	Mnavu	Indigenous	1	0	0	7	1

## Appendix I: Species Lists

No.	Scientific name	Family	Common English name	Local Swahili name	Origin of species	No. of varieties	Mumias district (15 farms in 3 villages)		Vihiga district (15 farms in 3 villages)	
							Frequency of occurrence (%)	Number of individuals per species (no.)	Frequency of occurrence (%)	Number of individuals per species (no.)
58	<i>Vigna unguiculata</i>	Fabaceae	Cowpea	Kunde	Indigenous	4	73	8,548	80	8,949
<b>High-sugar foods</b>										
59	<i>Saccharum officinarum</i>	Poaceae	Sugarcane	Miwa	Exotic	8	53	86,065	67	94

\*refers to fruit tree species available in the present study. Nomenclature mainly follows PROTA (2010) and Maundu *et al.* (1999)

## Appendix I: Species Lists

### 9.1.2 Species List 6.1

List of food plant species (sorted by food use groups), their scientific and common names, nutrient amounts, on-farm annual yields and market access levels in 30 farms and seven markets surveyed in Mumias and Vihiga districts, Western Kenya, in September/October 2012 and July/August 2014

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
<b>Cereals</b>									
1	<i>Zea mays</i>	Maize	Mahindi	Carbohydrates	76.9 g/100g (A)	2038	1642	Medium	High
2	<i>Eleusine corocana</i>	Finger millet	Mtama	Carbohydrates	76.2 g/100g (A)	0	0	Medium	Medium
3	<i>Sorghum bicolor</i>	Sorghum	Mawele	Carbohydrates	73.7 g/100g (A)	116	276	Medium	Medium
<b>Fruits</b>									
4	<i>Ananas comosus</i>	Pineapple	Nanasi	Vitamin C	15.0 mg/100g (A)	77	54	Low	Low
5	<i>Annona muricata</i>	Soursop	Mtomoko	Vitamin C	20.6 mg/100g (E)	80	0	NA	NA
6	<i>Carica papaya</i>	Papaya	Paipai	Folic acid	38.0 µg/100g (A)	240	432	NA	Medium
7	<i>Citrus limon</i>	Lemon	Ndimu	Vitamin C	53.0 mg/100g (A)	0	0	Medium	Low
8	<i>Citrullus lanatus</i>	Watermelon	-	Vitamin C	6.0 mg/100g (A)	0	0	Medium	Low

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
9	<i>Citrus sinensis</i>	Orange	Chungwa	Vitamin C	53.0 mg/100g (A)	0	0	Medium	Medium
10	<i>Eriobotrya japonica</i>	Loquat	Zabibu	Vitamin C	5.0 mg/100g (E)	32	33	NA	NA
11	<i>Mangifera indica</i>	Mango	Embe	Vitamin A	400.0 µg/100g (A)	1121	635	High	High
12	<i>Morus alba</i>	White mulberry	Mfurusadi	Carbohydrates	9.8 g/100g (E)	80	40	NA	NA
13	<i>Musa sapientum</i>	Dessert banana	Ndizi ya kuivisha	Carbohydrates	31.2 g/100g (A)	559	984	High	Medium
14	<i>Passiflora</i> species	Granadilla	-	Vitamin A	54.0 µg/100g (A)	84	230	NA	Low
				Carbohydrates	11.1 g/100g (A)				
15	<i>Persea americana</i>	Avocado	Parachichi	Vitamin C	8.0 mg/100g (A)	1059	1136	High	High
				Carbohydrates	7.4 g/100g (A)				
16	<i>Psidium guajava</i>	Guava	Pera	Vitamin C	184.0 mg/100g (A)	389	469	NA	NA
<b>Pulses/nuts/seeds</b>									
17	<i>Arachis</i>	Groundnut	Njugu karanga	Proteins	25.8 g/100g	611	382	Low	Low

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
	<i>hypogaea</i>				(A)				
				Zinc	3.3 mg/100g (A)				
18	<i>Cajanus cajan</i>	Pigeon pea	Mbaazi	Proteins	22.0 g/100g (A)	50	10	NA	NA
				Folic acid	302.0 µg/100g (A)				
19	<i>Glycine max</i>	Soy bean	Soya	Proteins	35.1 g/100g (A)	99	398	Low	Medium
20	<i>Phaseolus vulgaris</i>	Common bean	Maharagwe	Proteins	22.4 g/100g (A)	444	460	Medium	Low
				Folic acid	334.0 µg/100g (A)				
21	<i>Pisum sativum</i>	Pea	Minji	Vitamin C	25.0 mg/100g (A)	0	0	NA	High
22	<i>Sesamum indicum</i>	Sesame	Simsim	Proteins	17.7 g/100g (A)	0	0	Low	Low
				Zinc	7.8 mg/100g (A)				
				Iron	10.0 mg/100g (A)				
23	<i>Vigna radiata</i>	Mung	Ndengu	Proteins	20.3 g/100g	180	113	Low	Low

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
		bean/greengram			(A)				
				Folic acid	549.0 µg/100g (A)				
<b>Spices/condiments</b>									
24	<i>Capsicum annuum</i>	Chilli pepper	Pilipili	Vitamin C	292.0 mg/100g (A)	121	15	High	Low
25	<i>Capsicum</i> species	Sweet pepper	Pilipili hoho	Vitamin C	109.0 mg/100g (A)	0	0	Low	Low
26	<i>Coriandrum sativum</i>	Coriander	Dhania	Vitamin C	566.7 mg/100g (E)	0	0	Low	Low
				Iron	42.5 mg/100g (E)				
27	<i>Cymbopogon citratus</i>	Lemon grass	-	Folic acid	75.0 µg/100g (E)	0	11	NA	NA
<b>Starchy roots/tubers/ green bananas</b>									
28	<i>Colocasia esculenta</i>	Taro	Nduma	Carbohydrates	26.8 g/100g (A)	281	328	NA	Medium
29	<i>Dioscorea bulbifera</i>	Air potato	-	Carbohydrates	27.9 g/100g (D)	20	0	NA	NA
30	<i>Ipomoea batatas</i>	Sweet potato	Kiazi kitamu	Carbohydrates	22.9 g/100g	717	716	High	High

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
					(A)				
31	<i>Manihot esculenta</i>	Cassava	Mhogo	Carbohydrates	31.9 g/100g (A)	647	823	Medium	High
32	<i>Musa paradisiaca</i>	Cooking banana	Ndizi ya kupika	Carbohydrates	23.4 g/100g (A)	355	1171	NA	High
33	<i>Solanum tuberosum</i>	Irish potato	Kiazi	Carbohydrates	21.6 g/100g (A)	110	0	Medium	High
<b>Vegetables</b>									
34	<i>Abelmoschus esculentus</i>	Okra	-	Carbohydrates	8.2 g/100g (C)	0	13	NA	NA
35	<i>Allium cepa</i>	Bulb onion	Kitunguu	Vitamin C	5.0 mg/100g (A)	0	0	Medium	High
36	<i>Allium fistulosum</i>	Spring onion	Kitunguu cha kijiti	Vitamin C	13.0 mg/100g (A)	26	17	Low	High
37	<i>Amaranthus</i> species	Amaranth	Mchicha	Iron	8.9 mg/100g (C)	354	69	High	Medium
38	<i>Basella alba</i>	Indian spinach	Nderema	Vitamin A	347.4 µg/100g (E)	460	53	NA	NA
39	<i>Brassica carinata</i>	Ethiopian cabbage	Kanzira	Vitamin A	740.0 µg/100g (A)	60	20	High	Low
40	<i>Brassica oleracea</i> var.	African kale	Sukuma wiki	Vitamin A	500.0 µg/100g (E)	253	107	High	Medium

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
	<i>acephala</i>								
41	<i>Cleome</i> species	Spider plant	Mkabili	Iron	6.0 mg/100g (C)	78	110	High	Medium
42	<i>Comellina</i> species	Dayflower	Linyolonyolo	Iron	11.6 mg/100g (B)	0	16	NA	NA
				Folic acid	73.0 µg/100g (A)				
43	<i>Corchorus</i> species	Jew's mallow	Mlenda	Folic acid	800.0 µg/100g (A)	167	46	High	Medium
44	<i>Crotalaria ochroleuca</i>	Slender leaf	Mito	Vitamin A	303.0 µg/100g (A)	71	99	High	Medium
45	<i>Cucurbita</i> species	Pumpkin	Malenge	Folic acid (leaves)	36.0 µg/100g (E)	217	65	High	High
				Vitamin C (fruits)	5.0 mg/100g (A)	383	357	Medium	High
46	<i>Daucus carota</i>	Carrot	Karoti	Vitamin A	835.0 µg/100g (E)	0	0	Medium	High
47	<i>Erythrococca bongensis</i>	-	Shirieto	Vitamin A	303.0 µg/100g (A)	12	33	NA	NA
48	<i>Solanum lycopersicum</i>	Tomato	Nyanya	Vitamin C	19.0 mg/100g (A)	65	18	High	High
49	<i>Solanum</i>	Egg plant	Biringanya	Carbohydrates	6.6	21	10	Medium	High

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
	<i>melongena</i>				g/100g (A)				
50	<i>Solanum americanum</i>	Black nighshade	Mnavu	Vitamin C	24.0 mg/100g (A)	843	52	High	Medium
51	<i>Solanum scabrum</i>	Black nighshade	Mnavu	Vitamin C	24.0 mg/100g (A)	80	23		
52	<i>Solanum villosum</i>	Black nighshade	Mnavu	Vitamin C	24.0 mg/100g (A)	0	40		
53	<i>Vigna unguiculata</i>	Cowpea	Kunde	Vitamin A (leaves)	519.0 µg/100g (A)	333	113	High	Medium
				Zinc(seeds)	1.3 mg/100g (A)	0	0	Low	Medium
<b>High-sugar foods</b>									
54	<i>Saccharum officinarum</i>	Sugarcane	Miwa	Carbohydrates	6.8 g/100g (A)	97157	107496	NA	NA
<b>Animal source foods</b>									
55	<i>Bos taurus</i>	Cattle	Ng'ombe	Proteins (meat)	24.9 g/100g (A)	2108	1150	Low	Low
				Zinc (meat)	4.1 mg/100g (A)				
				Vitamin A (milk)	55.0 µg/100g (A)	6956	2400	Low	Medium

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
				Carbohydrates (milk)	4.8 g/100g (A)				
56	<i>Gallus gallus domesticus</i>	Chicken	Kuku	Proteins (meat)	18.8 g/100g (A)	241	218	Low	Low
				Proteins (egg)	12.6 g/100g (A)	132	91	Low	Low
57	<i>Tilapia</i> species	Tilapia fish	Samaki ya tilapia	Proteins	22.1 g/100g (A)	0	600	Medium	High
58	<i>Capra aegagrus hircus</i>	Goat	Mbuzi	Proteins (meat)	17.4 g/100g (A)	840	560	Low	NA
				Vitamin A (milk)	56.0 µg/100g (A)	0	10	NA	NA
				Carbohydrates (milk)	4.5 g/100g (A)				
59	<i>Isoptera</i> species	Termite	Kumbikumbi	Proteins	19.7 g/100g (A)	0	0	NA	Low
60	<i>Ovis aries</i>	Sheep	Kondoo	Proteins (meat)	24.9 g/100g (A)	733	880	Medium	NA
				Zinc (meat)	4.1 mg/100g (A)				
61	<i>Sus scrofa domesticus</i>	Pig	Nguruwe	Proteins (meat)	28.7 g/100g (A)	360	3240	Low	NA

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Main nutrient(s) responsible for clustering each species relative to others in the dendrogram (where applicable, plant or animal part consumed)	Nutrient amount of edible portion (with alphabetical symbols denoting the reference sources, detailed at the end of the table)	On-farm species average annual yield (g/100g edible portion)		Market species access level (High/Medium/Low /NA: unavailable)	
						2012	2014	2012 High: >12.3 Medium: 4.6-12.3 Low: 1.3-4.5	2014 High: >10.3 Medium: 5.4-10.3 Low: 1.5-5.3
				Zinc (meat)	4.1 mg/100g (A)				
62	<i>Oryctolagus cuniculus</i>	Rabbit	Sungura	Proteins (meat)	26.9 g/100g (A)	75	100	NA	NA

Nomenclature mainly follows PROTA (2010) and Maundu *et al.* (1999). The alphabetical symbols denoting the nutrient amount reference sources are: A= (Erhardt, 2007), B= (Maundu *et al.*, 1999), C= (PROTA, 2010), D= (Saxholt, 2009), E= (USDA, 2014)

## Appendix I: Species Lists

### 9.1.3 Species List 7.1

List of food plant species (sorted by food use groups), their scientific and common names as well as their availability in seven markets and 30 farms surveyed in Mumias and Vihiga districts, Western Kenya, in September/October 2012

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part /product available)	Availability on farms (where applicable, animal part/product available)
<b>Cereals</b>					
1	<i>Zea mays</i>	Maize	Mahindi	Available	Available
2	<i>Eleusine corocana</i>	Finger millet	Mtama	Available	Unavailable
3	<i>Oryza sativa</i>	Rice	Mchele	Available	Unavailable
4	<i>Sorghum bicolor</i>	Sorghum	Mawele	Available	Available
5	<i>Triticum aestivum</i>	Wheat	Wimbi	Available	Unavailable
<b>Fruits</b>					
6	<i>Ananas comosus</i>	Pineapple	Nanasi	Available	Available
7	<i>Annona muricata</i>	Soursop	Mtomoko	Unavailable	Available
8	<i>Carica papaya</i>	Papaya	Paipai	Unavailable	Available
9	<i>Citrus limon</i>	Lemon	Ndimu	Available	Available
10	<i>Citrullus lanatus</i>	Watermelon	-	Available	Unavailable
11	<i>Citrus sinensis</i>	Orange	Chungwa	Available	Unavailable
12	<i>Dovyalis caffra</i>	Kei apple	-	Unavailable	Available
13	<i>Eriobotrya japonica</i>	Loquat	Zabibu	Unavailable	Available
14	<i>Mangifera indica</i>	Mango	Embe	Available	Available
15	<i>Morus alba</i>	White mulberry	Mfurusadi	Unavailable	Available
16	<i>Musa sapientum</i>	Dessert banana	Ndizi ya kuivisha	Available	Available
17	<i>Passiflora species</i>	Granadilla	-	Unavailable	Available
18	<i>Passiflora edulis</i>	Passion fruit	Marakucha	Unavailable	Available
19	<i>Persea americana</i>	Avocado	Parachichi	Available	Available
20	<i>Physalis peruviana</i>	Cape gooseberry	-	Unavailable	Available
21	<i>Psidium guajava</i>	Guava	Pera	Unavailable	Available

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part /product available)	Availability on farms (where applicable, animal part/product available)
22	<i>Solanum betaceum</i>	Tree tomato	Gogwe	Unavailable	Available
23	<i>Syzygium cuminii</i>	Java plum	Zambarau	Unavailable	Available
24	<i>Vitex doniana</i>	Black plum	Fudu	Unavailable	Available
<b>Pulses/nuts/seeds</b>					
25	<i>Arachis hypogaea</i>	Groundnut	Njugu karanga	Available	Available
26	<i>Cajanus cajan</i>	Pigeon pea	Mbaazi	Unavailable	Available
27	<i>Glycine max</i>	Soy bean	Soya	Available	Available
28	<i>Lens culinaris</i>	Lentil	Kamande	Unavailable	Available
29	<i>Phaseolus vulgaris</i>	Common bean	Maharagwe	Available	Available
30	<i>Sesamum indicum</i>	Sesame	Simsim	Available	Available
31	<i>Vigna radiata</i>	Mung bean/greengram	Ndengu	Available	Available
32	<i>Vigna subterranea</i>	Bambara nut	Njugu mawe	Unavailable	Available
<b>Spices/condiments</b>					
33	<i>Allium sativum</i>	Garlic	Kitunguu saumu	Available	Unavailable
34	<i>Camellia sinensis</i>	Tea	Chai	Unavailable	Available
35	<i>Capsicum annum</i>	Chilli pepper	Pilipili	Available	Available
36	<i>Coffea arabica</i>	Coffee	Kahawa	Unavailable	Available
37	<i>Coriandrum sativum</i>	Coriander	Dhania	Available	Unavailable
38	<i>Zinziger officinale</i>	Ginger	Tangawizi	Available	Unavailable
<b>Starchy roots/tubers/ green bananas</b>					
39	<i>Colocasia esculenta</i>	Taro	Nduma	Unavailable	Available
40	<i>Dioscorea bulbifera</i>	Air potato	-	Unavailable	Available
41	<i>Ipomoea batatas</i>	Sweet potato	Kiazi kitamu	Available	Available
42	<i>Manihot esculenta</i>	Cassava	Mhogo	Available	Available
43	<i>Musa paradisiaca</i>	Cooking banana	Ndizi ya kupika	Unavailable	Available

Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part /product available)	Availability on farms (where applicable, animal part/product available)
44	<i>Solanum tuberosum</i>	Irish potato	Kiazi	Available	Available
<b>Vegetables</b>					
45	<i>Allium cepa</i>	Bulb onion	Kitunguu	Available	Available
46	<i>Allium fistulosum</i>	Spring onion	Kitunguu cha kijiti	Available	Available
47	<i>Amaranthus</i> species	Amaranth	Mchicha	Available	Available
48	<i>Basella alba</i>	Indian spinach	Nderema	Unavailable	Available
49	<i>Brassica carinata</i>	Ethiopian cabbage	Kanzira	Available	Available
50	<i>Brassica oleracea</i> var. <i>acephala</i>	African kale	Sukuma wiki	Available	Available
51	<i>Brassica oleracea</i> var. <i>acephala</i>	(White) cabbage	Kabichi	Available	Unavailable
52	<i>Cleome gynandra</i>	Spider plant	Mkabili	Available	Available
53	<i>Cleome hirta</i>	Spider plant	Mkabili	Unavailable	Available
54	<i>Corchorus</i> species	Jew's mallow	Mlenda	Available	Available
55	<i>Crotalaria</i> species	Slender leaf	Mito	Available	Available
56	<i>Cucurbita</i> species	Pumpkin	Malenge	Available	Available
57	<i>Daucus carota</i>	Carrot	Karoti	Available	Available
58	<i>Erythrococca bongensis</i>	-	Shirieto	Unavailable	Available
59	<i>Solanum lycopersicum</i>	Tomato	Nyanya	Available	Available
60	<i>Solanum melongena</i>	Egg plant	Biringanya	Available	Available
61	<i>Solanum</i> species	Black nighshade	Mnavu	Available	Available
62	<i>Spinacia oleracea</i>	Spinach	-	Available	Unavailable
63	<i>Vigna unguiculata</i>	Cowpea	Kunde	Available	Available
<b>High-sugar foods</b>					
64	<i>Saccharum officinarum</i>	Sugarcane	Miwa	Unavailable	Available
<b>Animal source foods</b>					

## Appendix I: Species Lists

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part /product available)	Availability on farms (where applicable, animal part/product available)
65	<i>Bos taurus</i>	Cattle	Ng'ombe	Available (whole animal, milk, meat)	Available (whole animal, milk)
66	<i>Gallus gallus domesticus</i>	Chicken	Kuku	Available (whole animal, egg)	Available (whole animal, egg)
67	<i>Tilapia species</i>	Tilapia fish	Samaki ya tilapia	Available	Unavailable
68	<i>Capra aegagrus hircus</i>	Goat	Mbuzi	Available (whole animal)	Available (whole animal, milk)
69	<i>Ovis aries</i>	Sheep	Kondoo	Available (whole animal)	Available (whole animal)
70	<i>Sus scrofa domesticus</i>	Pig	Nguruwe	Available (meat)	Available (whole animal)
71	<i>Oryctolagus cuniculus</i>	Rabbit	Sungura	Unavailable	Available (whole animal)

Nomenclature mainly follows PROTA (2010) and Maundu *et al.* (1999)

## 9.2 Appendix II: Co-author declarations



Nairobi, 7<sup>th</sup> August 2015

To whom it may concern:

**RE: Statement for inclusion with Mary Ng'endo Kanui's thesis**

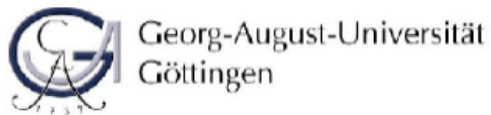
I declare that the manuscript presented in Paper 1 (Title "Variability of on-farm food plant diversity and its contribution to food security: A case study of smallholder farming households in Western Kenya") within this DPhil thesis for which I am a co-author, is substantially the work of the first author, Mary Ng'endo Kanui, and that my role has been limited to supervisory input and comments on drafts.

Yours sincerely,

A handwritten signature in purple ink, appearing to read "Katja Kehlenbeck", with a stylized flourish at the end.

**Katja Kehlenbeck, PhD**  
Food Tree Scientist  
Tree Diversity, Domestication and Delivery  
E: k.kehlenbeck@cgiar.org  
T: +254 20 7224381

## Appendix II: Co-author declarations



Department of  
Crop Sciences

Crop Sciences · Carl-Sprengel-Weg 1 · D-37075 Göttingen

Division Quality of Plant Products

Dr. Gudrun Keding  
Carl-Sprengel-Weg 1  
D-37075 Goettingen  
Fon: +49 (0) 551 / 39-5541  
Fax: +49 (0) 551 / 39-25570  
gkeding@gwdg.de

To whom it may concern:

Göttingen, 7 August 2015

### **RE: Statement for inclusion with Mary Ng'endo Kanui's thesis**

I declare that the manuscripts presented in Papers 1, 2, 3 and 4 within this DPhil thesis for which I am a co-author, are substantially the work of the first author, Mary Ng'endo Kanui, and that my role has been limited to supervisory input and comments on drafts.

Yours sincerely,



Dr. Gudrun B. Keding

Carl-Sprengel-Weg 1  
D-37075 Göttingen

Fon: +49 (0)551 / 39-5541  
Fax: +49 (0)551 / 39-25570

gkeding@gwdg.de

## Appendix II: Co-author declarations



Dr Shonil A Bhagwat  
Department of Geography  
Faculty of Social Sciences

The Open University  
Walton Hall  
Milton Keynes  
United Kingdom  
MK7 6AA

To Whom It May Concern:

Tel +44 (0) 1908 65 5375  
Fax +44 (0) 1908 654 488  
Email: [shonil.bhagwat@open.ac.uk](mailto:shonil.bhagwat@open.ac.uk)  
Web: <http://tinyurl.com/shonilbhagwat>

Ref 08 August 2015

### Statement for inclusion with Mary Ng'endo Kanui's thesis

I declare that the manuscripts presented in Papers 1, 2, 3 and 4 within this DPhil thesis for which I am a co-author, are substantially the work of the first author, Mary Ng'endo Kanui, and that my role has been limited to supervisory input and comments on drafts.

Yours sincerely,

Shonil A Bhagwat

Fellow of Royal Geographical Society with the Institute of British Geographers, London

Lecturer in Geography, Department of Geography; and Director of Research Degrees Programme, Faculty of Social Sciences, The Open University, UK  
Web: <http://tinyurl.com/shonilbhagwat>

Senior Visiting Research Associate, School of Geography and the Environment, University of Oxford

Senior Research Associate, Biodiversity Institute, Oxford Martin School, University of Oxford  
Adjunct Fellow, Linacre College, Oxford

The Open University is incorporated by Royal Charter (RC 000391), an exempt charity in England & Wales and a charity registered in Scotland (SC 038302)

## 9.3 Appendix III: Additional thesis output - policy brief

To link to this article: <http://www.biodiversityinternational.org/e-library/publications/detail/diversifying-local-agriculture-agricultural-diversity-on-smallholder-farms-and-in-local-markets-in-western-kenya/>



### Diversifying local agriculture Agricultural diversity on smallholder farms and in local markets in Western Kenya

#### Background

While malnutrition in all its forms still imposes high economic and social costs on many countries in the world, agricultural productivity growth remains crucial but is not sufficient to bring about a rapid reduction in malnutrition, especially undernutrition. Beyond staple foods, agriculture needs a stronger focus on nutrient-dense foods (vegetables, fruits, legumes and animal source foods), suggesting the diversification of smallholder production, such as integrated farming systems (FAO 2013, The State of Food and Agriculture).

Traditional mixed farms with their diverse set of food crops and their focus on local production are considered to be sustainable and resilient agro-ecological systems (Kremen et al., 2012). They significantly contribute to meeting food and nutrition needs of farming households (Dury et al., 2014) as well as providing additional income especially for women through sale of surplus produce. For meeting household's food and nutrition needs all year round, the diversity of different food plant species cultivated on a farm is not as important as a good mixture of species from different food groups with different

nutritional values. This study tried to assess food plant but also animal diversity in different smallholder farms and in local markets in Western Kenya.

#### INULA – Improving nutrition through local agrobiodiversity

- 2.5-year research programme (2012-2014) in Western Kenya
- Studied quality and accessibility of complementary foods in rural households
- Examined the availability and use of local agricultural biodiversity on smallholder farms
- Carried out four nutrition education sessions for mothers/ caregivers on diversifying complementary foods



#### References

- Kremen, C., Iles, A., Bacon, C., 2012. Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture. *Ecology and Society* 17, 44.
- Dury, S., Alpha, A., Bichant, A., 2014. What risks do agricultural interventions entail for nutrition? UMAR- MOISA (Unité mixte de recherche- Marchés, Organisations, Institutions et Stratégies d'Acteurs), Montpellier

## Summary of findings and recommendations

Food availability is highly seasonal, especially in semi-arid regions, and foods are largely sourced from the own farm with the market playing an important role in closing food and preference gaps.

Smallholder farmers need support to diversify more into high-value nutrient-dense crops and livestock species and get organized to fill in local market gaps, e.g. through developing markets and improving extension services especially for nutrient-dense products.

Stronger communication/information for and by agriculture extension workers on nutrition and the importance of dietary diversity is needed. Thereby, knowledge about different food types within one food group and their nutritional values is important. In addition, understanding how they can replace each other in order to not rely on one food plant species within one group only is key.

Seasonal gaps in food groups such as fruits and pulses need to be addressed through agriculture in order to be more nutrition-sensitive.



Figure 4: Percentage of households (n=439) facing food shortage/hunger (blue columns) and availability of different foods within 4 major food groups as reported by focus group discussion members in 12 villages in Western Kenya (dark colour = high availability; light colour = low availability; no colour = no availability)

## Contact us

Bioversity International Africa  
 c/o ICRAF, PO Box 30677 - 00100  
 Nairobi, Kenya  
 Tel: (254-20) 7224500  
**Email: [bioversity-kenya@cgiar.org](mailto:bioversity-kenya@cgiar.org)**  
**[www.bioversityinternational.org](http://www.bioversityinternational.org)**  
 All pictures:  
 Bioversity International/VG. Keding

## Citation

Keding GB, Ng'endo M, 2015. *Diversifying local agriculture: Agricultural diversity on smallholder farms and in local markets in Western Kenya*. Bioversity International, 4 p.

This scientific brief was published by Bioversity International as part of the CGIAR Research Program on Agriculture for Nutrition and Health.



Bioversity International delivers scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security. Bioversity International is a member of the CGIAR Consortium, a global research partnership for a food-secure future.

## 9.4 Appendix IV: Questionnaires

### 9.4.1 Farm survey September/October 2012

1<sup>st</sup> Survey, Western Kenya 2012 Identity No. □-□□□-□

Date: \_\_\_\_\_ Interviewee: \_\_\_\_\_ Village: \_\_\_\_\_

Start time: \_\_\_\_\_ End time: \_\_\_\_\_ Total time: \_\_\_\_\_

Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_ Altitude: \_\_\_\_\_

Household area: \_\_\_\_\_ Non-farm area (e.g. house, stables, yard...): \_\_\_\_\_

#### Household Data

1	What is your relationship to the household head? / <i>uhusiano wako na mwenye nyumba ni upi?</i>	1= household head → <i>Q3</i> 2= conjugal partner (wife/husband, girlfriend/boyfriend) 3= other (please specify):	RELAHHH	
2	What is your name and age? / <i>unaitwa nani na umri wako ni upi?</i>  <i>Observe: is he / she male / female?</i>	Name:  Age:  (or) age class (e.g. 20-24 years):  Sex: <input type="checkbox"/> male <input type="checkbox"/> female	HHMNAME  HHMAGE  HHMCLASS  HHMSEX	
3	If household head:/kama ni mwenye nyumba What is your name and age? Observe: male or female?/unaitwa nani na umri wako ni upi?  If household member: What is the name, age and sex of the household head?	Name:  Age:  (or) age class (e.g. 25-29 years):  Sex: <input type="checkbox"/> male <input type="checkbox"/> female	HHHNAME  HHHAGE  HHhCLASS  HHHSEX	
4	What is your mobile number in case we would like to contact your household again?	Number:	PHONE	
5	What is the main source of income for your household (mention one or two with priority):/ <i>ni njia ipi unayopata pesa kwa jamii yako?</i>	1= Farming (focus crops) 2= Farming (focus livestock) 3= Farming (mixed crop/livestock) 4= Business 5= Petty trader/vocational skills 6= Casual labour 7= Wage employment 8= None	MAINOCC1    MAINOCC2	  

Appendix IV: Questionnaires

6	How many hectares of agricultural land do members of this household own?/ <i>ni ekari ngapi ya shamba wanafamilia wako wanamiliki?</i> <i>If more than 99, record '99'. If unknown, record '00'.</i>	Acres:  (or) hectares:	LANDACR  LANDHEC	 
7	Do you sometimes hire labour for agricultural activities?/ <i>kuna wakati unapoajiri wafanyikazi kwa shamba yako?</i>	1= yes 2= no	HIRELAB	
8	For how many years do you cultivate the farm? / <i>Umelima shamba yako kwa miaka ngapi?</i>	Since (year):	FARMYEAR	
9	How was the farm used before? / <i>shamba yako ilitumika vipi mwanzoni?</i>	1= farmland 2= other (please specify):	FARMUSE	
10	How do you rate the fertility of your soil? / <i>unaweza kuweka kiwango kipi cha rutuba ya mchanga wako?</i>	1= poor 2= intermediate 3= high	FARMSOIL	
11	<i>To be asked at the end of the interview:</i> How much does the household earn from agricultural activities?	1= up to 30,000 KES 2= 30,000 – 60,000 KES 3= 60,000 – 90,000 KES 4= 90,000 – 120,000 KES	FAINCOME	
12	<i>To be asked at the end of the interview:</i> What is the annual income of whole household?	1= up to 60,000 KES 2= 60,000 – 120,000 KES 3= 120,000 – 180,000 KES 4= 180,000 – 240,000 KES	TOINCOME	

**Animal Production**

13	Does this household own any livestock?/ <i>katika nyumba yako, mnamiliki wanyama wowote ambao wanawapa vyakula?</i>	1= yes 2= no → <i>Q 10</i>	ANIMALS				
14. <b>If yes:</b> Can we go outside/to the place where the animals are to have a look at them? <i>Count by yourself how many animals of each species and breed are around – if these are less than was stated by the farmer please ask where the other animals are and make a note (sold, eaten, lost etc.)./kama ndio:tunaweza kwenda nje/mahali wanyama wamo tuwatazame?</i>							
a) What types of livestock / breeds does your household own?*/ <i>ni aina gani ya wanyama nyumba yako inayomiliki?</i>		b) How much livestock does your household own (number of each breed)? / <i>ni wanyama wangapi nyumba yako inayomiliki (nambari ya kila aina)?</i>		c) Which use(s) does your livestock have?/ <i>wanyama wako wana matumizi gani?</i>	<i>Comments / photos Maoni/picha</i>		
Species	Breed	Total	Fe- males	Males	Young animals	Use(s)	

\*Possible types of livestock are cattle, goats, sheep, pigs, rabbits, guinea pigs, chicken or ducks. If not sure about the breed take a picture!

\*\*This information is important for the animal & income list.

Appendix IV: Questionnaires

**Animal usage & income**

15. Depending which livestock the family owns, capture the quantities and usage as well as the income of each animal food product. / <b>kulingana na wanyama wagani familia inayomiliki, andika nambari na matumizi pamoja na pesa inayopatikana kutoka kwa kila aina ya bidhaa ya chakula</b>								
Fill in the information ...	a) How often do you harvest / collect / rear this food product?*/ <b>ni mara ngapi unavuna/okota/fuga bidhaa hii ya chakula?</b>	b) How much of the product do you harvest / collect / rear? <b>/ni kiasi kipi cha bidhaa unachovuna/okota/fuga?</b>	c) At which time period(s) do you harvest / collect / rear the food product?/ <b>ni wakati upi unapovuna/okota/fuga bidhaa ya chakula hiki?</b>		d) How do you use the animal food product (percentages)?/ <b>unatumia vipi bidhaa kutoka wanyama (asilimia)?</b>		e) If you sell, how much income do you earn?/ <b>kama unauza, unapata pesa ngapi?</b>	
Animal food product	Frequency (daily, weekly, monthly...)	Amount & unit	Time period (e.g. dry or wet season...)	Additional notes	Home consumption	Give away	Sale	Income per week / month / year or price per unit)

\*We have to capture the last 12 months!

**Plant Production**

16. I would like to see your garden/farm and all crops that you grow there at the moment. Ask not only for major crops but also <b>vegetables, shrubs, trees</b> etc./ <b>ningetaka kuona bustani/shamba yako na mimea yote unayopanda kwa muda huu. Usiulize tu kuhusu mimea kuu lakini pia mboga, miti etc</b>							
a) Which (i) species and (ii)sub-species / types do you grow?/ <b>unakuza (i)aina/spishi na (ii) mfano wa aina/spishi ndogo ipi?</b>			b) How much of them are available (abundance)?/ <b>ni kiasi ipi inayopatikana (wingi)?</b>		c) Which part of the plant do you use?/ <b>ni sehemu gani ya mmea unayotumia?</b>	d) If a shrub or tree, how big is the plant?/ <b>kama ni mti mkubwa ama mdogo,ukubwa wake ni upi?</b>	e) Comments / photos <b>Maoni/picha</b>
(i)Species	(ii)Subspecies / types	(iii)Other	Number	Density	Plot	Height	

## Appendix IV: Questionnaires

	/ varieties	names*			size			

\*Add language in brackets e.g. (English), (Kiswahili), (Luhya)

### Plant usage & income

17. From the above, copy information on species/subspecies/types/varieties in first column, then proceed to ask questions in remaining columns								
Fill in the information below.....		a) How often do you harvest this plant? <i>/ni mara ngapi unavuna mmea huu?</i>	b) How much do you harvest? <i>/unavuna kiasi gani?</i>	At which time periods(s) do you harvest the plant (major and / or minor seasons)? <i>/ni wakati upi unapovuna mmea huu (mavuno ya juu/mavuno ya chini)</i>	f) How do you use these plants? How much do you consume / sale / give away (percentages)? <i>/unatumia mmea huu vipi?/unatumia kiasi gani?/kuuza/kupeana ukitarajia kurudishiwa na njia hiyo au nyingine (asilimia)?</i>			How much do you earn from selling (income)? <i>/unapata pesa ngapi kwa kuuza (mapato)?</i>
(i)Species	(ii)Subspecies / types / varieties	Frequency (daily, weekly, monthly...)	Amount & unit*	Time period(s) (months)	home consumption	give away	sale	Income (income per week / month / year or price per unit)

\*Define you unit!

9.4.2 Farm survey November/December 2012

2nd Survey, Western Kenya 2012

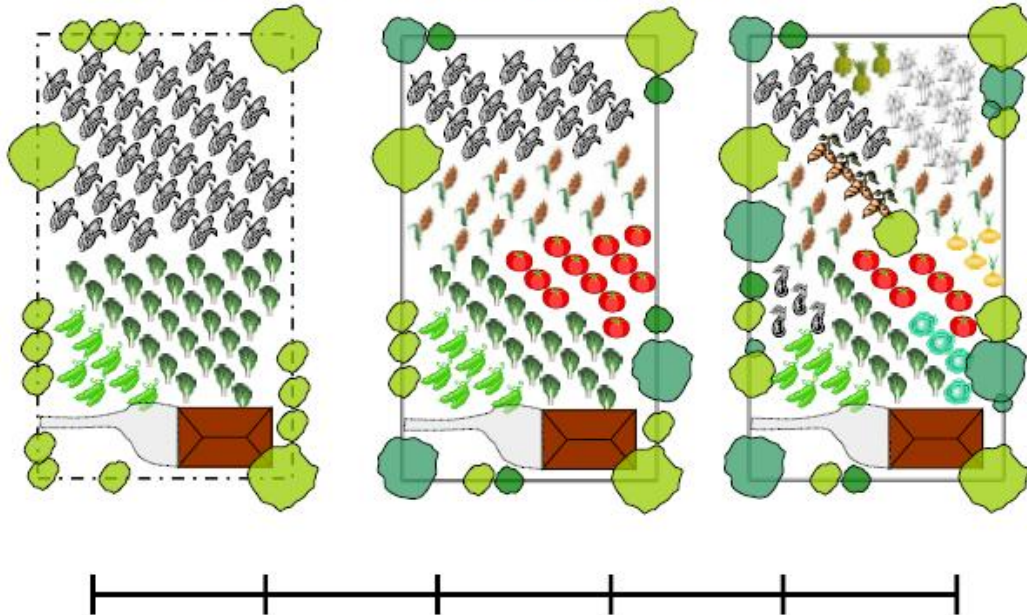
Identity No. □-□□□-□

Date: \_\_\_\_\_ Interviewee: \_\_\_\_\_ Village: \_\_\_\_\_

2nd Survey, Western Kenya 2012

Identity No. □-□□□-□

Question No.1: In terms of plant diversity, where would you rank your farm on the scale below?



**Part I: Farmer's perceptions on agrobiodiversity**

1	<p>Show and explain the farmer the diversity scale, above. How does the farmer rate the species richness of his farm? Does he think his level of agrobiodiversity is low medium or high? Onyesha na elezea skali. Mkulima anaweka shamba yake katika kiwango kipi katika wingi ya mimea tofauti aliyonayo? Anafikiria mimea tofauti aliyonayo iko katika kiwango cha katikati ama juu?</p> <table border="1"> <tr> <td>Low</td> <td>0 – 1.7</td> </tr> <tr> <td>Medium</td> <td>1.8-3.3</td> </tr> <tr> <td>High</td> <td>3.4-5</td> </tr> </table>	Low	0 – 1.7	Medium	1.8-3.3	High	3.4-5	<p>Rating:</p> <p>Category:</p>	RATING	
Low	0 – 1.7									
Medium	1.8-3.3									
High	3.4-5									
2	<p>How many species does the farmer have? Is his/her agrobiodiversity low, medium or high? Mkulima ako na mimea ngapi tofauti? Ako na mimea tofauti ya kiwango cha chini, katikati au juu?</p> <table border="1"> <tr> <td>Low</td> <td>≤ 9</td> </tr> <tr> <td>Medium</td> <td>10 – 20</td> </tr> <tr> <td>High</td> <td>≥ 21</td> </tr> </table>	Low	≤ 9	Medium	10 – 20	High	≥ 21	<p>Species richness (last time counting):</p> <p>Category:</p>	RICHNESS	
Low	≤ 9									
Medium	10 – 20									
High	≥ 21									
3	<p>Did the farmer estimate his farm diversity correctly? Compare the scale with the actual species richness. Mkulima aliweka kiwango sahihi ya mimea tofauti</p>	<p>1= overestimated 2= underestimated 3= correctly</p>	PERSEP	<input type="checkbox"/>						

Appendix IV: Questionnaires

	alinyonayo katika shamba yake? Linganisha skali na uhakika wa mimea tofauti alinyonayo	estimated → Q5										
4	Regarding the data we collected last time, we think you overestimated / underestimated the number of species you have on your farm. Why do you consider yourself of having so many / few plant species? Tukitumia mambo uliyotueleza wakati wa mwisho tulipokuwa hapa, tunafikiria umeweka katika hali ya juu sana/hali ya chini sana nambari ya mimea uliyonayo katika shamba yako. Kwa nini unafikiria uko na mimea mingi sana/chache sana?		PERREA									
5	Imagine if there were no limitations. Do you rather prefer having a diversified farm with many different kinds of plants or a specialized farm concentrating on few plants? <b><i>Kama hakungekuwa na vikwazo vyovyote, ungependelea kuwa na shamba ambayo ina mimea mingi tofauti ama shamba ambayo ina mimea mmoja au mimea chache tofauti?</i></b>	1= diversified farm (many species) 2= specialised farm (few species) 3= neither	VALUE	<input type="checkbox"/>								
6	Why is your farm not already like this? Kwa nini shamba yako haiko hivi tayari?		VALREA									
7	Check external document! Angalia karatasi nyingine											
	<table border="1"> <tr> <td></td> <td>☺</td> <td>☹</td> </tr> <tr> <td>High diversity /aina ya mimea mingi tofauti</td> <td></td> <td></td> </tr> <tr> <td>Low diversity/aina ya mimea chache tofauti</td> <td></td> <td></td> </tr> </table>		☺	☹	High diversity /aina ya mimea mingi tofauti			Low diversity/aina ya mimea chache tofauti				
	☺	☹										
High diversity /aina ya mimea mingi tofauti												
Low diversity/aina ya mimea chache tofauti												

8	How strongly do you think about the following statements? <b><i>Unapea uzito upi sentensi zifuatazo?</i></b>	strongly disagree <b><i>kataa kwa uzito</i></b> --	Disagree <b><i>kataa</i></b> -	Neutral <b><i>katikati</i></b> o	Agree <b><i>kubali</i></b> +	strongly agree <b><i>kubali kwa uzito</i></b> ++	don't know <b><i>sijui</i></b>
a	A farm with many different kinds of plants provides a household with a sufficient amount of food throughout the year(food security) Shamba iliyokuwa na mimea mingi tofauti hupa familia na kiasi cha kutosha cha chakula wakati wote wa mwaka(kuwa na chakula cha kutosha wakati wote).					X	
b	Farms with many different kinds of plants don't generate much income (income - control question) Mashamba yaliyo na mimea	x					

Appendix IV: Questionnaires

8	How strongly do you think about the following statements? <i>Unapea uzito upi sentensi zifuatazo?</i>	strongly disagree <i>kataa kwa uzito</i> --	Disagree <i>kataa</i> -	Neutral <i>katikati</i> o	Agree <i>kubali</i> +	strongly agree <i>kubali kwa uzito</i> ++	don't know <i>sijui</i>
	mingi tofauti hazileti pesa nyingi(kuwa na pesa-swali ya kupima ufahamu).						
c	A farm producing many different kinds of foods helps to provide a family with meals that supply the body with all the different kinds of nutrients it needs (balanced diet) Shamba inayoleta aina nyingi tofauti ya vyakula inasaidia kupa familia vyakula vinavyowapa madini mengi tofauti (chakula kinachokupa madini mengi tofauti).					X	
d	A family having a farm with few kinds of plants spends little money to have a variety of food (saving money) Familia ambayo iko na shamba ya aina ya mimea chache tofauti hutumia pesa kidogo kupata aina tofauti ya vyakula (kuokoa pesa).	X					
e	A farmer provides enough food for the family if he/she specializes on a few kinds of plants (food security - control question) Mkulima huweza kuwapa familia yake chakula cha kutosha kama anapanda aina chache ya mimea chache tofauti( kuwa na chakula cha kutosha-swali ya kupima ufahamu).	X					
f	Pests and diseases occur more frequently on farms with few kinds of plants (pests and diseases) Wadudu na wanyama wa mimea huwa wengi zaidi kwa mashamba yaliyo na aina chache ya mimea tofauti (wadudu na wanyama wa mimea).					X	
g	A farm with many different kinds of plants provides the household with a secure source of income throughout the year (income) Shamba iliyo na aina mingi ya mimea tofauti inawapa familia pesa ya kutegemewa kwa wakati wote wa mwaka (kuwa na pesa).					X	
h	Having few kinds of plants	X					

Appendix IV: Questionnaires

8	How strongly do you think about the following statements? <i>Unapea uzito upi sentensi zifuatazo?</i>	strongly disagree <i>kataa kwa uzito</i> --	Disagree <i>kataa</i> -	Neutral <i>katikati</i> o	Agree <i>kubali</i> +	strongly agree <i>kubali kwa uzito</i> ++	don't know <i>sijui</i>
	contributes to healthy soils (fertile soils) Kuwa na aina ya mimea chache inachangia kuwa na mchanga wa hali ya juu(mchanga wa hali ya juu).						
i	Farms with many different kinds of plants require fewer inputs such as fertiliser and chemicals (lack of inputs) Shamba iliyo na aina mingi tofauti ya mimea inahitaji mahitaji chache ya shamba, kama mbolea na kemikali(kukosa mahitaji ya shamba).					X	
j	A farm has to be big to accommodate many different kinds of plants (land scarcity) Shamba lazima iwe kubwa ili iweze kuwa na aina ya mimea mingi tofauti (shamba ndogo).	X					
k	If a drought occurs, a farm with many different kinds of plants cannot provide its family with enough food (unreliable weather/ Kama kiangazi inaweza kutokea, shamba iliyo na aina ya mimea mingi tofauti haiwezi kuipa familia chakula cha kutosha(ubadilikaji wa hali ya anga).	X					
l	Farmers who have an easy access to seeds can have more different kinds of plants (inputs) Wakulima ambao wanaweza kupata mbegu kwa urahisi wanaweza kuwa na aina mingi ya mimea tofauti(mahitaji ya shamba).					X	
m	If farmers cooperate, they can manage more different kinds of plants (lack of cooperation) Kama wakulima wanaweza kushirikiana, wanaweza kuwa na aina ya mimea mingi tofauti (kukosa ushirikiano)					X	
n	The overall yields from a farm with many different kinds of plants are small (small yields	X					

Appendix IV: Questionnaires

8	How strongly do you think about the following statements? <i>Unapea uzito upi sentensi zifuatazo?</i>	strongly disagree <i>kataa kwa uzito</i> --	Disagree <i>kataa</i> -	Neutral <i>katikati</i> o	Agree <i>kubali</i> +	strongly agree <i>kubali kwa uzito</i> ++	don't know <i>sijui</i>
	Kwa ujumla, mavuno yote kutoka shamba iliyo na aina ya mimea mingi tofauti ni kidogo(mavuno chache).						
o	Farms with high plant diversity attract a lot of thieves (theft/ Mashamba iliyo na aina ya mimea mingi tofauti inaweza kuleta wezi wengi(wizi).					X	
p	To manage many different kinds of plants a lot of knowledge on e.g. planting, weeding and harvesting is needed (lack of knowledge) Kulinda aina ya mimea mingi tofauti inahitaji ujuzi mwingi, kwa mfano, ujuzi wa kupanda, kutoa kwekwe na kuvuna(kukosa ujuzi).					X	
q	Farms with fewer kinds of plants are more time demanding (high labour required) Shamba iliyo na aina chache ya mimea tofauti inahitaji muda mwingi(kazi nyingi ya shamba).	X					
9	If a farmer wants to increase his plant diversity, what do you think can be done? Which is the most important action? Please rank the action according to their importance. Kama mkulima anataka kuboresha aina ya mimea tofauti aliyonayo, nini unafikiria inaweza kufanywa? Ni ipi kitendo cha muhimu zaidi? Tafadhali orodhesha vitendo hivi kwa umuhimu wake					IMPROVE	

**Part II: Household Food Sources, Post Harvest Losses & Other Questions**

10	From where do you get your food? <i>Unapata chakula chako kutoka wapi?</i>	<input type="checkbox"/> farm <input type="checkbox"/> market <input type="checkbox"/> family, friends, neighbours <input type="checkbox"/> wild <input type="checkbox"/> lake <input type="checkbox"/> other– specify:	SOURCES
11	What is the most important source of food for your family? <i>Ni njia ipi kuu unayopata chakula ya familia yako?</i>	1= farm 2= market 3= family, friends, neighbours 4= wild 5= lake 6= other – specify:	SOURCE1
12	Which is the second most important source of food for your family?	1= farm 2= market 3= family, friends, neighbours	SOURCE2

Appendix IV: Questionnaires

	<i>Ni njia ipi ya pili unayopata chakula ya familia yako?</i>	4= wild 5= lake 6= other – specify:						
13	We would like to estimate how much food comes from each source. <i>Capture the last five times a farmer has eaten any food from each food group. Tungependa kujua ni kiasi kipi cha chakula unayopata kwa kila njia Ulizia mara tano ya mwisho mkulima amekula chakula chochote kutoka kila kikundi cha chakula</i>	Time period	Farm	Market	Family, friends, neighbours	Wild	Lake	
a	Cereals (e.g. maize) <i>nafaka (kama mahindi)</i>							
b	Starchy roots, tubers, bananas (e.g. cassava, sweet potatoes) <i>mizizi na mandizi (kama miogo na viazi vitamu)</i>							
c	Green Leafy Vegetables (e.g. amaranth, kale) <i>Mboga ya kijai kibichi (kama mchicha na sukuma)</i>							
d	Non-leafy vegetables (e.g. tomatoes, onions) <i>Mboga isiyo ya kijani kibichi (kama nyanya na vitunguu)</i>							
e	Fruits (e.g. guava) <i>Matunda (kama mapera)</i>							
f	Pulses, nuts and seeds (e.g. beans) <i>Maharagwe na njugu</i>							
g	Animal sourced foods (e.g. eggs, meat) <i>Vyakula kutoka kwa wanyama (kama mayai na nyama)</i>							
h	Sweets (e.g. sugar cane) <i>Switi (kama miwa)</i>							
i	Spices, condiments (e.g. coriander) <i>Viongezi vya chakula (kama dhania)</i>							

Appendix IV: Questionnaires

14	<p>In the last one year, were there certain months where you mainly relied on getting food from other sources than your farm? <i>Katika mwaka mmoja uliopita, kulikuwa na miezi ambayo ulitegemea vyakula kutoka kwa shamba?</i></p>	<p>1= yes 2= no → <i>Q16</i></p>	MARELY
<p>Which months? <i>Ni miezi ipi?</i></p>			
15	<p>In the last one year, did you harvest any large quantities of foods that have gone to waste? Ask specifically for fruits and vegetables. <i>Katika mwaka mmoja uliopita, ulivuna viwango vikubwa vya vyakula vyovyote ambavyo vimiharibika/vimepotea? Ulizia matunda na mboga</i></p>	<p>1= yes 2= no → <i>Q16</i></p>	POSTLOSS
<p>Foods/<i>Vyakula</i></p>		<p>Months /<i>Miezi</i></p>	
16	<p>In the last one year, did you have certain foods in large quantities on your farm that could not be used? Ask specifically for fruits and vegetables. <i>Katika mwaka mmoja uliopita, ulivuna viwango vikubwa vya vyakula vyovyote ambavyo havijatumika? Ulizia matunda na mboga</i></p>	<p>1= yes 2= no → <i>Q17</i></p>	PRELOSS
<p>Foods/<i>Vyakula</i></p>		<p>Months /<i>Miezi</i></p>	
17	<p>How often in a month do you visit markets in general? <i>Ni mara ngapi kwa mwezi unapoenda kwa soko?</i></p>		MAVISIT
18	<p>What is the name of the nearest market? <i>Soko iliyo karibu inaitwa aje?</i></p>	Name:	MANAME
19	<p>How many minutes do you need to walk to the nearest market? <i>Unachukua dakika ngapi ukitembea kufika kwa soko iliyo karibu?</i></p>	Walking minutes:	MAMINUT

Appendix IV: Questionnaires

20	How many times in a month do you go to the nearest market? <i>Ni mara ngapi kwa mwezi unapoenda kwa soko iliyo karibu?</i>		
21	Where is the nearest agrovet? <i>Duka ya kununua mbegu iliyo karibu iko wapi?</i>	Place:	
22	How many minutes do you need to walk to the nearest agrovet? <i>Unahitaji dakika ngapi ukitembea kufika kwa duka ya kununa mbegu iliyo karibu?</i>	Walking minutes:	
23	Where is the nearest tree nursery? <i>Mahali pa karibu wanapouza mimea midogo (nasari) iko wapi?</i>	Place:	
24	How many minutes do you need to walk to the nearest tree nursery? <i>Unahitaji dakika ngapi kutembea kwa nasari ya karibu?</i>	Walking minutes:	
25	Did your family migrate to this area? <i>Familia yako iliamia katika eneo hii?</i>	1= yes 2= no → Q27	
26	Where does the household head come from? When did you migrate here? <i>Mwenye nyumba ametoka wapi? Alihamia lini katika eneo hii?</i>  Ask about the wife: <i>Ulizia kuhusu bibi Bibi wa nyumba ametoka wapi? Alihamia lini katika eneo hii?</i>	District, location of household head:  Time:  District, location of wife:  Time:	
27	Which ethnicity does the household head have? <i>If the mother is not the household head:</i> Which ethnicity does the wife of the household head have?  <i>Mwenye nyumba ni wa kabila ipi? Kama mama si mwenye nyumba: Bibi ya mwenye nyumba ni wa kabila ipi?</i>	Ethnicity household head:  Ethnicity mother:	
28	Are large parts of your farm waterlogged when it rains a lot?	1= yes 2= no	

Appendix IV: Questionnaires

	<i>Kuna sehemu kubwa ya shamba yako ambayo inaloa maji kukinyesha sana?</i>		
29	Do you have secure means to keep out roaming animals from your farm during the planting season? <i>Uko na njia ya kufungia wanyama wanaorandaranda katika msimu wa kupanda mimea?</i>	1= yes 2= no	

## 9.4.3 Farm survey July/August 2014

3<sup>rd</sup> survey, Western Kenya 2014

Identity No:

Date: \_\_\_\_\_ Interviewee: \_\_\_\_\_ Contact phone no.: \_\_\_\_\_

Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_ Altitude: \_\_\_\_\_ Village: \_\_\_\_\_

Location/Division/District: \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_

Sub-county/County: \_\_\_\_\_ / \_\_\_\_\_

Start time: \_\_\_\_\_ End time: \_\_\_\_\_ Total time: \_\_\_\_\_

Cropped farm area: \_\_\_\_\_

Part I: Socioeconomic data			
1	What is your name and age?	Name:	INAME
		Age/Age class:	IAGE
2	What is your marital status?	1=currently married/monogamous 2=currently married/polygamous 3=widowed 4=divorced 5=single	IMARITAL <input type="checkbox"/>
3	What is the sex of the household head?	1=male 2=female 999=Not Applicable (NA)	HHSEX <input type="checkbox"/>
4	What is the name and age of your spouse?	Name:	SNAME
		Age/Age class:	SAGE
5	What is the tribe of this household?	Hhold head tribe:.....	HHTRIBE
		Spouse tribe:.....	STRIBE
6	What is the religion of this household?	Hhold head religion: 1=Christian 2=Muslim 3=Non-religious 99=other (specify).....	HHRELIG <input type="checkbox"/>
		Spouse religion: 1=Christian 2=Muslim 3=Non-religious 99=other (specify).....	SRELIG <input type="checkbox"/>
7a	How many people live permanently in your household for the last 6 months?		HNO
7b	What are their age groups?	0-2 years:----- 2-5 years:----- 5-15 years:----- 15-49 years:----- >49 years:-----	HAGE
8	What is the highest level of education the household head	0=no education 1=some primary	HHEDUC <input type="checkbox"/>

Appendix IV: Questionnaires

	achieved?	2=completed primary (class 8) 3=some secondary 4=completed secondary (form 4) 5=higher 99=other (specify).....		
9	What is the main occupation of the household head (mention one or two with priority)	0=None 1= Farming (focus crops) 2= Farming (focus livestock) 3=Farming(mixed crop/livestock) 4=Casual labour on people's farms 5= Petty trader/juakali (Seasonal) 6= Business (Established) 7= Wage employment 8=Retired 99=other (specify).....	HHOCCUP	<input type="checkbox"/>
10	Did your household migrate from other areas to this district?	Hhold head migration: 1=No 2=Yes (where from).....	HHMIG	<input type="checkbox"/>
		Spouse migration: 1=No 2=Yes (where from).....	SMIG	<input type="checkbox"/>
11a	Is there any problem for households migrating into this village to acquire land for farming?	1=No → Q 12 2=Yes	HMIGPROB	<input type="checkbox"/>
11b	If 'yes', what's the main problem?	Record answer:	HMIGPROBR	<input type="checkbox"/>
12	Does any member of your household own land that can be used for agriculture?	1=No 2=Yes	HLAND	<input type="checkbox"/>
13	Do you sometimes hire labour for agriculture activities?	1= No 2= Yes	HLABHIRE	<input type="checkbox"/>
14	What kind of land ownership is your farm under (if more than one farm, focus on priority one eg biggest or long-time farm)	1=Inherited 2=Bought 3=Borrowed 4=Hired/leased 5=Gift 6=Communal land	HLANDTYPE	<input type="checkbox"/>
15a	Do you have a title deed for your farm?	1=No → Q 16 2=Yes	HLANDDEED	<input type="checkbox"/>
15b	Under whose name is the title deed?	1=household head 2=spouse 3=family of household head 4=family of spouse	HLANDDEEDNAME	<input type="checkbox"/>
<b>Part II: Wealth index and decision making data</b>				
16	Observe, but do not ask: What is the main	1= Non-finished roofing: -Natural roofing eg bamboo	HROOF	<input type="checkbox"/>

Appendix IV: Questionnaires

	<i>material of the roof?</i>	with grass -Rustic mat -Wood planks 2= <u>Finished/durable roofing</u> : -Corrugated iron, Wood, Calamine/cement fibre, Ceramic tiles, Cement, Roofing shingles 99=Other(specify):..... _____		
17	Observe, but do not ask: <i>What kind of toilet facility do members of the household usually use?</i>	1= -Flush / pour flush to: piped sewer system,septic tank, pit (latrine), unknown place/ not known where -Ventilated Improved Pit latrine (VIP) -Pit latrine with slab -Composting toilet 2= -Flush/ pour flush to elsewhere -Pit latrine without slab(unfinished floor)/open pit -Bucket -Hanging toilet/hanging latrine -No facilities or bush or field 99=Other(specify):..... _____	H T O I L E T	<input type="checkbox"/>
18	What is the main source of drinking water for members of your household?	1= -Piped water into dwelling, yard or plot, -Public tap/standpipe, -Tube well / borehole -Protected dug well, protected spring -Rainwater collection 2= -Unprotected well, unprotected spring -Water from trucks/cars/animals -Cart with small tank/drum -Surface water (river, stream, dam, lake, pond, canal, irrigation channel) 99=other(specify): _____	H D R I N K I N G	<input type="checkbox"/>
19	Does your household, you or anyone in your household own:		1=No 2=Yes	
a	Electricity/solar for lighting the house	HELEC		<input type="checkbox"/>
b	Radio	HRADIO		<input type="checkbox"/>

Appendix IV: Questionnaires

c	Mobile phone	HPHONE	<input type="checkbox"/>	
d	Watch or clock	HWATCH	<input type="checkbox"/>	
	1=No 2=Yes			
e	Television	HTV	<input type="checkbox"/>	
f	Sprayer	HSPRAYER	<input type="checkbox"/>	
g	Plough or any other ox-drawn implements/agricultural instrument (kitu ya kukusaidia kulima kama tractor au ng'ombe dume, punda au mnyama mwingine)	HPLOUGH	<input type="checkbox"/>	
h	Ox or donkey cart/animal for transporting (mnyama wa kubebea mizigo kama punda au ng'ombe dume)	HCART	<input type="checkbox"/>	
i	Bicycle	HBIKE	<input type="checkbox"/>	
j	Motorcycle	HCYCLE	<input type="checkbox"/>	
k	Car or lorry	HCAR	<input type="checkbox"/>	
l	Computer	HCOMP	<input type="checkbox"/>	
20a	Who usually decides: how money is spent on purchase of food (which foods/food groups to buy)?	1=household head only 2=spouse only 3=shared decision making	HFOOD	<input type="checkbox"/>
20b	Who usually decides: If any plants harvested (eg maize, beans) are sold or used for home consumption?	1=household head only 2=spouse only 3=shared decision making 999=NA (eg if doesn't use crops for home consumption)	HCROP	<input type="checkbox"/>
20c	Who usually decides: If any animal products (eg milk, eggs) are to be sold or used for home consumption?	1=household head only 2=spouse only 3=shared decision making 999=NA (eg if doesn't use ASFs for home consumption)	HASF	<input type="checkbox"/>

## Appendix IV: Questionnaires

### 21. Part III: Household food sources

Please specify for each month (in the last one year) if the specific food group you consume mainly comes from your own production or from elsewhere. Ask for the different food groups. Use calendar as assistance to indicate seasons. More than one answer is possible. Write details into last column.

Record:

- |   |                        |    |                           |
|---|------------------------|----|---------------------------|
| 0 | Not consumed/available | 3  | Family/friends/neighbours |
| 1 | Mainly own farm        | 4  | Collected from the wild   |
| 2 | Mainly market          | 99 | Other (specify)           |

Food Group / Month	1 Jun 14'	2 May 14'	3 Apr 14'	4 Mar 14'	5 Feb 14'	6 Jan 14'	7 Dec 13'	8 Nov 13'	9 Oct 13'	10 Sep 13'
Animal source foods (e.g. eggs, meat)										
Cereals (e.g. maize)										
Vegetables (e.g. sukuma wiki, mboga)										
Vitamin-A rich fruits ( pawpaw, ripe mangoes+ other locally available vitamin A-rich fruits)										
Other fruits, including wild fruits( e.g. guavas, watermelon, oranges, lemons, avocado, pears, bananas)										
Starchy roots, tubers, green bananas (e.g. cassava, sweet potatoes, matoke)										
Pulses/nuts/seeds (e.g. beans)										
Sugarcane										

Any other comments:

22	Have you (or any household member) been fasting for the past one week?	1=N	2=Y	
----	--	-----	-----	--

Appendix IV: Questionnaires

**Part IVa: Household dietary diversity**

23	Please describe the foods (meals and snacks) that you or any member of your household ate or drank yesterday during the day and night. Include only foods consumed at home, not those purchased and consumed outside of the home. Start with the first food eaten in the morning.				
Write down in the space below all foods and drinks mentioned. When composite dishes are mentioned ask for the list of ingredients. Probe for any meals/snacks not mentioned. When the recall is complete, fill in the food groups based on the foods mentioned during the recall. For any food groups not mentioned, ask the respondent if a food item from this group was consumed.					
breakfast	Snack	Lunch	snack	dinner	snack

Food groups	Examples mentioned	Past 24 hours 1=No 2=Yes		Number of days How often in the last 7 days?	
Cereals		HHDD1	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD1	<input type="checkbox"/>
Vitamin A rich vegetables and tubers		HHDD2	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD2	<input type="checkbox"/>
White tubers and roots		HHDD3	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD3	<input type="checkbox"/>
Dark green leafy vegetables		HHDD4	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD4	<input type="checkbox"/>
Other vegetables		HHDD5	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD5	<input type="checkbox"/>
Vitamin A rich fruits		HHDD6	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD6	<input type="checkbox"/>
Other fruits		HHDD7	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD7	<input type="checkbox"/>
Organ meat (iron rich)		HHDD8	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD8	<input type="checkbox"/>
Flesh meats		HHDD9	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD9	<input type="checkbox"/>
Eggs		HHDD10	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD10	<input type="checkbox"/>
Fish		HHDD11	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD11	<input type="checkbox"/>
Legumes, nuts and seeds		HHDD12	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD12	<input type="checkbox"/>
Insects		HHDD13	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD13	<input type="checkbox"/>
Milk and milk products		HHDD14	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD14	<input type="checkbox"/>
Oils and fats		HHDD15	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD15	<input type="checkbox"/>

Appendix IV: Questionnaires

Sweets		HHDD16	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD16	<input type="checkbox"/>
Spices, condiments, beverages		HHDD17	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD17	<input type="checkbox"/>
Sugarcane		HHDDS18	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDDS18	<input type="checkbox"/>

**Part IVb: Women's dietary diversity**

24	Please describe everything that you (alone) ate yesterday during the day or night, whether at home or outside the home.				
Write down in the space below all foods and drinks mentioned. When composite dishes are mentioned ask for the list of ingredients. Probe for any meals/snacks not mentioned. When the recall is complete, fill in the food groups based on the foods mentioned during the recall. For any food groups not mentioned, ask the respondent if a food item from this group was consumed.					
breakfast	Snack	Lunch	snack	dinner	snack

Food groups	Examples mentioned	Past 24 hours 1=No 2=Yes		Number of days How often in the last 7 days?	
Cereals		WDD1	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD1	<input type="checkbox"/>
Vitamin A rich vegetables and tubers		WDD2	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD2	<input type="checkbox"/>
White tubers and roots		WDD3	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD3	<input type="checkbox"/>
Dark green leafy vegetables		WDD4	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD4	<input type="checkbox"/>
Other vegetables		WDD5	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD5	<input type="checkbox"/>
Vitamin A rich fruits		WDD6	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD6	<input type="checkbox"/>
Other fruits		WDD7	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD7	<input type="checkbox"/>
Organ meat (iron rich)		WDD8	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD8	<input type="checkbox"/>
Flesh meats		WDD9	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD9	<input type="checkbox"/>
Eggs		WDD10	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD10	<input type="checkbox"/>
Fish		WDD11	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD11	<input type="checkbox"/>
Legumes, nuts and seeds		WDD12	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD12	<input type="checkbox"/>
Insects		WDD13	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD13	<input type="checkbox"/>

Appendix IV: Questionnaires

Milk and milk products		WDD14	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD14	<input type="checkbox"/>
Oils and fats		WDD15	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD15	<input type="checkbox"/>
Sweets		WDD16	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDD16	<input type="checkbox"/>
Spices, condiments, beverages		WDD17	<input type="checkbox"/>	□□□□□□ MTWTFSSM HHDD17	<input type="checkbox"/>
Sugarcane		WDDS18	<input type="checkbox"/>	□□□□□□ MTWTFSSM WDDS18	<input type="checkbox"/>

**Part V: Household Hunger Scale**

25	In the past one month (June 14'), did you worry ( <i>ulikuwa na wasiwasi</i> ) that your household would not have enough food?	1= No → <u>Q 27</u> 2=Yes	FOODWOR
26	For each of the following questions, consider whether this has happened in the past 4 weeks. If the answer is 'yes' to a question, please indicate how often this happened.		
a	In the past one month (June 14'), was there ever no food to eat of any kind in your house because of lack of resources to get food?	1= No → <u>Q c</u> 2= Yes	HRES
b	How often did this happen in the past one month (June 14')?	1= rarely (1-2 times) 2= sometimes (3-10 times) 3= often (more than 10 times)	HRESFREQ
c	In the past one month (June 14'), did you or any household member <b>go to sleep at night hungry</b> because there was not enough food?	1= No → <u>Q e</u> 2= Yes	HHUN
d	How often did this happen in the past one month (June 14')?	1= rarely (1-2 times) 2= sometimes (3-10 times) 3= often (more than 10 times)	HHUNFREQ
e	In the past one month (June 14'), did you or any household member <b>go a whole day and night without eating</b> anything at all because there was not enough food?	1= No → <u>Q 27</u> 2= Yes	HHUNG
f	How often did this happen in the past one month (June 14')?	1= rarely (1-2 times) 2= sometimes (3-10 times) 3= often (more than 10 times)	HHUNGFREQ
27	In the past 12 months did your household experience a hungry season? <i>The hungry season means the number of month a household does not have enough food because their own food stores are depleted and they do not have enough money to buy food.</i>	1= No → <u>Q 29</u> 2= Yes 88= don't know	HSEAS
28	During what month did the hungry season begin, when did it end?	Begun... Ended..	

Appendix IV: Questionnaires

**Part V: Livestock numbers and productivity**

29	Does your household own any animals?		1=No → Q 30 2=Yes				HANIMAL	□							
If any livestock owned: Can we go to the place where the animals are to have a look at them?															
a) What types of livestock (and breeds) does your household own?			b) How much livestock does your household own (number of each breed)?				ASF got <i>from each livestock</i> (if selling/give away/barter traded, have 'meat'/'equivalent' ASF)	How often did you harvest/collect this ASF <u>in the last 1 year?</u>  eg daily (*3 times)		How much of the ASF did you harvest/collect in the last 1 year?  eg 30 litres(*3 times)		Out of 100%, how did your household use the ASF in the last 1 year?			
	Species	Breed 1=local 2=exotic 3=mixed	Total	Females	Males	Young		Frequency eg daily, weekly etc	No. of times	Amount	No. of times	Home	Sale	Barter trade	Give away

**Part VI: Plant production**

30	I would like to see your farm and all crops that you grown there at the moment. Ask for all crops used as food by the household													
							Amount harvested in <u>last 1 year?</u>			Out of 100%, what is the use of harvested amounts for <u>last 1 year?</u>				
Species	Sub-species/types/varieties	No. of varieties	Other names	Abundance	Density	Plot size (m2)	Amount	No. of times	Unit	Home	Sale	Barter trade	Give away	

Appendix IV: Questionnaires

<b>Part VII: Fruit consumption</b>			
31	Do you like eating fruits?	1=No 2=Yes	FRULIKR
32	When considering the last 1 month (June 14'), did you ( <u>not</u> your household, you alone!) consume fruits every day?	1=No 2=Yes→Q34 88=don't know	FRUDAYR
33	<u>If no</u> , what prevents you from consuming fruits every day? ( <i>Several answers possible.</i> )	1= Too expensive / lack of income 2= Not available (seasonal production/not offered at markets/highly perishable) 3= Don't like eating fruits (taste/preference) 4= It is not good to eat too much fruit 5= Adult women should not eat fruits 6= Cultural factors ( <i>specify</i> ) 7= Fruits are more important for Income Generation 88= don't know 99= other ( <i>specify</i> ).....	FRUPREVR
34	Would you like to eat more fruits?	1=No → Q36 2=Yes	FRUMORER
35	If yes, why?		FRUWHYR
36	Does your husband like eating fruits?	1=No 2=Yes 88= don't know	FRULIKH
37	When considering the last 1 month(June 14'), did your husband consume fruits every day?	1=No 2=Yes→Q39 88=don't know	FRUDAYH
38	<u>If no</u> , what prevents him from consuming fruits every day? ( <i>Several answers possible.</i> )	1= Too expensive / lack of income 2= Not available (seasonal production/not offered at markets/highly perishable) 3= Don't like eating fruits (taste/preference) 4= It is not good to eat too much fruit 5= Adult men should not eat fruits 6= Cultural factors ( <i>specify</i> ) 7= Fruits are more important for Income Generation 88= don't know 99= other ( <i>specify</i> )	FRUPREVH
39	Would he like to eat more fruits?	1=No→ Q41 2=Yes 88= don't know	FRUMOREH
40	If yes, why?		FRUWHYH
41	Do your children/grandchildren like eating fruits?	1=No 2=Yes 3= some like some don't like	FRULIKC

Appendix IV: Questionnaires

	(focus is on <u>upper age limit of 15 years</u> )	88= don't know	
42	When considering the last 1 month (June 14'), did your children/grandchildren consume fruits every day?	1=No → Q44 2=Yes 88=don't know	FRUDAYC
43	<u>If yes</u> , please specify the age groups:	Below 2 years	FRUDAYC2
		2 to 5 years	FRUDAYC25
		6 to 15 years	FRUDAYC615
44	<u>If no</u> , what prevents them from consuming fruits every day? (Several answers possible.)	1= Too expensive / lack of income 2= Not available (seasonal production/not offered at markets/highly perishable) 3= Don't like eating fruits (taste/preference) 4= It is not good to eat too much fruit 5= Children should not eat fruits 6= Cultural factors (specify) 7= Fruits are more important for Income Generation 88= don't know 99= Other (specify)	FRUPREVC
45	Would they like to eat more fruits?	1=No → Q47 2=Yes 88= don't know	FRUMOREC
46	If yes, why?		FRUWHYC
47	Are there any people (of certain age, gender, religion, pregnant women) who should <u>not</u> eat fruits? If yes, which groups of people are concerned	1=No 2=Yes 88=don't know	FRUNO1  FRUNO2a FRUNO2b FRUNO2c
	Which fruits should <u>not</u> be eaten by the group?	1. 2. 3.	FRUNO3a FRUNO3b FRUNO3c
48	What do you think could help you and your family to eat more fruits?	Record the answer: _____  _____	

**9.4.4 Focus group discussion guidelines (facilitator's version):**

**September/October 2012**

<b>Focus Group Discussion (FGD)- Facilitator's Version</b>
Time management
Estimated total time: 2h 30min (+5minutes)
Start time:.....End time:.....
This section consists of:
1.Oral informed consent (5minutes)
2.Introduction/welcome (5minutes)
3.Warm-up activity
(a)Listing foods of 2 food groups (10 minutes)
(b)Ranking foods of the 2 food groups (10 minutes)
4.Main section
Seasonal calendars
Food group1(5 minutes*5 food types= 25minutes)
Food group2 (5minutes *5 food types= 25minutes)
Incentives &disincentives
For high ABD (20 minutes)
Activity (10minutes)
For farm specialisation (20 minutes)

Appendix IV: Questionnaires

Activity (10minutes)	
5. Hunger season (5minutes)	
6. Review and conclusion (5minutes)	
FGD No. ....	
(Mixed age-group)women FGD	(Mixed age-group)men FGDs/
FGD1-animal source foods, pulses/ vyakula kutoka wanyama, na maharagwe	FGD1-animal source foods, pulses/vyakula kutoka wanyama, na maharagwe
FGD2-fruits, staples/ matunda na mazao ya chakula	FGD2-fruits, staples/matunda na mazao ya chakula
FGD3-vegetables, fats and oils /mboga na mafuta-ngumu na ya maji	FGD3-vegetables, fats and oils/mboga na mafuta-ngumu na ya maji
*for fats and oils, think of oil crops, not the products only (fats and oils)* kwa mafuta-ngumu na ya maji, fikiria pia mimea ya mafuta, sio bidhaa zinazopatikana kutoka kwa mafuta tuu	*for fats and oils, think of oil crops, not the products only (fats and oils)* kwa mafuta-ngumu na ya maji, fikiria pia mimea ya mafuta, sio bidhaa zinazopatikana kutoka kwa mafuta tuu

**1. Oral informed consent (5min)/ Kuomba ruhusa kwa kuzungumza**

Overview/Kwa ujumla

Greetings and explain who is doing project and what it is about/ Kusalimiana na kueleza kazi tunayofanya na watu wanaohusika

Introduce the team members (as above)/ Tambulisha watu wa timu yako (kama ilivyo hapo juu)

Explain why selected women/men/ eleza kwa nini tumewachagua wanawake ama wanaume hao

Emphasise anonymity of information provided/Sisitiza usiri wa mambo watakayotueleza

Participation is voluntary/ Ushiriki kwa majadiliano ni kwa hiari/si kwa kulazimishwa

Provide contact information (leave student's phone number and email address if applicable. If uncomfortable with this, leave Gudrun's landline office number with them)/ Wafahamishe vile wanaweza kuwasiliana nawe. Kwa mfano, wape nambari ya mwanafunzi ama kama haupendelei hivi, wape nambari ya ofisi ya Gudrun

Invite any general questions/ Waulize kama wako na maswali yoyote ya kijumla

Confirm women/men willing to participate/ Uliza tena kama wanataka kuhusika kwa majadiliano

An example of a consent (led by Facilitator) /Mfano wa kuomba ruhusa (ukiongozwa na kiongozi)

Good morning/afternoon everyone, my name is.....and I will be taking you

through the discussion for today. The reason for inviting you here today is because we would like to discuss some issues that relate to foods that are locally available in this area. This is part of a project by Bioversity International (Nairobi) that is looking into the diversity of agricultural foods that are grown in this area and how it relates to food consumption. This work is being done together with a University student, working on this project as part of her Masters studies. If you allow us, the note-taker will write down some notes so that we can refer to them later on as we write the final report (note-taker introduces him/herself).

Habari yenu asubuhi ya leo/mchana wa leo, naitwa.....na nitawaongoza kwa majadiliano yetu ya leo. Sababu ya kuwaalika hapa leo ni kwa sababu tungetaka kujadiliana nanyi mambo kadha kuhusu vyakula vinavyopatikana katika eneo hii . Hii ni sehemu moja ya kazi inayofanywa na Bioversity International (Nairobi), wakiangalia vyakula tofauti mnavyokuza katika sehemu hii na vile inavyohusiana na ulaji wa vyakula. Kwa hii kazi, Bioversity International wanashirikiana na mwanafunzi wa chuo kikuu, anayefanya kazi hii kama sehemu ya kutekeleza masomo yake. Ukituruhusu, mwandishi ataandika majadiliano yenu ya leo ndivyo tuweze kuyarejelea tunapoandike ripoti yetu ya mwisho (mwandishi ajitambulishe)

Part of this project involves holding group discussions with (women/men) small scale farmers, who have been selected to represent a cross-section of households in this community. All the information you give and the notes we write down will be confidential to the public. It will only be shared with their supervisors and work colleagues should they require some further guidance and discussions. Also, no specific

#### Appendix IV: Questionnaires

names will be included in generating the final report. The interview will take a maximum of 2 hours and participation is voluntary, so you may choose either to take part in it or not. Feel free to ask me (or any member of the team) any questions at any time regarding the project that may not be clear to you. Do you have any questions now?/

Sehemu moja ya kazi hii inahusika na kupanga majadaliano na wakulima (wanawake/wanaume) wa mashamba madogo, ambao wamechaguliwa kuwakilisha jamii katika sehemu hii. Mambo yote mtakayotueleza itakuwa siri kwa umma; tutafamisha tu wasimamizi wetu na tunaofanya kazi nao watakapohitaji kujadiliana zaidi. Vilevile, majina yenu hayataandikwa katika ripoti ya mwisho. Tukienda sana, majadiliano ya leo yatachukua masaa mawili na ushiriki ni kwa hiari, kwa hivyo unaweza kuchagua kama utahusika nasi ama la. Jiskie huru kuniuliza mimi (ama mtu yeyote katika timu yetu) maswali yoyote wakati wowote kuhusu lolote ambalo si wazi kwenu kuhusu kazi tunayofanya. Mko na maswali yoyote kwa sasa?

Can we continue with the group discussion? No.....Yes...../

Tunaweza kuendelea na majadiliano? La.....Ndio.....

If 'No', why?...../

Kama 'La', kwa nini?.....

If 'Yes', Proceed to 'Introduction section'/?

Kama 'Ndio', endelea na sehemu ya utangulizi

**2. Introduction/ welcome (5 minutes)/ Sehemu ya utangulizi/kukaribisha**

Goal: help to make the group feel comfortable and let them know what to expect/

Lengo: kusaidia kikundi kujiskia vizuri na huru na kuwafahamisha nini watakachotarajia

Allow the participants in the group to briefly tell you something about themselves ( name 2. State whether they are (mainly) crop, livestock or mixed farmers )/ Ruhusu wanakikundi wakueleza kwa ufupi kitu kuhusu wao wenyewe (1.jina 2. aseme kama ni (kwa sehemu kubwa) mkulima wa mimea, wanyama ama anachanganisha mimea na wanyama

Thank the participants for coming and tell them they were chosen because they are knowledgeable about the community and can help us understand why ABD is high or low in this area. /Washukuru wanakikundi kwa kuja na wafahamishe wamechaguliwa kwa sababu ni wenye ujuzi kuhusu jamii yao na wanaweza kutusaidia kuelewa kwa nini ukuzaji wa vitu tofauti uko juu ama chini katika eneo hii

Explain the basic schedule for the FGD session and also mention the key goals of the FGD session. /Eleza ratiba ya leo ya majadaliano ya kikundi, na pia utaje malengo ya muhimu ya kikao cha leo.

Tell the women/men that they should feel comfortable speaking, that it is okay to disagree and that there are not “right” or “wrong” answers/ Ambia wanakikundi wanajiskie huru kuzungumza, na ni sawa kutoelewana na pia hakuna jawabu sahihi au kosa

**3. Warm-up activity/ Shughuli ya kuanzisha majadiliano**

In general, we will discuss with different groups on six different food groups that are important for complementary feeding of children but also for all other family members:

(1) animal source foods (including milk and milk products), (2) vegetables, (3) fruits, (4) staples (cereals, roots, tubers), (5) pulses, (6) fats and oils. For your group, we will focus on two food groups (FGD1/FGD2/FGD3) /*kwa ujumla, tutajadiliana na vikundi tofauti kuhusu aina sita tofauti za vikundi vya vyakula ambavyo ni muhimu za kulisha ziada za watoto lakini pia wanafamilia wengine: (i)vyakula kutoka kwa wanyama (ii) mboga (iii)matunda (iv)mazao ya chakula (nafaka na mizizi) (v)maharagwe (vi)mafuta-ngumu na ya maji. Kwa kikundi chenu, tutazingatia vikundi viwili vya vyakula (FGD1/FGD2/FGD3).*

Listing down food types of the 2 food groups (10 minutes)

Start the FGD by asking the following question/*anzisha majadiliano kwa kuuliza swali lifuatalo*

In the 2 food groups , what are the different foods types typically produced on the farms and gardens?/ *kwa vikundi viwili vya vyakula (FGD1/FGD2/FGD3), ni vyakula vipi tofauti vinavyopatikana kwa kawaida kutoka mashamba na bustani zenu?*

Write down all the foods on a flip-chart/ *andika vyakula vyote kwenye chati*

Ranking list food types of the 2 food groups (10 minutes)

Rank the five most important food types in each of the 2 food groups (NB:be flexible on this-ie if heard a lot about one type of food type, move to the next one in the rank order)

**4.Main Section: /Sehemu kuu**

**Seasonal Calendar/ Msimu wa kalenda**

**Seasonal calendar for food group 1:.....(25 minutes)**

\*Have one flip-chart paper prepared for each food group with seasonal calendar.

\**Kuwa na chati moja ya karatasi iliyotengenezwa kwa kila kikundi cha chakula na ambayo iko na sehemu ya kujaza msimu wa kalenda*

Months of year/ <i>Miezi ya mwaka</i>	Food Group 1: .....	Availability 1.high 2.low 3.none <i>Upatikanaji</i> 1.kwa wingi 2.kwa uchache 3.hakuna	Accessibility 1.grow/rear 2.collect/hunt from wild 3.buy from market 4.Any other way? <i>Uwezo/namna ya kupata</i> 1.kupanda/kukuza 2.kuokota/kuwinda kwa mwitu 3.kununua kwa soko 4.njia nyingine yeyote?	Perception of consuming food 1.would you give it to visitors? <i>Mtizamo wa kula chakula</i> 1.unaweza wapa wageni?
	1. 2.			

Appendix IV: Questionnaires

	3.			
	4.			
	5.			

We will start with food group No. 1:...../ *Tutaanza na kikundi cha chakula cha kwanza:.....*

Working with the list generated at 3(b), ask for each of the five food types:

(i)during which month of the year are these foods available?/*ni miezi ipi ya mwaka ambayo hivi vyakula vinapatikana?*

\*Distinguish precisely between major season (when food is plenty available) and minor season (when food is less available) by ticking against the option the participants select/

*\*tofautisha kwa makini baina msimu kuu (wakati chakula kinapatikana kwa wingi) na msimu mdogo (wakati chakula hakipatikani kwa wingi) kwa kuweka alama kando ya chaguo ya wanakikundi*

(ii)How can you access these foods? / *mnaweza kupata vyakula hivi kwa namna gani?*

\*Only if the group does not come up with any suggestion probe for: grow/rear them, collect/hunt from the wild, buy on the market, any other way? Note way of access behind each single food.

*\*ni wakati wanakikundi hawakupi jibu lolote ambapo utauliza kwa undani kama wanapata vyakula kwa:kupanda/kukuza, kuokota/kuwinda kwa mwitu,kununua kwa soko, njia nyingine yeyote? Andika njia ya kupata kando ya kila chakula*

(iii) What is your perception of the food types we just discussed? /*mtizamo wako ni upi kuhusu aina ya vyakula tumevyojadiliana?*

\*probe: ‘would you give it to visitors’? (only if no response given, go on to probe:

Appendix IV: Questionnaires

‘would you consider it as a poor man’s or rich man’s crop’

*\*uliza kwa undani: unaweza wapa wageni?(kama hakuna jawabu, endelea kuuliza: ‘unaweza kuichukulia kama chakula cha maskini au tajiri’?)*

*Seasonal calendar for food group 2: ..... (25minutes)*

*Prepare flip-chart with seasonal calendar and Repeat questions 4i – iii for the second food group / rudia maswali 4i-iii kwa kikundi cha pili cha chakula kwa kikundi cha pili cha chakula*

*Incentives and Disincentives for high agrobiodiversity (20minutes)*

• What are (i) incentives and (ii) disincentives for farmers of your community to maintain a high agrobiodiversity on their farm, i.e. to crop and rear many different plant and animal species? Draw a table with two columns, one for incentives and one for disincentives (use also “+” and “-“ for better understanding)/ *nini (i)inawapa motisha na (ii)inayowakatisha tamaa wakulima wa jamii hii ili wazingatie hali ya juu ya ukuzaji wa vitu tofauti kwa mashamba yao, yaani, kukuza mimea na kulea wanyama wa aina nyingi tofauti? Chora jedwali ya nguzo mbili, moja ya ‘motisha’ na nyingine ya ‘inayowakatisha tamaa’ (tumia pia alama ya ‘+’ na ‘-’ ili uweze kueleweka kwa urahisi)*

<p>(+) incentives/encouragement for high agrobiodiversity (plant and animal)/</p> <p>(+) <i>motisha/kinachowatia moyo ili wazingatie hali ya juu ya ukuzaji wa vitu tofauti (mimea na wanyama)</i></p>	<p>(-) disincentives/discouragement for high agrobiodiversity (plant and animal)/</p> <p>(-) <i>inayowakatisha tamaa/ kufanya wafe roho wakijaribu kuzingatia hali ya juu ya ukuzaji wa vitu tofauti (mimea na</i></p>
--	--

Appendix IV: Questionnaires

	wanyama)
<p><i>Group activity: Ranking incentives and disincentives for high agrobiodiversity (10min)</i></p>	
<p>Rank the different incentives and disincentives (Group game/activity)/ <i>orodhesha motisha na mambo inayowakatisha tama (mchezo wa kikundi)</i></p> <p>After the activity: present results to group members and ask if they agree with the results</p>	
<p><i>Incentives and disincentives for farm specialisation (20 minutes)</i></p>	
<p>What are incentives/disincentives for farmers of your community to specialise their farm, i.e. to crop and rear only a limited number of certain plant and animal species? Draw a table with two columns, one for incentives and one for incentives (use also “+” and “-“ for better understanding)/ <i>nini (i) inawapa motisha na (ii) inayowakatisha tama wakulima wa jamii hii ili wawe wataalam wa aina fulani kwa mashamba yao, yaani, wakuze na walee aina chache na fulani pekee ya mimea na wanyama? Chora jedwali ya nguzo mbili, moja ya ‘motisha’ na nyingine ya ‘inayowakatisha tamaa’ (tumia alama ya ‘+’ na ‘-’ ili uweze kueleweka kwa urahisi)</i></p>	
<p>(+) incentives/encouragement for farm specialisation/ (+) <i>motisha/kinachowatia moyo ili wawe wataalam wa aina fulani</i></p>	<p>(-) disincentives/discouragement for farm specialisation/ (-) <i>inayowakatisha tamaa/kufanya wafe roho wakijaribu</i></p>

Appendix IV: Questionnaires

<i>kwa mashamba yao</i>	<i>kuwa wataalam wa aina fulani kwa mashamba yao</i>
<p>Group activity: ranking incentives and disincentives for farm specialisation (10minutes)</p>	
<p>Rank the different incentives and disincentives (Group game/activity)/ <i>orodhesha motisha na mambo inayowakatisha tama (mchezo wa kikundi)</i></p> <p>After the activity: present results to group members and ask if they agree with the results</p>	
<p><b>5.Hungry Season/Msimu wa njaa (5 minutes)</b></p>	
<p>If hungry season existed in the last 5 years, which month(s) did it begin and end?/<i>kama kumekuwa na msimu wa njaa kwa wakati wowote kwa miaka tano ilitopita, ilianza na ikaisha mwezi/miezi ipi?</i></p> <p>Definition of hungry season: number of months a household doesn't have enough food because their own food stores are depleted and they don't have enough money to buy food</p>	
<p><b>6. Review and Conclude (5 minutes) / kupitia tena na kumalizia (dakika tano)</b></p>	
<p>I would like to thank you very much for your time and your valuable input. The information you have shared with will help us to understand the diversity of agriculture existing in this community and different factors that predict its accessibility and availability./</p> <p>Ningetaka kuwashukuru sana kwa muda wenu na mawazo ya muhimu mmeyotupa. Mambo ambayo tumejadiliana nanyi itatusaidia kuelewa aina tofauti ya ukulima iliyoko</p>	

#### Appendix IV: Questionnaires

katika jamii hii na pia sababu tofauti inayoweza kutabiri upatikanaji na namna ya kupata aina tofauti ya kilimo.

As we conclude, would you be okay if I took one group photo? This will help us to remember certain issues if we have a photo in front us.../tukimalizia, itakuwa sawa nikuchukua picha moja ya kikundi chote? Hii itatusaidia kukumba mambo kadha tukiwa na picha mbele yetu

If consent provided, take a group photo of all the group members...../kama umepewa ruhusa, chukua picha moja ya wanakikundi wote.....

At this point, I would like to conclude the session./ kwa sasa, ningetaka kuhitimisha kikao hiki

In case there are any further questions, I will be available during the snack break/ kama kuna maswali mengine yeyote ya kijumla, nitakuwa nanyi mnapochukua kiburudisho

9.4.5 Focus group discussion guidelines (note taker’s version):

September/October 2012

Focus Group Discussion (FGD)- Note Taker’s Version	
<b>Key guideline: write down as much as possible, also what is not clear!</b>	
<b>Time management</b>	
Estimated total time: 2h 30min (+5minutes)	
Start time:.....End time:.....	
This section consists of:	
1.Oral informed consent (5minutes)	
2.Introduction/welcome (5minutes)	
3.Warm-up activity	
<ul style="list-style-type: none"> <li>• Listing foods of 2 food groups (10 minutes)</li> <li>• Ranking foods of the 2 food groups (10 minutes)</li> </ul>	
4.Main section	
(a)Seasonal calendars	
<ul style="list-style-type: none"> <li>○ Food group1(5 minutes*5 food types= 25minutes)</li> <li>○ Food group2 (5minutes *5 food types= 25minutes)</li> </ul>	
(b)Incentives &disincentives	
<ul style="list-style-type: none"> <li>○ For high agrobiodiversity (20 minutes)</li> <li>○ Activity (10minutes)</li> <li>○ For farm specialisation (20 minutes)</li> <li>○ Activity (10minutes)</li> </ul>	
5. Hunger season (5minutes)	
6. Review and conclusion (5minutes)	
FGD No. ....	
(Mixed age-group)women FGD	(Mixed age-group)men FGDs/
FGD1-animal source foods,pulsess/ <i>vyakula kutoka wanyama, na maharagwe</i>	FGD1-animal source foods, pulses/ <i>vyakula kutoka wanyama, na maharagwe</i>
FGD2-fruits, staples/ <i>matunda na mazao ya chakula</i>	FGD2-fruits, staples/ <i>matunda na mazao ya chakula</i>
FGD3-vegetables, fats and oils	FGD3-vegetables, fats and

Appendix IV: Questionnaires

<p><i>/mboga na mafuta-ngumu na ya maji</i></p> <p><i>*for fats and oils, think of oil crops, not the products only (fats and oils)* kwa mafuta-ngumu na ya maji, fikiria pia mimea ya mafuta, sio bidhaa zinazopatikana kutoka kwa mafuta tuu</i></p>	<p><i>oils/mboga na mafuta-ngumu na ya maji</i></p> <p><i>*for fats and oils, think of oil crops, not the products only (fats and oils)* kwa mafuta-ngumu na ya maji, fikiria pia mimea ya mafuta, sio bidhaa zinazopatikana kutoka kwa mafuta tuu</i></p>
--	--

**1. Oral informed consent (5min)/ Kuomba ruhusa kwa kuzungumza (dakika tano)**

Can we continue with the group discussion? No.....Yes...../

Tunaweza kuendelea na majadiliano? La.....Ndio.....

If 'No', why?...../

Kama 'La', kwa nini?.....

If 'Yes', Proceed to 'Introduction section' /

Kama 'Ndio', endelea na sehemu ya utangulizi

**2. Introduction/ welcome (5 minutes)/ Sehemu ya utangulizi/kukaribisha(dakika kumi)**

Appendix IV: Questionnaires

	Name	Type of farmer (crop, livestock, mixed)..  (if details on any of the above provided, also note down)

**3. Warm-up activity**

**(a) Listing foods of 2 food groups**

	Food Group 1: .....	Food Group 2: .....

**(b) Ranking foods of the 2 food groups**

	Food Group 1:.....	Food Group 2:.....

**4. Main Section/Seheme kuu:**

**(a) Seasonal calendars**

Months of year	Food Group 1: .....	Availability 1.high 2.low 3.none	Accessibility 1.grow/rear 2.collect/hunt from wild	Perception of consuming food	Additional comments

Appendix IV: Questionnaires

			3.buy from market 4.Any other way?	1.can you offer it to visitors?	

Months of year	Food Group 2: .....	Availability: 1.high 2.low 3.none	Accessibility 1.grow/rear 2.collect/hunt from wild 3.buy from market 4.any other way?	Perception of consuming food 1.of high value 2.poor man's crop 3.any other way?	Additional comments

**4 (b) Incentives and Disincentives for high agrobiodiversity**

Appendix IV: Questionnaires

(+) incentives/encouragement for high agrobiodiversity (plant and animal)	(-) disincentives/discouragement for high agrobiodiversity (plant and animal)										
<b>Rank order on incentives and disincentives for high agrobiodiversity (group activity)</b>											
Incentives/encouragement for high agrobiodiversity(plant and animal)	Disincentives/discouragement for high agrobiodiversity (plant and animal)										
<b>Incentives and disincentives for farm specialisation</b>											
(+) incentives/encouragement for farm specialisation	(-) disincentives/discouragement for farm specialisation										
<b>Rank order on incentives and disincentives for farm specialisation (group activity)</b>											
Incentives/encouragement for farm specialisation	Disincentives/discouragement for farm specialisation										
<b>5.Hungry Season/Msimu wa njaa</b>											
Start of hungry season(s):.....											
J	F	M	A	M	J	J	A	S	O	N	D

Appendix IV: Questionnaires

End of hungry season(s):.....											
J	F	M	A	M	J	J	A	S	O	N	D
<b>6. Review and Conclude (5 minutes) / <i>kupitia tena na kumalizia (dakika tano)</i></b>											
As we conclude, would you be okay if I took one group photo? This will help us to remember certain issues if we have a photo in front us.....											
If consent provided, take a group photo of all the group members.....											



Appendix IV: Questionnaires

**Part II: Market Inventory – Market Stand**

Date: \_\_\_\_ Start time: \_\_\_\_\_ End time: \_\_\_\_\_ Market stand code:  -  -

Type of market stand: \_\_\_\_\_ Name of seller: \_\_\_\_\_ Gender: \_\_\_\_\_ Age or age class: \_\_\_\_\_

Mobile no.: \_\_\_\_\_ Where do you live?: \_\_\_\_\_ In this business since (year): \_\_\_\_\_

Frequency (monthly / weekly): \_\_\_\_\_ Owner of the stand: Yes / No

Food product/ <i>bidhaa ya chakula</i>	Sub-species/types/ varieties/ <i>aina</i>	Plant or animal part/ <i>sehemu ya mmea au mnyama</i>	Price per unit* and number of units <i>/bei kwa kila kitengo na nambari ya vitengo</i>	How many units do you sell per day?/ <i>unauza vitengo ngapi kila siku?</i>	Origin/Source 1= own production 2= bought 3= other (specify)	Sources from where? <i>/inapatikana kutoka wapi?</i>	Months available** <input type="checkbox"/> = no availability <input checked="" type="checkbox"/> = low availability <input type="checkbox"/> = high availability	Comments <i>/maoni</i>
			Price (KES)	Unit				
							<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
Apart from these products, do you sell any other products at these other times of the year (last 12 months)?								

\* Define unit e.g. bundle, piece, sack, tin and define the size of the unit or measure content with a portable kitchen scale

\*\* Each box stands for one month starting from January (first box 1<sup>st</sup> row) till June (last box 1<sup>st</sup> row) and from August (first box 2<sup>nd</sup> row) till December (last box 2<sup>nd</sup> row)

**9.4.7 Market survey July/August 2014**

**Part I: Overall market stands**

Date: \_\_\_\_\_ Start time: \_\_\_\_\_ End time: \_\_\_\_\_ Market stand code:  -  -

General market data

Name of market: \_\_\_\_\_ Market days: \_\_\_\_\_ Opening hours: \_\_\_\_\_ Type of market: \_\_\_\_\_

General area data

County/Sub-county: \_\_\_\_\_ / \_\_\_\_\_ District: \_\_\_\_\_ Division: \_\_\_\_\_ Location: \_\_\_\_\_

Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_ Altitude: \_\_\_\_\_

Market stand category	Number of stands	Mixed stand details	Number of stands
1 Cereals (maize, sorghum, rice, millet...)			
2 Roots/tubers/matoke			
3 Fruits			
4 Vegetables			
5 Fruits and vegetables			
6 Pulses/nuts/seeds			
7 Animal source foods			
8 Spices/condiments (dhanian, ginger, garlic...)			
9 Butchery			
10 Kiosk			
11 Mixed stand (specify details in 3 <sup>rd</sup> column)			
Total			

**Part II: Market Survey July 2014**

Date: \_\_\_\_\_ Start time: \_\_\_\_\_ End time: \_\_\_\_\_ Market stand code: -- Type of market stand: \_\_\_\_\_  
 Name of seller: \_\_\_\_\_ Gender: \_\_\_\_\_ Age or age class: \_\_\_\_\_ Mobile no.: \_\_\_\_\_  
 Do you live within this district (Mumias/Vihiga)? No/Yes \_\_\_\_\_ Ethnicity \_\_\_\_\_ Owner of the stand: No/ Yes \_\_\_\_\_ In this business since (year): \_\_\_\_\_  
 How much money do you usually pay as a fee for your market stand? KES..... Per..... (eg market day/week/month/year)

Structure of stand			Food item bidhaa ya chakula	Variety aina	Source of supply	If source of supply is not 1 or 2, ask...	Area of Origin (product) bidhaa zinatoka sehemu gani	Buying price bei ya kununua			Selling price bei ya kuuza			
Table	Ground	Other (specify)			1=own farm 2=retailer (sourcing from local farmers within district) 3=retailer (sourcing from farmers outside the district) 4=wholesaler 5=other (specify)	Why do you not source the product from a local farmer? (options at bottom*)		Price (KES)	No. of units	Def. of unit	Price (KES)	No. of units	Def. of unit	Average unit size/weight (can use scale)

1)Unavailable in high amounts; 2)available but expensive; 3)available but product unwanted by customer (because of taste, appearance, etc); 4)lack of trust/could be stolen products eg livestock ; 5) other (specify)

## 9.5 Appendix V: Food plant and livestock standardised measurements

Category	Food available in farms and markets (measure for 1 piece or unit, unless otherwise indicated)	Grams of food consumed or sold	Comments
<b>General local terms</b>	Gorogoro	2 000	
<b>Starchy roots/tubers/bananas</b>	<i>Manihot esculenta</i> / Cassava	300	A 90kg bag=300 cassavas (exactly 0.4kg for 1 piece, so on average take it as roughly 0.3kg)
	<i>Colocasia esculenta</i> /Taro	300	A 20kg bag=50 pieces(exactly 0.4kg for 1 piece, so on average take it as roughly 0.3kg)
	<i>Ipomoea batatas</i> /Sweet potato	300	1 bag=100 sweet potato pieces
	<i>Solanum tuberosum</i> /Irish potato	80	1 sack=20kg
	Banana	100	1 full banana=150 banana pieces (10 'hands'×15 'fingers')
<b>Vegetables</b>	Pumpkin	2 000	
	Cabbage	500	¼ sack=22 cabbages
	Beet root	100	Roughly same weight as carrot
	Egg plant	100	
	Spring onions (1 piece/stick)	10	20 pieces/sticks=1 bunch=0.25kg
	Bulb onion	10	1 kg=10 pieces bulb onions 1 net=10kg
	Garlic	10	
	Ginger	10	
	Tomato	10	1kg tomatoes=10 tomatoes 1 box/crate=20kg
	Carrot	10	
<b>Leafy vegetables (eg Amaranthus, pumpkin leaves etc.)</b>	1 handful /bunch	250	1 handful could have anything between 10-20 pieces
<b>Fruits</b>	Watermelon	2 000	
	Pawpaw	1 000	
	Mango	200	A 20kg bag= 100 mangoes
	Orange	200	A 20kg net=100 oranges
	Avocado	200	A 90kg bag=400 big avocados
	Guava	50	A 20kg bag= 400 guavas
	Lemon	50	
	Passion fruit	30	
	Loquat	50	Average yield per month is 2-4kg
	<i>Dovyalis caffra</i> /Kei apple	50	
	<i>Syzygium cumini</i> /java plum/zambarau	50	
	Pineapple	600	

Appendix V: Food plant and animal standardised measurements

Category	Food available in farms and markets (measure for 1 piece or unit, unless otherwise indicated)	Grams of food consumed or sold	Comments
<b>Whole spices</b>	Capsicum annum (whole): -bell/sweet pepper	70	15 sweet peppers= 1kg
	Capsicum annum (whole): -chilli pepper	30	30 chilli peppers=1kg
	Coriander (one handful/bunch)	50	
<b>Ground spices</b>	¼ pinch powdered chilli pepper	1	
	1 tablespoon or bottle top	10	
<b>Sugarcane</b>	Sugarcane (for sale) 1 truck load	6 000 000	One can get 4 truck loads after 2 years, hence 2 truck loads in a year
	Sugarcane (for home use) 1 stem	250	
<b>Cereals</b>	Maize cob	200	
<b>Animal source foods</b>	1 cow (medium-sized)	115 000	According to the local market butcheries surveyed, the weight ranges between 100 and 130kg, hence mean=115kg
	1 tin of fish	2 000	
	1 piece of medium-sized fish eg tilapia	500	
	1 chicken, 1 duck	2 300	Reference source: (Infonet-Biovision, 2014)
	1 chicken egg	60	
	1 rabbit	2 500	This is a rough estimate as it's likely to have a slightly higher weight than chicken
	1 pig	36 000	Based on the below information, the mean of 30 and 42 kg=36kg <i>Weights (mean) of the young, market-age, and breeding-age pigs were 12 kg, 30 kg, and 42 kg, respectively (Mutua et al., 2011)</i>
	1 goat	28 000	Based on the below information, use the female upper range=28kg  Using East African goat estimates, body weight: Males up to 35 kg, females 25-30 kg (Infonet-Biovision, 2012a)

Appendix V: Food plant and animal standardised measurements

Category	Food available in farms and markets (measure for 1 piece or unit, unless otherwise indicated)	Grams of food consumed or sold	Comments
	1 sheep	44 000	Based on the below information, use the lowest weight given, ie mean for females=44kg  Adult live-weight was 74 kg for males and 44 kg for females (Infonet-Biovision, 2012b)
<b>References for standardised measurements</b>			
<p>Infonet-Biovision (2012a) <i>Goat meat breeds: East African goat</i>. [Online]. Available from: <a href="http://archive.infonet-biovision.org/default/ct/270/livestockSpecies">http://archive.infonet-biovision.org/default/ct/270/livestockSpecies</a> [Accessed 24 November 2014]</p> <p>Infonet-Biovision (2012b) <i>Sheep breeds used in Kenya: hair sheep</i>. [Online]. Available from: <a href="http://archive.infonet-biovision.org/default/ct/269/livestockSpecies">http://archive.infonet-biovision.org/default/ct/269/livestockSpecies</a> [Accessed 24 November 2014]</p> <p>Infonet-Biovision (2014) <i>Chicken breeds and breeding: light breeds</i>. [Online]. Available from: <a href="http://archive.infonet-biovision.org/default/ct/274/livestockSpecies">http://archive.infonet-biovision.org/default/ct/274/livestockSpecies</a> [Accessed 24 November 2014]</p> <p>Mutua, F.K., Dewey, C.E., Arimi, S.M., Schelling, E. and Ogara, W.O. (2011) <i>Prediction of live body weight using length and girth measurements for pigs in rural western Kenya</i>. [Online]. Available from: <a href="http://www.ilri.org/aggregator/sources/98">http://www.ilri.org/aggregator/sources/98</a> [Accessed 24 November 2014]</p>			

## References

- Abdulai, A. and CroleRees, A. (2001) Determinants of income diversification amongst rural households in southern Mali. *Food Policy*, **26**(4), 437-452
- Abebe, T. (2013) Determinants of crop diversity and composition in enset-coffee agroforestry homegardens of southern Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, **114**(1), 29-38
- Abebe, T. and Bongers, F. (2012) Land-use dynamics in enset-based agroforestry homegardens in Ethiopia. In: B. Arts, S. van Bommel, M. Ros-Tonen and G. Verschoor (eds.). *Forest-people interfaces: understanding community forestry and biocultural diversity*. Wageningen: Wageningen Academic Publishers, 69-85.
- Abebe, T., Wiersum, K. and Bongers, F. (2010) Spatial and temporal variation in crop diversity in agroforestry homegardens of southern Ethiopia. *Agroforestry Systems*, **78**(3), 309-322
- Abebe, T., Wiersum, K., Bongers, F. and Sterck, F. (2006) Diversity and dynamics in homegardens of southern Ethiopia. In: B. Kumar and P. Nair (eds.). *Tropical Homegardens: a time-tested example of sustainable agroforestry*, vol 3. Dordrecht: Springer, 123-142.
- Abukutsa-Onyango, M.O. (2002) Market survey on African indigenous vegetables in western Kenya. [Online]. In: J. M. Wesonga, T. Losenge, C. K. Ndung'u, K. Ngamau, J. B. M. Njoroge, F. K. Ombwara, S. G. Agong, A. Fricke, B. Hau and H. Stutzel (eds) *Proceedings of the second horticulture seminar on sustainable horticultural production in the tropics*, Juja, Kenya, 6-9 August 2002. Nairobi and Hannover: JKUAT (Jomo Kenyatta University of Agriculture and Horticulture), University of Hannover and DAAD (German Academic Exchange Service), 39-46. Available from: <http://www.gem.uni-hannover.de/fileadmin/institut/gemuesebau/pdf/SVepit/Proceedings2002.pdf> [Accessed 5 July 2013]
- Abukutsa-Onyango, M.O. (2009) Development and promotion of technologies for sustainable production and utilisation of indigenous vegetables for nutrition security and wealth creation in Kenya. In: K. Urama, M. Momanyi, S. Ochugboju, M. Ominde and G. Manners (eds.). *Agricultural innovations for sustainable development: contributions from the finalists of the African women professionals in science competition*. Nairobi: African Technology Policy Studies Network, 100-108.
- Abukutsa-Onyango, M.O. (2010) *African indigenous vegetables in Kenya: strategic re-positioning in the horticultural sector*. Second inaugural lecture of JKUAT (Jomo Kenyatta University of Agriculture and Technology). Nairobi: JKUAT. [https://www.researchgate.net/publication/235323508\\_AFRICAN\\_INDIGENOUS\\_VEGETABLES\\_IN\\_KENYA\\_Strategic\\_Repositioning\\_in\\_the\\_Horticultural\\_Sector](https://www.researchgate.net/publication/235323508_AFRICAN_INDIGENOUS_VEGETABLES_IN_KENYA_Strategic_Repositioning_in_the_Horticultural_Sector).
- Abukutsa-Onyango, M.O. (2011) Strategic repositioning of agrobiodiversity in the horticulture sector for sustainable development in Africa. In: G. Manners and A. Sweetmore (eds.). *Agricultural innovations for sustainable development:*

## References

- contributions from the finalists of the 2009/2010 Africa-wide women and young professionals in science competitions*. Accra: CTA and FARA, 8-16.
- Abukutsa-Onyango, M.O. and Onyango, J.C. (2005) Conservation and seed production of African leafy vegetables at Maseno University botanic garden, Kenya. [Online]. In: *African crop science conference proceedings*, Kampala, Uganda, 5-9 December 2005. Available from: <http://www.acss.ws/Upload/XML/Research/726.pdf> [Accessed 15 August 2013]
- Acharya, T., Fanzo, J., Gustafson, D., Ingram, J. and Schneeman, B. (2014) *Assessing sustainable nutrition security: the role of food systems*. Washington, D.C.: The International Life Sciences Institute, Research Foundation, Center for Integrated Modeling of Sustainable Agriculture and Nutrition. <http://goo.gl/gEyQ1F>.
- Agea, J.G., Obua, J., Kaboggoza, J.R. and Waiswa, D. (2007) Diversity of indigenous fruit trees in the traditional cotton-millet farming system: the case of Adwari subcounty, Lira district, Uganda. *African Journal of Ecology*, **45**(Suppl. 3), 39-43
- Aguilar-Stoen, M., Moe, S.R. and Camargo-Ricalde, S.L. (2009) Home gardens sustain crop diversity and improve farm resilience in Candelaria Loxicha, Oaxaca, Mexico. *Human Ecology*, **37**(1), 55-77
- Albuquerque, U., Andrade, L. and Caballero, J. (2005) Structure and floristics of homegardens in northeastern Brazil. *Journal of Arid Environments*, **62**(3), 491-506
- Alene, A.D., Manyong, V., Omany, G., Mignouna, H., Bokanga, M. and Odhiambo, G. (2008) Smallholder market participation under transactions costs: maize supply and fertilizer demand in Kenya. *Food Policy*, **33**(4), 318-328
- Aliber, M. and Hart, T.G. (2009) Should subsistence agriculture be supported as a strategy to address rural food insecurity? *Agrekon*, **48**(4), 434-458
- Allen, L.H. (2003) Interventions for micronutrient deficiency control in developing countries: past, present and future. *The Journal of Nutrition*, **133**(11), 3875S-3878S
- Allen, L.H. (2006) Causes of nutrition-related public health problems of preschool children: available diet. *Journal of Pediatric Gastroenterology and Nutrition*, **43**(Suppl. 3), S8-S12
- Almekinders, C. (2001) *Management of crop genetic diversity at community level*. [Online]. Eschborn: GTZ (German Technical Co-operation). Available from: [https://www.researchgate.net/profile/Conny\\_Almekinders/publication/40219209\\_Management\\_of\\_Crop\\_Genetic\\_Diversity\\_at\\_Community\\_Level/links/53e088680cf2aede4b4cce2e.pdf](https://www.researchgate.net/profile/Conny_Almekinders/publication/40219209_Management_of_Crop_Genetic_Diversity_at_Community_Level/links/53e088680cf2aede4b4cce2e.pdf) [Accessed 28 July 2015]
- Altieri, M.A. (2008) *Small farms as a planetary ecological asset: five key reasons why we should support the revitalisation of small farms in the global south*. Environment and Development Series 7. Penang: TWN (Third World Network). <http://www.agroeco.org/doc/smallfarms-ecolasset.pdf>.
- Altieri, M.A., Funes-Monzote, F.R. and Petersen, P. (2012) Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agronomy for Sustainable Development*, **32**(1), 1-13
- Amekawa, Y. (2011) Agroecology and sustainable livelihoods: towards an integrated approach to rural development. *Journal of Sustainable Agriculture*, **35**(2), 118-162

## References

- Anderman, T.L., Remans, R., Wood, S.A., DeRosa, K. and DeFries, R.S. (2014) Synergies and tradeoffs between cash crop production and food security: a case study in rural Ghana. *Food Security*, **6**(4), 541-554
- Andersson, C.I.M., Chege, C.G.K., Rao, E.J.O. and Qaim, M. (2015) Following up on smallholder farmers and supermarkets in Kenya. *American Journal of Agricultural Economics*, **97**(4), 1247-1266
- Argwings-Kodhek, G. (2005) *Background document on umbrella legislation for Kenyan agriculture*. Working Paper 20/2005. Nairobi: Tegemeo Institute of Agricultural Policy and Development.  
[http://www.tegemeo.org/images/downloads/publications/working\\_papers/WP20.pdf](http://www.tegemeo.org/images/downloads/publications/working_papers/WP20.pdf).
- Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M.C., Deitchler, M., Fanou-Fogny, N., Joseph, M.L., Kennedy, G. and Martin-Prevel, Y. (2010) Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. *The Journal of Nutrition*, **140**(11), 2059S-2069S
- Arsenault, J.E., Yakes, E.A., Islam, M.M., Hossain, M.B., Ahmed, T., Hotz, C., Lewis, B., Rahman, A.S., Jamil, K.M. and Brown, K.H. (2013) Very low adequacy of micronutrient intakes by young children and women in rural Bangladesh is primarily explained by low food intake and limited diversity. *The Journal of Nutrition*, 197-203
- AVRDC (The World Vegetable Center) (2009) *Jute mallow: discovering indigenous treasures: promising indigenous vegetables from around the world*. [Online]. Available from: <http://avrdc.org/jute-mallow-corchorus-olitorius/> [Accessed 6 April 2015]
- Ayinde, O.E., Omotesho, O.A. and Adewumi, M.O. (2008) Risk attitudes and management strategies of small - scale crop producer in Kwara State, Nigeria: A ranking approach. *African Journal of Business Management*, **2**(12), 217-221
- Babu, S.C. and Quinn, V.J. (1994) Food security and nutrition monitoring in Africa: Introduction and historical background. *Food Policy*, **19**(3), 211-217
- Baidu-Forson, J.J., Hodgkin, T. and Jones, M. (2012) Introduction to special issue on agricultural biodiversity, ecosystems and environment linkages in Africa. *Agriculture, Ecosystems and Environment*, **157**(1), 1-4
- Baiphethi, M.N. and Jacobs, P.T. (2009) The contribution of subsistence farming to food security in South Africa. *Agrekon*, **48**(4), 459-482
- Ballard, T., Coates, J., Swindale, A. and Deitchler, M. (2011) *Household hunger scale: indicator definition and measurement guide*. Washington, D.C.: FANTA-2 (Food and Nutrition Technical Assistance).
- Ballard, T.J., Kepple, A.W. and Cafiero, C. (2013) *The food insecurity experience scale: development of a global standard for monitoring hunger worldwide*. Technical Paper. Rome: FAO (Food and Agriculture Organization of the United Nations). <http://www.fao.org/economic/ess/ess-fs/voices/fiessscale/en/>.
- Bamidele, J., Dania, O. and Oyomoare, L. (2011) Plant genetic resources of home gardens in three ecological zones of Nigeria. *African Scientist*, **12**(2), 89-98
- Barbet-Massin, M. and Jetz, W. (2015) The effect of range changes on the functional turnover, structure and diversity of bird assemblages under future climate scenarios. *Global Change Biology*. doi:<http://dx.doi.org/10.1111/gcb.12905>

## References

- Barrett, C.B. (2008) Smallholder market participation: concepts and evidence from eastern and southern Africa. *Food Policy*, **33**(4), 299-317
- Barrett, C.B. (2010) Measuring food insecurity. *Science*, **327**(5967), 825-828
- Barrett, C.B., Clark, M.B., Clay, D.C. and Reardon, T. (2000) Heterogeneous constraints, incentives and income diversification strategies in rural Africa. *Quarterly Journal of International Agriculture*, **44**(1), 37-60
- Basch, C.E. (1987) Focus group interview: an underutilized research technique for improving theory and practice in health education. *Health Education and Behavior*, **14**(4), 411-448
- Baudron, F., Andersson, J.A., Corbeels, M. and Giller, K.E. (2012) Failing to yield? Ploughs, conservation agriculture and the problem of agricultural intensification: an example from the Zambezi Valley, Zimbabwe. *Journal of Development Studies*, **48**(3), 393-412
- Baul, T.K., Rahman, M.M., Moniruzzaman, M. and Nandi, R. (2015) Status, utilization, and conservation of agrobiodiversity in farms: a case study in the northwestern region of Bangladesh. *International Journal of Biodiversity Science, Ecosystem Services and Management* DOI: <http://dx.doi.org/10.1080/21513732.2015.1050456>.
- Bayala, J., Kalinganire, A., Tchoundjeu, Z., Sinclair, F. and Garrity, D. (2011) *Conservation agriculture with trees in the west African Sahel - a review*. ICRAF (World Agroforestry Centre) Occasional Paper 14. Nairobi: ICRAF.
- Bayala, J., Kindt, R., Belem, M. and Kalinganire, A. (2011) Factors affecting the dynamics of tree diversity in agroforestry parklands of cereal and cotton farming systems in Burkina Faso. *New Forests*, **41**(3), 281-296
- Baye, K., Guyot, J.-P., Icard-Verniere, C. and Mouquet-Rivier, C. (2012) Nutrient intakes from complementary foods consumed by young children (aged 12-23 months) from north Wollo, northern Ethiopia: the need for agro-ecologically adapted interventions. *Public Health Nutrition*, **16**(10), 1741-1750
- Beckford, C., Barker, D. and Bailey, S. (2007) Adaptation, innovation and domestic food production in Jamaica: some examples of survival strategies of small scale farmers. *Singapore Journal of Tropical Geography*, **28**(3), 273-286
- Beddington, J.R. (2011) *The future of food and farming: challenges and choices for global sustainability: final project report of the UK Government foresight global food and farming futures*. Government Office for Science.
- Bennett-Lartley, S.O., Ayernor, G.S., Markwei, C.M., Asante, I.K., Abbiw, D.K., Boateng, S.K., Anchirinah, V.M. and Ekpe, P. (2002) Contribution of home gardens to in situ conservation of plant genetic resources farming systems in Ghana. [Online]. In: J. W. Watson and P. B. Eyzaguirre (eds) *Home gardens and in situ conservation of plant genetic resources in farming systems*, Proceedings of the second international home gardens workshop, Witzenhausen, Germany, 17-19 July 2001. Rome: IPGRI (International Plant Genetic Resources Institute), 83-95. Available from: [http://www.biodiversityinternational.org/uploads/tx\\_news/Home\\_gardens\\_and\\_in\\_situ\\_conservation\\_of\\_plant\\_genetic\\_resources\\_in\\_farming\\_systems\\_753.pdf](http://www.biodiversityinternational.org/uploads/tx_news/Home_gardens_and_in_situ_conservation_of_plant_genetic_resources_in_farming_systems_753.pdf) [Accessed 3 June 2013]
- Bernard, T. and Spielman, D.J. (2009) Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia. *Food Policy*, **34**(1), 60-69

## References

- Bernholt, H., Kehlenbeck, K., Gebauer, J. and Buerkert, A. (2009) Plant species richness and diversity in urban and peri-urban gardens of Niamey, Niger. *Agroforestry Systems*, **77**(3), 159-179
- Berti, P.R., Krasevec, J. and FitzGerald, S. (2004) A review of the effectiveness of agriculture interventions in improving nutrition outcomes. *Public Health Nutrition*, **7**(5), 599-609
- Biesalski, H.K., Dragsted, L.O., Elmalfa, I., Grossklaus, R., Muller, M., Schrenk, D., Walter, P. and Weber, P. (2009) Bioactive compounds: definition and assessment of activity. *Nutrition*, **25**(11), 1202-1205
- Bihn, J.H., Gebauer, G. and Brandl, R. (2010) Loss of functional diversity of ant assemblages in secondary tropical forests. *Ecology*, **91**(3), 782-792
- Bisht, I., Pandravada, S., Rana, J., Malik, S., Singh, A., Singh, P., Ahmed, F. and Bansal, K.C. (2014) Subsistence farming, agrobiodiversity, and sustainable agriculture: a case study. *Agroecology and Sustainable Food Systems*, **38**(8), 890-912
- Bjorklund, J., Westberg, L., Geber, U., Milestad, R. and Ahnstrom, J. (2009) Local selling as a driving force for increased on-farm biodiversity. *Journal of Sustainable Agriculture*, **33**(8), 885-902
- Boffa, J., Kindt, R., Katumba, B., Jourget, J. and Turyomurugyendo, L. (2008) Management of tree diversity in agricultural landscapes around Mabira forest reserve, Uganda. *African Journal of Ecology*, **46**(Suppl. 1), 24-32
- Borlaug, N. (2007) Feeding a hungry world. *Science*, **318**(5849), 359-359
- Border, D.K. and Mwanza, R.N. (2011) Rabbit production in Kenya, current status and way forward. In: *Proceedings of annual scientific symposium of the animal production society of Kenya: driving livestock entrepreneurship towards attainment of food sufficiency and Kenya Vision 2030*. Nairobi: Animal Production Society of Kenya, 13-19.
- Brookfield, H. and Padoch, C. (1994) Appreciating agrodiversity: a look at the dynamism and diversity of indigenous farming practices. *Environment: Science and Policy for Sustainable Development*, **36**(5), 6-45
- Brunori, G., Bartolini, F., Avermaete, T., Brzezina, N., Mathijs, E., Marsden, T., Faus, A.M. and Sonnino, R. (2015) *Assessment of the impact of global drivers of change on Europe's food and nutrition security*. TRANSMANGO Work Package 2. Leuven: TRANSMANGO.
- Bwibo, N.O. and Neumann, C.G. (2003) The need for animal source foods by Kenyan children. *The Journal of Nutrition*, **133**(11), 3936S-3940S
- Cadotte, M.W., Carscadden, K. and Mirotchnick, N. (2011) Beyond species: functional diversity and the maintenance of ecological processes and services. *Journal of Applied Ecology*, **48**(5), 1079-1087
- Carr, E.R. (2008) Men's crops and women's crops: the importance of gender to the understanding of agricultural and development outcomes in Ghana's central region. *World Development*, **36**(5), 900-915
- Cash, D.W., Adger, W.N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L. and Young, O. (2006) Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and Society*, **11**(2), 8
- Catacutan, D.C. and Duque-Pinon, C. (2009) The policy environment of vegetable-agroforestry in the Philippines and Vietnam: are there incentives for smallholders? *International Journal of Ecology and Development*, **14**(9), 47-62

## References

- Cavechia, L.A., Cantor, M., Begossi, A. and Peroni, N. (2014) Resource-use patterns in swidden farming communities: implications for the resilience of cassava diversity. *Human Ecology*, **42**(4), 605-616
- Chao, S. (2015) *Rabbit keeper makes fast cash from her dream job*. Business Daily: 24 November. <http://www.businessdailyafrica.com/Rabbit-keeper-makes-fast-cash-from-her-dream-job/-/1248928/1968766/-/item/1/-/mqda81z/-/index.html>.
- Chege, C.G.K., Andersson, C.I.M. and Qaim, M. (2015) Impacts of supermarkets on farm household nutrition in Kenya. *World Development*, **72**(1), 394-407
- Chibwana, C., Fisher, M. and Shively, G. (2012) Cropland allocation effects of agricultural input subsidies in Malawi. *World Development*, **40**(1), 124-133
- Chilonda, P. and Otte, J. (2006) *Indicators to monitor trends in livestock production at national, regional and international levels*. [Online]. Livestock Research for Rural Development 18 (8). Available from: <http://www.lrrd.org/lrrd18/8/chil18117.htm> [Accessed 7 April 2014]
- Chirwa, E.W. and Matita, M. (2012) *From subsistence to smallholder commercial farming in Malawi: a case of NASFAM (National Smallholder Farmer Association of Malawi) commercialisation initiatives*. Working Paper 037. Brighton: Future Agricultures Consortium.
- Cohen, J. (1990) Things I have learned (so far). *American Psychologist*, **45**(12), 1304-1312
- Collier, P. and Dercon, S. (2014) African agriculture in 50 years: smallholders in a rapidly changing world? *World Development*, **63**, 92-101
- Collier, W. (2010) *Re-thinking biodiversity in forest and field: colonial maize and climate: limits of agricultural development for adaptation in Rift Valley, Kenya*. Bulletin of the Yale Tropical Resources Institute.
- Committee on World Food Security (2012) *Coming to terms with terminology: food security, nutrition security, food security and nutrition, food and nutrition security*. 39th Session. Rome.
- Connelly, W.T. and Chaiken, M.S. (2000) Intensive farming, agro-diversity, and food security under conditions of extreme population pressure in western Kenya. *Human Ecology*, **28**(1), 19-51
- Coolsaet, B. (2015) Transformative participation in agrobiodiversity governance: making the case for an environmental justice approach. *Journal of Agricultural and Environmental Ethics* DOI: <http://dx.doi.org/10.1007/s10806-015-9579-2>.
- Coomes, O.T. and Ban, N. (2004) Cultivated plant species diversity in home gardens of an Amazonian peasant village in northeastern Peru. *Economic Botany*, **58**(3), 420-434
- Darmon, N., Darmon, M., Maillot, M. and Drewnowski, A. (2005) A nutrient density standard for vegetables and fruits: nutrients per calorie and nutrients per unit cost. *Journal of the American Dietetic Association*, **105**(12), 1881-1887
- De Weerd, J. (2009) Moving out of poverty in Tanzania: evidence from Kagera. *The Journal of Development Studies*, **46**(2), 331-349
- DeClerck, F.A., Fanzo, J., Palm, C. and Remans, R. (2011) Ecological approaches to human nutrition. *Food and Nutrition Bulletin*, **32**(Suppl. 1), 41S-50S
- DeFries, R., Fanzo, J., Remans, R., Palm, C., Wood, S. and Anderman, T.L. (2015) Metrics for land-scarce agriculture. *Science*, **349**(6245), 238-240

## References

- Deletre, M., McKey, D.B. and Hodkinson, T.R. (2011) Marriage exchanges, seed exchanges, and the dynamics of manioc diversity. *Proceedings of the National Academy of Sciences*, **108**(45), 18249-18254
- Delgado, C. (1999) Sources of growth in smallholder agriculture in sub-Saharan Africa: the role of vertical integration of smallholders with processors and marketers of high value-added items. *Agrekon*, **38**(S), 165-189
- Devereux, S. (2009) Why does famine persist in Africa? *Food Security*, **1**(1), 25-35
- Diaz, J.R., de las Cagigas, A. and Rodriguez, R. (2003) Micronutrient deficiencies in developing and affluent countries. *European Journal of Clinical Nutrition*, **57**(Suppl. 1), S70-S72
- Djurfeldt, A.A. (2012) Seasonality and farm/non-farm interactions in Western Kenya. *The Journal of Modern African Studies*, **50**(1), 1-23
- Djurfeldt, A.A. and Wambugu, S.K. (2011) In-kind transfers of maize, commercialization and household consumption in Kenya. *Journal of Eastern African Studies*, **5**(3), 447-464
- Doak, C.M., Adair, L.S., Bentley, M., Monteiro, C. and Popkin, B.M. (2005) The dual burden household and the nutrition transition paradox. *International Journal of Obesity*, **29**(1), 129-136
- Dorward, A. and Chirwa, E. (2011) The Malawi agricultural input subsidy programme: 2005/06 to 2008/09. *International Journal of Agricultural Sustainability*, **9**(1), 232-247
- Doss, C.R. (2002) Men's crops? Women's crops? The gender patterns of cropping in Ghana. *World Development*, **30**(11), 1987-2000
- Dovie, D.B., Witkowski, E. and Shackleton, C.M. (2003) Direct-use value of smallholder crop production in a semi-arid rural South African village. *Agricultural systems*, **76**(1), 337-357
- Dror, D.K. and Allen, L.H. (2011) The importance of milk and other animal-source foods for children in low-income countries. *Food and Nutrition Bulletin*, **32**(3), 227-243
- Dury, S., Alpha, A. and Bichard, A. (2014) *What risks do agricultural interventions entail for nutrition?* Working Paper MOISA 2014-3. Montpellier: UMR-MOISA (Unité mixte de recherche- Marchés, Organisations, Institutions et Stratégies d'Acteurs).
- Dury, S., Vallaud, M. and Coulibaly, H. (2011) Market access of small-scale farms and biodiversity management of food crops: the case of sorghum and pearl millet in Mali. [Online]. In: *5emes journées de recherches en sciences sociales des 08 et 09 Decembre 2011*, Dijon, France. Available from: <http://agritrop.cirad.fr/563103/> [Accessed 6 March 2013]
- Dytham, C. (2011) *Choosing and using statistics: a biologist's guide*. 3rd ed., Malden: Wiley- Blackwell.
- Ekesa, B., Walingo, M. and Abukutsa-Onyango, M. (2008) Influence of agricultural biodiversity on dietary diversity of preschool children in Matungu division, Western Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, **8**(4), 390-404
- Ekesa, B., Walingo, M. and Onyango, M. (2009) Accessibility to and consumption of indigenous vegetables and fruits by rural households in Matungu division, western Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, **9**(8), 1725-1738

## References

- Ellis, F. (1998) Household strategies and rural livelihood diversification. *The Journal of Development Studies*, **35**(1), 1-38
- Ellis, F. and Bahigwa, G. (2003) Livelihoods and rural poverty reduction in Uganda. *World Development*, **31**(6), 997-1013
- Ellis, F. and Mdoe, N. (2003) Livelihoods and rural poverty reduction in Tanzania. *World Development*, **31**(8), 1367-1384
- Enters, T., Durst, P.B., Brown, C., Carle, J. and McKenzie, P. (2004) *What does it take? The role of incentives in forest plantation development in the Asia-Pacific region*. FAO Executive summary. Bangkok: FAO Regional Office for Asia and the Pacific.
- Erenstein, O., Oswald, A. and Mahaman, M. (2006) Determinants of lowland use close to urban markets along an agro-ecological gradient in West Africa. *Agriculture, Ecosystems and Environment*, **117**(2), 205-217
- Erhardt, J. (2007) *Description of NutriSurvey*. [Online]. Available from: <http://www.nutrisurvey.de/index.html> [Accessed 15 May 2014]
- Ericksen, P., Stewart, B., Dixon, J., Barling, D., Loring, P., Anderson, M. and Ingram, J. (2010) The value of a food system approach. In: J. Ingram, P. Ericksen and D. Liverman (eds.). *Food security and global environmental change*. London: Earthscan, 25-45.
- Fafchamps, M. (1992) Cash crop production, food price volatility, and rural market integration in the third world. *American Journal of Agricultural Economics*, **74**(1), 90-99
- Fanjul, G. and Guereña, A. (2009) *Markets working for the rural poor*. Background paper for the IFAD Rural poverty report 2011. Madrid: Intermon Oxfam.
- Fanzo, J. (2014) Strengthening the engagement of food and health systems to improve nutrition security: synthesis and overview of approaches to address malnutrition. *Global Food Security*, **3**(3), 183-192
- Fanzo, J., Holmes, M., Junega, P., Musinguzi, E., Smith, I.F., Ekesa, B. and Bergamini, N. (2011) *Improving nutrition with agricultural biodiversity: a manual on implementing food systems field projects to assess and improve dietary diversity, nutrition and health outcomes*. Rome: Bioversity International. [http://www.bioversityinternational.org/uploads/tx\\_news/Improving\\_nutrition\\_with\\_agricultural\\_biodiversity\\_1478.pdf](http://www.bioversityinternational.org/uploads/tx_news/Improving_nutrition_with_agricultural_biodiversity_1478.pdf).
- Fanzo, J., Marshall, Q., Dobermann, D., Wong, J., Merchan, R.I., Jaber, M.I., Souza, A., Verjee, N. and Davis, K. (2015) Integration of nutrition into extension and advisory services: a synthesis of experiences, lessons, and recommendations. *Food and Nutrition Bulletin*, **36**(2), 120-137
- FAO (Food and Agriculture Organization of the United Nations) (1996) *Rome declaration and world food summit plan of action*. Rome: FAO.
- FAO (Food and Agriculture Organization of the United Nations) (2010a) *FAO at work 2009-2010: growing food for nine billion*. [Online]. Rome: FAO. Available from: <http://www.fao.org/docrep/013/am023e/am023e00.pdf> [Accessed 23 June 2015]
- FAO (Food and Agriculture Organization of the United Nations) (2010b) *Expert Consultation on Nutrition Indicators for Biodiversity :2. Food Consumption*. Rome: FAO.
- FAO (Food and Agriculture Organization of the United Nations) (2011) *Guidelines for measuring household and individual dietary diversity*. Rome: FAO.

## References

- FAO (Food and Agriculture Organization of the United Nations) (2012) *Factsheet: smallholders and family farmers*.  
[http://www.fao.org/fileadmin/templates/nr/sustainability\\_pathways/docs/Factsheet\\_SMALLHOLDERS.pdf](http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDERS.pdf).
- FAO (Food and Agriculture Organization of the United Nations) (2013) *The state of food and agriculture: food systems for better nutrition*. Rome: FAO.
- FAO (Food and Agriculture Organization of the United Nations) (2014) *Compendium for sustainable crop production intensification*. [Online]. FAO. Available from: <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/framework/en/> [Accessed 13 May 2014]
- FAO (Food and Agriculture Organization of the United Nations) (2015) *Social protection and agriculture: breaking the cycle of rural poverty*. The State of Food and Agriculture 2015. Rome: FAO. <http://www.fao.org/3/a-i4910e.pdf>.
- FAO (Food and Agriculture Organization of the United Nations) and FANTA (Food and Nutrition Technical Assistance) (2014) *Introducing the MDD-W (Minimum Dietary Diversity-Women) global dietary diversity indicator for women*. Washington, D.C.: FAO and FANTA.
- FAO (Food and Agriculture Organization of the United Nations) and PAR (Platform on Agrobiodiversity Research) (2011) *Biodiversity for food and agriculture: contributing to food security and sustainability in a changing world*. Rome: FAO and PAR.
- FAO/INFOODS (Food and Agriculture Organization of the United Nations/International Network of Food Data Systems) (2012a) *West African food composition table*. [Online]. FAO. Available from: <http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/> [Accessed 11 November 2014]
- FAO/INFOODS (Food and Agriculture Organization of the United Nations/International Network of Food Data Systems) (2012b) *FAO/INFOODS analytical food composition database, Version 1.0 (AnFood1.0)*. [Online]. FAO. Available from: <http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/> [Accessed 11 November 2014]
- Fentahun, M. and Hager, H. (2009) Integration of indigenous wild woody perennial edible fruit bearing species in the agricultural landscapes of Amhara region, Ethiopia. *Agroforestry Systems*, **78**(1), 79-95
- Field, A. (2013) *Discovering statistics using IBM SPSS Statistics*. 4th ed., London: Sage Publications Ltd.
- Fifanou, V.G., Ousmane, C., Gauthier, B. and Brice, S. (2011) Traditional agroforestry systems and biodiversity conservation in Benin (West Africa). *Agroforestry Systems*, **82**(1), 1-13
- Figueroa, B.M., Tittonell, P., Giller, K.E. and Ohiokpehai, O. (2009) The contribution of traditional vegetables to household food security in two communities of Vihiga and Migori districts, Kenya. [Online]. In: H. Jaenicke, I. Ganry, I. Hoeschle-Zeledon and R. Kahane (eds), International symposium on underutilized plant species for food, nutrition, income and sustainable development, Arusha, Tanzania, 3-7 May 2008. Leuven: ISHS (International Society for Horticultural Science) Acta Horticulturae 806, 57-64. Available from: [http://www.actahort.org/books/806/806\\_4.htm](http://www.actahort.org/books/806/806_4.htm) [Accessed 5 June 2013]

## References

- Filmer, D. and Pritchett, L.H. (2001) Estimating wealth effects without expenditure data - or tears: an application to educational enrollments in states of India. *Demography*, **38**(1), 115-132
- Fischer, E. and Qaim, M. (2012) Gender, agricultural commercialization, and collective action in Kenya. *Food Security*, **4**(3), 441-453
- Folberth, C., Yang, H., Gaiser, T., Liu, J., Wang, X., Williams, J. and Schulin, R. (2014) Effects of ecological and conventional agricultural intensification practices on maize yields in sub-Saharan Africa under potential climate change. *Environmental Research Letters*, **9**(4), 044004
- Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K. and West, P.C. (2011) Solutions for a cultivated planet. *Nature*, **478**(7369), 337-342
- Foote, J.A., Murphy, S.P., Wilkens, L.R., Basiotis, P.P. and Carlson, A. (2004) Dietary variety increases the probability of nutrient adequacy among adults. *The Journal of Nutrition*, **134**(7), 1779-1785
- Francis, C., Lieblein, G., Gliessman, S., Breland, T., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D. and Salvador, R. (2003) Agroecology: the ecology of food systems. *Journal of Sustainable Agriculture*, **22**(3), 99-118
- Frison, E.A., Cherfas, J., Eyzaguirre, P.B. and Johns, T. (2004) Biodiversity, nutrition and health: making a difference to hunger and conservation in the developing world. [Online]. In: *Seventh meeting of the COP 7 (Conference of the Parties to the Convention on Biological Diversity)*, Kuala Lumpur, 9-20 February 2004. Available from: <https://www.cbd.int/doc/speech/2004/sp-2004-02-09-cop-02-en.pdf> [Accessed 6 April 2012]
- Frison, E.A., Cherfas, J. and Hodgkin, T. (2011) Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*, **3**(1), 238-253
- Frison, E.A., Smith, I.F., Johns, T., Cherfas, J. and Eyzaguirre, P.B. (2006) Agricultural biodiversity, nutrition, and health: making a difference to hunger and nutrition in the developing world. *Food and Nutrition Bulletin*, **27**(2), 167-179
- Galhena, D.H., Freed, R. and Maredia, K.M. (2013) Home gardens: a promising approach to enhance household food security and wellbeing. *Agriculture and Food Security*, **2**(8), 1-13
- Gallagher, R.V., Hughes, L. and Leishman, M.R. (2013) Species loss and gain in communities under future climate change: consequences for functional diversity. *Ecography*, **36**(5), 531-540
- Galluzzi, G., Eyzaguirre, P. and Negri, V. (2010) Home gardens: neglected hotspots of agro-biodiversity and cultural diversity. *Biodiversity and Conservation*, **19**(13), 3635-3654
- Garnett, T. and Godfray, C. (2012) *Sustainable intensification in agriculture. Navigating a course through competing food system priorities* Oxford: Food Climate Research Network and the Oxford Martin Programme on the Future of Food.
- Garrity, D.P., Akinnifesi, F.K., Ajayi, O.C., Weldesemayat, S.G., Mowo, J.G., Kalinganire, A., Larwanou, M. and Bayala, J. (2010) Evergreen agriculture: a robust approach to sustainable food security in Africa. *Food Security*, **2**(3), 197-214

## References

- Giller, K.E., Witter, E., Corbeels, M. and Tittonell, P. (2009) Conservation agriculture and smallholder farming in Africa: the heretics' view. *Field Crops Research*, **114**(1), 23-34
- Gillespie, S., Harris, J. and Kadiyala, S. (2012) *The agriculture-nutrition disconnect in India: what do we know?* IFPRI (International Food Policy Research Institute) Discussion Paper 01187. Washington, D.C.: IFPRI.
- Girard, A.W., Self, J.L., McAuliffe, C. and Olude, O. (2012) The effects of household food production strategies on the health and nutrition outcomes of women and young children: a systematic review. *Paediatric and Perinatal Epidemiology*, **26**(Suppl.1), 205-222
- Gliessman, S. (2013) Agroecology: growing the roots of resistance. *Agroecology and Sustainable Food Systems*, **37**(1), 19-31
- Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. and Toulmin, C. (2010) Food security: the challenge of feeding 9 billion people. *Science*, **327**(5967), 812-818
- Gonthier, D.J., Ennis, K.K., Farinas, S., Hsieh, H.Y., Iverson, A.L., Batary, P., Rudolphi, J., Tschardtke, T., Cardinale, B.J. and Perfecto, I. (2014) Biodiversity conservation in agriculture requires a multi-scale approach. *Proceedings of the Royal Society B*, **281**(1791), 20141358
- Gotor, E. and Irungu, C. (2010) The impact of Bioversity International's African leafy vegetables programme in Kenya. *Impact Assessment and Project Appraisal*, **28**(1), 41-55
- Govere, J., Jayne, T. and Nyoro, J. (1999) *Smallholder commercialization, interlinked markets and food crop productivity: cross-country evidence in eastern and southern Africa*. Michigan: Michigan State University.
- Govere, J. and Jayne, T.S. (2003) Cash cropping and food crop productivity: synergies or trade-offs? *Agricultural Economics*, **28**(1), 39-50
- Government of Kenya (1955) *Agriculture Act (Chapter 318)*. Nairobi: Government Printer.
- Government of Kenya (2001) *Agriculture : natural resource aspects of sustainable development in Kenya*. Nairobi: Government Printer.
- Government of Kenya (2006) *Ministry of Agriculture - strategic plan 2006-2010*. Nairobi: Government Printer.
- Government of Kenya (2007) *Kenya Vision 2030*. Nairobi: Government Printer.  
[http://www.vision2030.go.ke/wp-content/uploads/2015/06/Popular\\_Version1.pdf](http://www.vision2030.go.ke/wp-content/uploads/2015/06/Popular_Version1.pdf).
- Government of Kenya (2009) *Sessional Paper No. 3 of 2009 on National Land Policy*. Nairobi: Government Printer.
- Government of Kenya (2010) *Agricultural Sector Development Strategy (ASDS) 2010-2020*. Nairobi: Government Printer.
- Government of Kenya (2011) *National Food and Nutrition Security Policy*. Nairobi: Government Printer.
- Graham, R.D., Welch, R.M., Saunders, D.A., Ortiz-Monasterio, I., Bouis, H.E., Bonierbale, M., de Haan, S., Burgos, G., Thiele, G., Liria, R., Meisner, C.A., Beebe, S.A., Potts, M.J., Kadian, M., Hobbs, P.R., K, G.R. and Twomlow, S. (2007) Nutritious subsistence food systems. *Advances in Agronomy*, **92**(1), 1-74

## References

- Grassini, P., Eskridge, K.M. and Cassman, K.G. (2013) Distinguishing between yield advances and yield plateaus in historical crop production trends. *Nature Communications*, **4**, 1-11
- Gregory, P.J., Ingram, J.S. and Brklacich, M. (2005) Climate change and food security. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **360**(1463), 2139-2148
- Gruere, G., Giuliani, A. and Smale, M. (2006) *Marketing underutilized plant species for the benefit of the poor: a conceptual framework*. EPT (Environment and Production Technology Division) Discussion Paper 154. Washington, D.C.: IFPRI (International Food Policy Research Institute).
- Haddad, L. (2013) From nutrition plus to nutrition driven: how to realize the elusive potential of agriculture for nutrition? *Food and Nutrition Bulletin*, **34**(1), 39-44
- Harris, D. and Orr, A. (2014) Is rainfed agriculture really a pathway from poverty? *Agricultural Systems*, **123**, 84-96
- Hawkesworth, S., Dangour, A.D., Johnston, D., Lock, K., Poole, N., Rushton, J., Uauy, R. and Waage, J. (2010) Feeding the world healthily: the challenge of measuring the effects of agriculture on health. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **365**(1554), 3083-3097
- Hazell, P.B.R. (2005) Is there a future for small farms? *Agricultural Economics*, **32**(Suppl. s1 ), 93-101
- Henry, M., Tittonell, P., Manlay, R., Bernoux, M., Albrecht, A. and Vanlauwe, B. (2009) Biodiversity, carbon stocks and sequestration potential in aboveground biomass in smallholder farming systems of western Kenya. *Agriculture, Ecosystems and Environment*, **129**(1), 238-252
- Herforth, A. (2010) Promotion of traditional African vegetables in Kenya and Tanzania: a case study of an intervention representing emerging imperatives in global nutrition.
- Herforth, A. and Ahmed, S. (2015) The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security*, **7**(3), 505-520
- Herforth, A., Frongillo, E.A., Sassi, F., Mclean, M.S., Arabi, M., Tirado, C., Remans, R., Mantilla, G., Thomson, M. and Pingali, P. (2014) Toward an integrated approach to nutritional quality, environmental sustainability, and economic viability: research and measurement gaps. *Annals of the New York Academy of Sciences*, **1332**(1), 1-21
- Hesselberg, J. and Yaro, J.A. (2006) An assessment of the extent and causes of food insecurity in northern Ghana using a livelihood vulnerability framework. *GeoJournal*, **67**(1), 41-55
- Hillocks, R. (2011) Farming for balanced nutrition: an agricultural approach to addressing micronutrient deficiency among the vulnerable poor in Africa. *African Journal of Food, Agriculture, Nutrition and Development*, **11**(2), 4688-4707
- Hoddinott, J., Headey, D. and Dereje, M. (2014) *Cows, missing milk markets and nutrition in rural Ethiopia*. ESSP (Ethiopia Strategy Support Program) Working Paper 63. Washington, D.C. and Addis Ababa: IFPRI (International Food Policy Research Institute) and EDRI (Ethiopian Development Research Institute). <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128038>.

## References

- Hoddinott, J. and Yohannes, Y. (2002) *Dietary diversity as a food security indicator*. FCND (Food Consumption and Nutrition Division) Discussion Paper 136. Washington, D.C.: IFPRI (International Food Policy Research Institute).
- Hodges, R.J., Buzby, J.C. and Bennett, B. (2011) Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *The Journal of Agricultural Science*, **149**(Suppl.1), 37-45
- Holt-Gimenez, E., Shattuck, A., Altieri, M., Herren, H. and Gliessman, S. (2012) We already grow enough food for 10 billion people... and still can't end hunger. *Journal of Sustainable Agriculture*, **36**(6), 595-598
- Horna, D., Timpo, S. and Gruere, G. (2007) *Marketing underutilized crops for biodiversity: the case of African garden egg (Solanum aethiopicum) in Ghana*. Rome: GFU (Global Facilitation Unit for Underutilized Species).  
[http://www.bioversityinternational.org/uploads/tx\\_news/Marketing\\_underutilized\\_crops\\_the\\_case\\_of\\_the\\_African\\_garden\\_egg\\_Solanum\\_ethiopicum\\_in\\_Ghana\\_1267.pdf](http://www.bioversityinternational.org/uploads/tx_news/Marketing_underutilized_crops_the_case_of_the_African_garden_egg_Solanum_ethiopicum_in_Ghana_1267.pdf).
- Hotz, C. and Gibson, R.S. (2005) Participatory nutrition education and adoption of new feeding practices are associated with improved adequacy of complementary diets among rural Malawian children: a pilot study. *European Journal of Clinical Nutrition*, **59**(2), 226-237
- Huai, H. and Hamilton, A. (2009) Characteristics and functions of traditional homegardens: a review. *Frontiers of Biology in China*, **4**(2), 151-157
- Hyder, A.A., Maman, S., Nyoni, J.E., Khasiani, S.A., Teoh, N., Premji, Z. and Sohani, S. (2007) The pervasive triad of food security, gender inequity and women's health: exploratory research from sub-Saharan Africa. *African Health Sciences*, **5**(4), 328-334
- IBM Corporation (2013) *IBM Statistical Package for Social Sciences (SPSS) Statistics for Windows, Version 22.0*. New York: IBM Corporation.
- IFPRI (International Food Policy Research Institute) (2015) *2014-2015 Global food policy report*. Washington, D.C.: IFPRI.
- IIRR (International Institute of Rural Reconstruction) (1996) *Recording and using indigenous knowledge: a manual*. Silang: IIRR.
- Iiyama, M., Maitima, J. and Kariuki, P. (2007) Crop-livestock diversification patterns in relation to income and manure use: a case study from a Rift Valley community, Kenya. *African Journal of Agricultural Research*, **2**(3), 58-66
- Infonet-Biovision (2012a) *Goat meat breeds: East African goat*. [Online]. Available from: <http://archive.infonet-biovision.org/default/ct/270/livestockSpecies> [Accessed 24 November 2014]
- Infonet-Biovision (2014) *Chicken breeds and breeding: light breeds*. [Online]. Available from: <http://archive.infonet-biovision.org/default/ct/274/livestockSpecies> [Accessed 24 November 2014]
- Ingram, J. (2011) A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, **3**(4), 417-431
- Institute of Medicine of the National Academies (2014) *Dietary reference intakes tables and application: DRI values summary*. [Online]. Available from: <http://www.iom.edu/activities/nutrition/summarydri/dri-tables.aspx> [Accessed 22 January 2015]

## References

- Isakson, S.R. (2011) Market provisioning and the conservation of crop biodiversity: an analysis of peasant livelihoods and maize diversity in the Guatemalan highlands. *World Development*, **39**(8), 1444-1459
- Jackson, L.E., Pascual, U. and Hodgkin, T. (2007) Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agriculture, Ecosystems and Environment*, **121**(3), 196-210
- Jaenicke, H. and Virchow, D. (2013) Entry points into a nutrition-sensitive agriculture. *Food Security*, **5**(5), 679-692
- Jaetzold, R., Schmidt, H., Hornetz, B. and Shisanya, C. (2005) *Farm management handbook of Kenya. Natural conditions and farm management information* vol II/A, Western Province. 2nd ed., Nairobi: Ministry of Agriculture/GTZ.
- Jama, B. and Pizarro, G. (2008) Agriculture in Africa: strategies to improve and sustain smallholder production systems. *Annals of the New York Academy of Sciences*, **1136**(1), 218-232
- Jamnadas, R., Dawson, I., Franzel, S., Leakey, R., Mithofer, D., Akinnifesi, F. and Tchoundjeu, Z. (2011) Improving livelihoods and nutrition in sub-Saharan Africa through the promotion of indigenous and exotic fruit production in smallholders' agroforestry systems: a review. *International Forestry Review*, **13**(3), 338-354
- Jarvis, D.I., Hodgkin, T., Sthapit, B.R., Fadda, C. and Lopez-Noriega, I. (2011) An heuristic framework for identifying multiple ways of supporting the conservation and use of traditional crop varieties within the agricultural production system. *Critical Reviews in Plant Sciences*, **30**(1-2), 125-176
- Jayne, T.S. and Rashid, S. (2013) Input subsidy programs in sub-Saharan Africa: a synthesis of recent evidence. *Agricultural Economics*, **44**(6), 547-562
- Jayne, T.S., Zulu, B. and Nijhoff, J. (2006) Stabilizing food markets in eastern and southern Africa. *Food Policy*, **31**(4), 328-341
- Johns, T. and Eyzaguirre, P.B. (2007) Biofortification, biodiversity and diet: a search for complementary applications against poverty and malnutrition. *Food Policy*, **32**, 1-24
- Johns, T., Francisca Smith, I. and Eyzaguirre, P.B. (2006) Understanding the links between agriculture and health. *IFPRI (International Food Policy Research Institute): Washington, D.C.*
- Johns, T. and Maundu, P. (2006) Forest biodiversity, nutrition and population health in market-oriented food systems. *UNASYLVA*, **57**(2), 34-40
- Johns, T. and Sthapit, B.R. (2004) Biocultural diversity in the sustainability of developing-country food systems. *Food and Nutrition Bulletin*, **25**(2), 143-155
- 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. *Food Policy*, **46**(1), 1-12
- Kabahenda, M., Mullis, R.M., Erhardt, J.G., Northrop-Clewes, C. and Nickols, S.Y. (2011) Nutrition education to improve dietary intake and micronutrient nutriture among children in less-resourced areas: a randomised controlled intervention in Kabarole district, western Uganda. *South African Journal of Clinical Nutrition*, **24**(2), 83-88
- Kader, A.A. (2003) A perspective on postharvest horticulture (1978-2003). *HortScience*, **38**(5), 1004-1008

## References

- Kaguongo, W., Maingi, G. and Giencke, S. (2014) *Post-harvest losses in potato value chains in Kenya: analysis and recommendations for reduction strategies*. Bonn and Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).
- Kaihura, F., Kiome, R., Stocking, M., Tengberg, A. and Tumuhairwe, J. (1999) Agrodiversity highlights in East Africa. [Online]. In: M. Brookfield and H. Brookfield (eds.). *The United Nations University Project on PLEC (People, Land Management and Environmental Change) News and Views*. Canberra: The Australian National University, 25-32. Available from: [Accessed
- Kaihura, F.B.S., Stocking, M.A. and Murnaghan, N. (2000) Agrodiversity as a means of sustaining small scale dryland farming systems in Tanzania. [Online]. In: *Agricultural biodiversity and sustainable livelihoods: the case of dryland ecosystems*, Workshop for the 15th session of the global biodiversity forum, Nairobi, Kenya, 12-14 May 2000. Available from: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.6723&rep=rep1&type=pdf> [Accessed 15 July 2012]
- Kandulu, J.M., Bryan, B.A., King, D. and Connor, J.D. (2012) Mitigating economic risk from climate variability in rain-fed agriculture through enterprise mix diversification. *Ecological Economics*, **79**, 105-112
- Kassam, A., Friedrich, T., Shaxson, F. and Pretty, J. (2009) The spread of conservation agriculture: justification, sustainability and uptake. *International Journal of Agricultural Sustainability*, **7**(4), 292-320
- Kawa, N.C., Michelangeli, J.A.C. and Clement, C.R. (2015) Household agrobiodiversity management on amazonian dark earths, oxisols, and floodplain soils on the lower Madeira river, Brazil. *Human Ecology*, **43**(2), 339-353
- Kayode, A.P.P., Adegbidi, A., Hounhouigan, J.D., Linnemann, A.R. and Nout, M.J.R. (2005) Quality of farmers' varieties of sorghum and derived foods as perceived by consumers in Benin. *Ecology of Food and Nutrition*, **44**(4), 271-294
- Kearney, J. (2010) Food consumption trends and drivers. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **365**(1554), 2793-2807
- Keding, G.B., Msuya, J.M., Maass, B.L. and Krawinkel, M.B. (2012) Relating dietary diversity and food variety scores to vegetable production and socio-economic status of women in rural Tanzania. *Food Security*, **4**(1), 129-140
- Keding, G.B., Msuya, J.M., Maass, B.L. and Krawinkel, M.B. (2013) Obesity as a public health problem among adult women in rural Tanzania. *Global Health: Science and Practice*, **1**(3), 359-371
- Kehlenbeck, K., Arifin, H. and Maass, B. (2007) Plant diversity in homegardens in a socio-economic and agro-ecological context. In: T. Tscharntke, C. Leuschner, M. Zeller, E. Guhardja and A. Bidin (eds.). *The stability of tropical rainforest margins: linking ecological, economic and social constraints of land use and conservation*. Berlin: Springer, 297-317.
- Kehlenbeck, K., Asaah, E. and Jamnadas, R. (2013) Diversity of indigenous fruit trees and their contribution to nutrition and livelihoods in sub-Saharan Africa: examples from Kenya and Cameroon. In: J. Fanzo, D. Hunter, T. Borelli and F. Mattei (eds.). *Diversifying foods and diets: Using agricultural biodiversity to improve nutrition and health*. London: Routledge, 257-269.
- Kehlenbeck, K. and Maass, B. (2004) Crop diversity and classification of homegardens in central Sulawesi, Indonesia. *Agroforestry Systems*, **63**(1), 53-62

## References

- Kennedy, G.L., Pedro, M.R., Seghieri, C., Nantel, G. and Brouwer, I. (2007) Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino children. *The Journal of Nutrition*, **137**(2), 472-477
- Kenya Forest Service (2010) *The Forest Service General Order 2010/2011*. Nairobi: Kenya Forest Service.
- Khoury, C.K., Bjorkman, A.D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., Jarvis, A., Rieseberg, L.H. and Struik, P.C. (2014) Increasing homogeneity in global food supplies and the implications for food security. *Proceedings of the National Academy of Sciences*, **111**(11), 4001-4006
- Khoury, C.K. and Jarvis, A. (2014) *The changing composition of the global diet: implications for CGIAR research*. CIAT (International Center for Tropical Agriculture) Policy Brief 18. Cali: CIAT.
- Kilelu, C.W., Klerkx, L. and Leeuwis, C. (2013) How dynamics of learning are linked to innovation support services: insights from a smallholder commercialization project in Kenya. *The Journal of Agricultural Education and Extension*, **20**(2), 213-232
- Kindt, R., Simons, A. and Van Damme, P. (2004) Do farm characteristics explain differences in tree species diversity among western Kenyan farms? *Agroforestry Systems*, **63**(1), 63-74
- Kipkorir, J. (2012). *Effectiveness of a nutrition education approach in improving complementary feeding practices of children 6-23 months in western Kenya*. Unpublished.
- Kirimi, L., Sitko, N., Jayne, T.S., Karin, F., Muyanga, M., Sheahan, M., Flock, J. and Bor, G. (2011) *A farm gate-to-consumer value chain analysis of Kenya's maize marketing system*. MSU (Michigan State University) International Development Working Paper 111. Michigan: MSU.
- Kirity, T. and Tisdell, C.A. (2002) *Commercialisation of agriculture in Kenya: case study of urban bias on food availability in farm households*. Working Paper 27. Queensland: University of Queensland.
- KIT (Royal Tropical Institute) and IIRR (International Institute of Rural Reconstruction) (2008) *Trading up: building cooperation between farmers and traders in Africa*. [Online]. Nairobi: KIT and IIRR. Available from: [http://www.kit.nl/sed/wp-content/uploads/publications/1441\\_TradingUp.pdf](http://www.kit.nl/sed/wp-content/uploads/publications/1441_TradingUp.pdf) [Accessed 12 March 2013]
- Kitzinger, J. (1994) The methodology of focus groups: the importance of interaction between research participants. *Sociology of Health and Illness*, **16**(1), 103-121
- Kitzinger, J. and Barbour, R.S. (1999) Introduction: the challenge and promise of focus groups. In: J. Kitzinger and R. S. Barbour (eds.). *Developing focus group research: politics, theory and practice*. London: Sage, 1-20.
- Klennert, K. (2009) *Achieving food and nutrition security: actions to meet the global challenge*. [Online]. Feldafing: InWEnt (Internationale Weiterbildung und Entwicklung gGmbH). Available from: [http://www.fao.org/docs/eims/upload/219148/food\\_reader\\_engl.pdf](http://www.fao.org/docs/eims/upload/219148/food_reader_engl.pdf) [Accessed 18 March 2014]
- KNBS (Kenya National Bureau of Statistics) (2009) *Kenya population and housing census: Population distribution by administrative units*. Vol. 1A. Nairobi: KNBS.

## References

- KNBS (Kenya National Bureau of Statistics) and ICF Macro (2010) *Kenya Demographic and Health Survey 2008-09*. Maryland: KNBS and ICF Macro.
- Kovach Computing Services (2013) *Multi-Variate Statistical Package (MVSP), Version 3.22*. Anglesey: Kovach Computing Services.
- Kremen, C., Iles, A. and Bacon, C. (2012) Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture. *Ecology and Society*, **17**(4), 44
- Kremen, C. and Miles, A. (2012) Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecology and Society*, **17**(4), 40
- Kris-Etherton, P., Lefevre, M., Beecher, G., Gross, M., Keen, C. and Etherton, T. (2004) Bioactive compounds in nutrition and health-research methodologies for establishing biological function: the antioxidant and anti-inflammatory effects of flavonoids on atherosclerosis. *Annual Review of Nutrition*, **24**(1), 511-538
- Kruijssen, F., Keizer, M. and Giuliani, A. (2009) Collective action for small-scale producers of agricultural biodiversity products. *Food Policy*, **34**(1), 46-52
- Kumar, B.M. and Nair, P.R. (2004) The enigma of tropical homegardens. *Agroforestry Systems*, **61-62**(1-3), 135-152
- Kusumaningtyas, R., Kobayashi, S. and Takeda, S. (2006) Mixed species gardens in Java and the transmigration areas of Sumatra, Indonesia: a comparison. *Journal of Tropical Agriculture*, **44**(1-2), 15-22
- Lachat, C., Nago, E., Ka, A., Vermeulen, H., Fanzo, J., Mahy, L., Wustefeld, M. and Kolsteren, P. (2015) Landscape analysis of nutrition-sensitive agriculture policy development in Senegal. *Food and Nutrition Bulletin*, **36**(2), 154-166
- Lachat, C., Nago, E., Roberfroid, D., Holdsworth, M., Smit, K., Kinabo, J., Pinxten, W., Kruger, A. and Kolsteren, P. (2014) Developing a sustainable nutrition research agenda in sub-Saharan Africa - findings from the SUNRAY project. *PLoS Medicine*, **11**(1), e1001593
- Leavy, J. and Poulton, C. (2007) *Commercialisations in agriculture*. Working Paper 003. Brighton: Future Agricultures Consortium.
- Letourneau, D.K., Armbrecht, I., Rivera, B.S., Lerma, J.M., Carmona, E.J., Daza, M.C., Escobar, S., Galindo, V., Gutierrez, C. and Lopez, S.D. (2011) Does plant diversity benefit agroecosystems? A synthetic review. *Ecological Applications*, **21**(1), 9-21
- Lie, H., Rich, K.M., Kurwijila, L.R. and Jervell, A.M. (2012) Improving smallholder livelihoods through local value chain development: a case study of goat milk yogurt in Tanzania. *International Food and Agribusiness Management Review*, **15**(3), 55-85
- Livingston, G., Schonberger, S. and Delaney, S. (2011) Sub-Saharan Africa: the state of smallholders in agriculture. [Online]. In: *IFAD (International Fund for Agricultural Development) conference on new directions for smallholder agriculture*, Rome, 24-25 January 2011. Available from: <http://www.ifad.org/events/agriculture/doc/papers/livingston.pdf> [Accessed 7 February 2015]
- Luckett, B.G., DeClerck, F.A., Fanzo, J., Mundorf, A.R. and Rose, D. (2015) Application of the nutrition functional diversity indicator to assess food system contributions to dietary diversity and sustainable diets of Malawian households. *Public Health Nutrition*. doi:<http://dx.doi.org/10.1017/S136898001500169X>

## References

- Luedeling, E., Kindt, R., Huth, N.I. and Koenig, K. (2014) Agroforestry systems in a changing climate - challenges in projecting future performance. *Current Opinion in Environmental Sustainability*, **6**, 1-7
- Lukmanji, Z., Hertzmark, E., Mlingi, N., Assey, V., Ndossi, G. and Fawzi, W. (2008) *Tanzania food composition tables*. [Online]. Dar es Salaam and Boston: MUHAS (Muhimbili University of Health and Allied Sciences), TFNC (Tanzania Food and Nutrition Centre) and HSPH (Harvard School of Public Health). Available from: <http://cdn1.sph.harvard.edu/wp-content/uploads/sites/30/2012/10/tanzania-food-composition-tables.pdf> [Accessed 27 November 2014]
- Ma, G., Jin, Y., Li, Y., Zhai, F., Kok, F.J., Jacobsen, E. and Yang, X. (2008) Iron and zinc deficiencies in China: what is a feasible and cost-effective strategy? *Public Health Nutrition*, **11**(6), 632-638
- Maass, B.L., Chiuri, W.L., Zozo, R., Katunga-Musale, D., Metre, T.K. and Birachi, E. (2014) Using the 'livestock ladder' as a means for poor crop-livestock farmers to exit poverty in Sud-Kivu province, eastern DR Congo. In: B. Vanlauwe, P. v. Asten and G. Blomme (eds.). *Agro-ecological Intensification of agricultural systems in the African highlands*, Earthscan, Routledge, London. London: Routledge, 145-155.
- Magnani, R. (1997) *Food and Nutrition Technical Assistance (FANTA) sampling guide*. Washington, D.C.: FANTA.
- Malapit, H.J., Kadiyala, S., Quisumbing, A.R., Cunningham, K. and Tyagi, P. (2013) *Women's empowerment in agriculture, production diversity and nutrition - evidence from Nepal*. Washington, D.C.: IFPRI (International Food Policy Research Institute).
- Maneepitak, S. (2007) Relative value of agricultural biodiversity on diversified farms: a case study in Donjaedee district, Suphanburi province, central Thailand. *Journal of Developments in Sustainable Agriculture*, **2**(2), 86-91
- Marongwe, L.S., Kwazira, K., Jenrich, M., Thierfelder, C., Kassam, A. and Friedrich, T. (2011) An African success: the case of conservation agriculture in Zimbabwe. *International Journal of Agricultural Sustainability*, **9**(1), 153-161
- Maroyi, A. (2009) Traditional homegardens and rural livelihoods in Nhema, Zimbabwe: a sustainable agroforestry system. *International Journal of Sustainable Development and World Ecology*, **16**(1), 1-8
- Maroyi, A. (2013) Use and management of homegarden plants in Zvishavane district, Zimbabwe. *Tropical Ecology*, **54**(2), 191-203
- Marsh, R. (1998) Building on traditional gardening to improve household food security. *Food Nutrition and Agriculture*, **22**(1), 4-14
- Mason, N.M., Jayne, T.S. and Mofya-Mukuka, R. (2013) Zambia's input subsidy programs. *Agricultural Economics*, **44**(6), 613-628
- Mason, N.M., Jayne, T.S. and Myers, R.J. (2015) Smallholder supply response to marketing board activities in a dual channel marketing system: the case of Zambia. *Journal of Agricultural Economics*, **66**(1), 36-65
- Mason, R., Ndlovu, P., Parkins, J.R. and Luckert, M.K. (2015) Determinants of food security in Tanzania: gendered dimensions of household headship and control of resources. *Agriculture and Human Values*, **32**(3), 539-549
- Matanda, D.J., Mittelmark, M.B. and Kigaru, D.M.D. (2014) Child undernutrition in Kenya: trend analyses from 1993 to 2008-09. *BMC Pediatrics*, **14**(1), 5

## References

- Maundu, M.P., Ngugi, W.G. and Kabuye, H.S.C. (1999) *Traditional food plants of Kenya*. Nairobi: National Museums of Kenya.
- Maundu, P. (2012). Head of Kenya Resource Centre for Indigenous Knowledge (KENRIK). *Trouble plant species identification*. Interview with the author, 8 October. Personal communication.
- Mayer, A.M. (2015) *Potential for nutrition-sensitive conservation agriculture in Zambia*. Final Report. Lusaka: Concern Worldwide.
- Mbagaya, G.M., Odhiambo, M.O. and Oniang'o, R.K. (2005) Mother's health seeking behaviour during child illness in a rural western Kenya community. *African Health Sciences*, **5**(4), 322-327
- McCune, B., Grace, J. and Urban, D. (2002) *Analysis of ecological communities* vol 28. Oregon: MjM Software Design.
- McDermott, J., Johnson, N., Kadiyala, S., Kennedy, G. and Wyatt, A.J. (2015) Agricultural research for nutrition outcomes - rethinking the agenda. *Food Security*, **7**(3), 593-607
- Meenakshi, J., Johnson, N.L., Manyong, V.M., DeGroot, H., Javelosa, J., Yanggen, D.R., Naher, F., Gonzalez, C., Garcia, J. and Meng, E. (2010) How cost-effective is biofortification in combating micronutrient malnutrition? An *ex ante* assessment. *World Development*, **38**(1), 64-75
- Mehra, R. and Rojas, M.H. (2008) *Women, food security and agriculture in a global marketplace*. Washington, D.C.: ICRW (International Center for Research on Women).
- Ministry of Agriculture (2008) *The ministry at a glance*. Nairobi: Ministry of Agriculture. [http://www.oerafrica.org/system/files/9178/ministry-glance-agriculture-2008\\_0.pdf?file=1&type=node&id=9178](http://www.oerafrica.org/system/files/9178/ministry-glance-agriculture-2008_0.pdf?file=1&type=node&id=9178).
- Ministry of Public Health and Sanitation (2012) *National nutrition action plan 2012-2017*. [Online]. Nairobi: Ministry of Public Health and Sanitation. Available from: <http://scalingupnutrition.org/wp-content/uploads/2013/10/Kenya-National-Nutrition-Action-Plan-2012-2017-final.pdf> [Accessed 9 October 2014]
- Misselhorn, A., Aggarwal, P., Ericksen, P., Gregory, P., Horn-Phathanothai, L., Ingram, J. and Wiebe, K. (2012) A vision for attaining food security. *Current Opinion in Environmental Sustainability*, **4**(1), 7-17
- Momsen, J.H. (2007) Gender and agrobiodiversity: introduction to the special issue. *Singapore Journal of Tropical Geography*, **28**(1), 1-6
- Monteiro, C. and Cannon, G. (2010) The big issue is ultra-processing. *World Nutrition*, **1**(6), 237-259
- Morton, J.F. (2007) The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences*, **104**(50), 19680-19685
- Mucha, H.J., Bartel, H.G. and Dolata, J. (2003) Core-based clustering techniques. In: M. Schader, W. Gaul and M. Vichi (eds.). *Between data science and applied data analysis*. Heidelberg: Springer-Verlag Berlin, 74-82.
- Muhanji, G., Roothaert, R.L., Webo, C. and Stanley, M. (2011) African indigenous vegetable enterprises and market access for small-scale farmers in East Africa. *International Journal of Agricultural Sustainability*, **9**(1), 194-202
- Murumba, S. (2014) *Quail farmers facing challenges as market saturates*. Daily Nation: 24 January. <http://mobile.nation.co.ke/counties/Quail-farmers-challenges/-/1950480/2158522/-/format/xhtml>.

## References

- Musinguzi, E., Kikafunda, J.K. and Kiremire, B. (2006) Utilization of indigenous food plants in Uganda: a case study of south-western Uganda. *African Journal of Food, Agriculture, Nutrition and Development*, **6**(2), 1-21
- Mutabazi, K., Wiggins, S. and Mdoe, N. (2013) *Commercialisation of African smallholder farming. The case of smallholder farmers in central Tanzania*. Working Paper 072. Brighton: Future Agricultures Consortium.
- Mutenje, M.J., Ortmann, G.F., Ferrer, S.R.D. and Darroch, M.A.G. (2010) Rural livelihood diversity to manage economic shocks: evidence from south-east Zimbabwe. *Agrekon*, **49**(3), 338-357
- Muthayya, S., Rah, J.H., Sugimoto, J.D., Roos, F.F., Kraemer, K. and Black, R.E. (2013) The global hidden hunger indices and maps: an advocacy tool for action. *Plos One*, **8**(6), e67860
- Mutua, F.K., Dewey, C.E., Arimi, S.M., Schelling, E. and Ogara, W.O. (2011) *Prediction of live body weight using length and girth measurements for pigs in rural western Kenya*. [Online]. Available from: <http://www.ilri.org/aggregator/sources/98> [Accessed 24 November 2014]
- Muyanga, M. and Jayne, T.S. (2006) *Agricultural extension in Kenya: practice and policy lessons*. Working Paper 26. Nairobi: Tegemeo Institute of Agricultural Policy and Development.
- Mwololo, B.M. (2010) The role of farmers in biodiversity conservation of maize landraces through farming systems in Kenya. *Journal of Developments in Sustainable Agriculture*, **5**(2), 155-177
- Nagarajan, L., Smale, M. and Glewwe, P. (2007) Determinants of millet diversity at the household-farm and village-community levels in the drylands of India: the role of local seed systems. *Agricultural Economics*, **36**(2), 157-167
- Negatu, W. (2004) *Reasons for food insecurity of farm households in south Wollo, Ethiopia: explanations at grassroots*. Wisconsin-Madison: BASIS CRSP (Broadening Access and Strengthening Input Market Systems Collaborative Research Support Group).
- Netondo, G.W., Waswa, F., Maina, L., Naisiko, T., Masayi, N. and Ngaira, J.K. (2010) Agrobiodiversity endangered by sugarcane farming in Mumias and Nzoia sugarbelts of western Kenya. *African Journal of Environmental Science and Technology*, **4**(7), 437-445
- Ng'endo, M., Catacutan, D., Kung'u, J., Muriuki, J., Kariuki, J. and Mowo, J. (2013) The policy environment of Conservation Agriculture With Trees (CAWT) in eastern Kenya: do small scale farmers benefit from existing policy incentives? *African Journal of Agricultural Research*, **8**(23), 2924-2939
- Ng'endo, M., Keding, G.B., Bhagwat, S. and Kehlenbeck, K. (2015) Variability of on-farm food plant diversity and its contribution to food security: a case study of smallholder farming households in western Kenya. *Agroecology and Sustainable Food Systems*, **39**(10), 1071-1103
- Ngugi, I.K., Gitau, R. and Nyoro, J.K. (2007) *Access to high value markets by smallholder farmers of African indigenous vegetables in Kenya*. Regoverning Markets Innovative Practice Series. London: IIED (International Institute for Environment and Development).
- Noack, A.L. and Pouw, N.R.M. (2014) A blind spot in food and nutrition security: where culture and social change shape the local food plate. *Agriculture and Human Values*, **32**(2), 169-182

## References

- Nuijten, E. (2010) Gender and management of crop diversity in The Gambia. *Journal of Political Ecology*, **17**, 42-58
- Nungo, R.A., Okoth, M.W. and Mbugua, S.K. (2012) Nutrition status of children under-five years in cassava consuming communities in Nambale, Busia of western Kenya. *Food and Nutrition Sciences*, **3**(1), 796-801
- Nyang, M.N., Webo, C. and Roothaert, R.L. (2010) *The power of farmers organisations in smallholder agriculture in East Africa: a review of 5 project initiatives of the maendeleo agricultural technology fund*. Working Paper 13. London: FARM-Africa.
- Ohna, I., Kaarhus, R. and Kinabo, J. (2012) No meal without ugali? Social significance of food and consumption in a Tanzanian village. *Culture, Agriculture, Food and Environment*, **34**(1), 3-14
- Oke, D.O. and Odebiyi, K.A. (2007) Traditional cocoa-based agroforestry and forest species conservation in Ondo State, Nigeria. *Agriculture, Ecosystems and Environment*, **122**(3), 305-311
- Omamo, S.W. (1998) Transport costs and smallholder cropping choices: an application to Siaya district, Kenya. *American Journal of Agricultural Economics*, **80**(1), 116-123
- Omiti, J., Otieno, D., Nyanamba, T. and McCullough, E. (2009) Factors influencing the intensity of market participation by smallholder farmers: a case study of rural and peri-urban areas of Kenya. *African Journal of Agricultural and Resource Economics*, **3**(1), 57-82
- Onduru, D.D. and Du Preez, C.C. (2007) Ecological and agro-economic study of small farms in sub-Saharan Africa. *Agronomy for Sustainable Development*, **27**(3), 197-208
- Outdoors Africa (2014) *What quail farmers have taught start-ups about business cycles*. [Online]. Available from: <http://www.outdoorsafrica.co.ke/what-quail-farmers-have-taught-start-ups-about-business-cycles/> [Accessed 21 November 2015]
- Pattison, J., Drucker, A. and Anderson, S. (2007) The cost of conserving livestock diversity? Incentive measures and conservation options for maintaining indigenous pelón pigs in Yucatan, Mexico. *Tropical Animal Health and Production*, **39**(5), 339-353
- Pellegrini, L. and Tasciotti, L. (2014) Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries. *Canadian Journal of Development Studies*, **35**(2), 211-227
- Ponisio, L.C., M'Gonigle, L.K., Mace, K.C., Palomino, J., de Valpine, P. and Kremen, C. (2015) Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B: Biological Sciences*, **282**(1799), 20141396
- Popkin, B.M. (2007) The world is fat. *Scientific American*, **297**(3), 88-95
- Poulton, C., Kydd, J. and Dorward, A. (2006) Overcoming market constraints on pro-poor agricultural growth in sub-Saharan Africa. *Development Policy Review*, **24**(3), 243-277
- Poulton, C., Kydd, J., Wiggins, S. and Dorward, A. (2006b) State intervention for food price stabilisation in Africa: can it work? *Food Policy*, **31**(4), 342-356
- Powell, B., Thilsted, S.H., Ickowitz, A., Termote, C., Sunderland, T. and Herforth, A. (2015) Improving diets with wild and cultivated biodiversity from across the landscape. *Food Security*, **7**(3), 535-554

## References

- PROTA (Plant Resources of Tropical Africa) (2010) *Updated list of species and commodity grouping*. Wageningen: PROTA Foundation/CTA (Technical Centre for Agricultural and Rural Cooperation).
- Puma, M.J., Bose, S., Chon, S.Y. and Cook, B.I. (2015) Assessing the evolving fragility of the global food system. *Environmental Research Letters*, **10**(2), 024007
- Purdue University Center for new crops and plant products (2008) *NewCROP crop index* [Online]. Available from: [http://www.hort.purdue.edu/newcrop/Indices/index\\_ab.html](http://www.hort.purdue.edu/newcrop/Indices/index_ab.html) [Accessed 17 December 2014]
- Qaim, M. (2014) *Evaluating nutrition and health impacts of agricultural innovations*. GlobalFood Discussion Paper 46. Göttingen: ECONSTOR.
- Qaim, M., Andersson, C.I., Chege, C.G., Kimenju, S.C., Klasen, S. and Rischke, R. (2014) *Nutrition effects of the supermarket revolution on urban consumers and smallholder farmers in Kenya*. GlobalFood Discussion Paper 40. Göttingen: ECONSTOR.
- Quiroz, C., Gutierrez, M., Rodriguez, D., Perez, D., Ynfante, J., Garnez, J., de Fernandez, T.P., Marquez, A. and Pacheco, W. (2002) Home gardens and in situ conservation of agrobiodiversity-Venezuelan component. [Online]. In: J. W. Watson and P. B. Eyzaguirre (eds) *Home gardens and in situ conservation of plant genetic resources in farming systems*, Proceedings of the second international home gardens workshop, Witzenhausen, Germany, 17-19 July 2001. Rome: IPGRI (International Plant Genetic Resources Institute), 73-82. Available from: [http://www.biodiversityinternational.org/uploads/tx\\_news/Home\\_gardens\\_and\\_in\\_situ\\_conservation\\_of\\_plant\\_genetic\\_resources\\_in\\_farming\\_systems\\_753.pdf](http://www.biodiversityinternational.org/uploads/tx_news/Home_gardens_and_in_situ_conservation_of_plant_genetic_resources_in_farming_systems_753.pdf) [Accessed 3 June 2013]
- Quisumbing, A.R., Brown, L.R., Feldstein, H.S., Haddad, L. and Pena, C. (1995) *Women: the key to food security*. Food Policy Report. Washington, D.C.: International Food Policy Research Institute Washington (IFPRI).
- R Core Team (2014) *R: A language and environment for statistical computing, Version 3.1.2*. Vienna: R Foundation for statistical computing.
- RABAK (Rabbit Breeders Association of Kenya) (2014) *Rabbit Breeders Association of Kenya: empowering communities with health and wealth*. [Online]. Available from: <http://rabak.or.ke/> [Accessed 20 November 2015]
- Rabbinge, R. and Bindraban, P.S. (2012) Making more food available: promoting sustainable agricultural production. *Journal of Integrative Agriculture*, **11**(1), 1-8
- Rabiee, F. (2004) Focus-group interview and data analysis. *Proceedings of the Nutrition Society*, **63**, 655-660
- Rajendran, S., Afari-Sefa, V., Bekunda, M., Dominick, I. and Lukumay, P.J. (2014) Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize based farming systems in Tanzania. [Online]. In: *88th annual conference of the agricultural economics society*, Paris, France, 9-11 April 2014. Available from: [http://ageconsearch.umn.edu/bitstream/170542/2/Srinivasulu\\_Rajendran\\_Rajendran%20et%20al%202014.pdf](http://ageconsearch.umn.edu/bitstream/170542/2/Srinivasulu_Rajendran_Rajendran%20et%20al%202014.pdf) [Accessed 31 August 2015]
- Rao, E.J. and Qaim, M. (2010) Supermarkets, farm household income, and poverty: insights from Kenya. *World Development*, **39**(5), 784-796

## References

- Ray, D.K., Mueller, N.D., West, P.C. and Foley, J.A. (2013) Yield trends are insufficient to double global crop production by 2050. *PLoS One*, **8**(6), e66428
- Regmi, A. and Meade, B. (2013) Demand side drivers of global food security. *Global Food Security*, **2**(3), 166-171
- Remans, R. (2014). Associate Research Scientist, Agriculture and Food Security Center of the Earth Institute at Columbia University. *Calculation of market nutrient functional diversity*. Email to the author, 28 November. Personal communication.
- Remans, R., Flynn, D.F., DeClerck, F., Diru, W., Fanzo, J., Gaynor, K., Lambrecht, I., Mudioppe, J., Mutuo, P.K. and Nkhoma, P. (2011) Assessing nutritional diversity of cropping systems in African villages. *PLoS One*, **6**(6), e21235
- Remans, R., Wood, S.A., Saha, N., Anderman, T.L. and DeFries, R.S. (2014) Measuring nutritional diversity of national food supplies. *Global Food Security*, **3**(3), 174-182
- Renzaho, A.M. (2004) Fat, rich and beautiful: changing socio-cultural paradigms associated with obesity risk, nutritional status and refugee children from sub-Saharan Africa. *Health and Place*, **10**(1), 105-113
- Reyniers, F.N., Sibelet, N. and Torquebiau, E. (2002) How farmers use agrobiodiversity to cope with climatic variability and community change. [Online]. In: *Farming and rural systems research and extension: local identities and globalisation*, Fifth international farming system association European symposium, Florence, Italy, 8-11 April 2002. Available from: <http://agritrop.cirad.fr/514228/> [Accessed 8 March 2013]
- Ricker-Gilbert, J., Jayne, T. and Shively, G. (2013) Addressing the 'wicked problem' of input subsidy programs in Africa. *Applied Economic Perspectives and Policy*, **35**(2), 322-340
- Rietbergen, S., Bishop, J. and Mainka, S. (2002) *Ecosystem conservation-a neglected tool for poverty reduction*. WSSD (World Summit on Sustainable Development) Opinion Paper. London: IIED/ RING (International Institute for Environment and Development/ the Regional and International Network Group).
- Ruel, M.T. (2002) *Is dietary diversity an indicator of food security or dietary quality? A review of measurement issues and research needs*. FCND (Food Consumption and Nutrition Division) Discussion Paper 140. Washington, D.C.: IFPRI (International Food Policy Research Institute).
- Ruel, M.T., Minot, N. and Smith, L. (2005) *Patterns and determinants of fruit and vegetable consumption in sub-Saharan Africa: a multicountry comparison*. Geneva: WHO (World Health Organization).
- Sagar, V. and Kumar, P.S. (2010) Recent advances in drying and dehydration of fruits and vegetables: a review. *Journal of Food Science and Technology*, **47**(1), 15-26
- Sanchez, P.A. and Swaminathan, M.S. (2005) Cutting world hunger in half. *Science*, **307**(5708), 357-359
- Satzinger, F., Kerr, R.B. and Shumba, L. (2009) Intergenerational participatory discussion groups foster knowledge exchange to improve child nutrition and food security in northern Malawi. *Ecology of Food and Nutrition*, **48**(5), 369-382
- Savy, M., Martin-Prevel, Y., Traissac, P. and Delpeuch, F. (2007) Measuring dietary diversity in rural Burkina Faso: comparison of a 1-day and a 3-day dietary recall. *Public Health Nutrition*, **10**(1), 71-78

## References

- Savy, M., Martin-Prevel, Y., Traissac, P., Eymard-Duvernay, S. and Delpeuch, F. (2006) Dietary diversity scores and nutritional status of women change during the seasonal food shortage in rural Burkina Faso. *The Journal of Nutrition*, **136**(10), 2625-2632
- Saxholt, E., Christensen, A.T., Møller, A. Hartkopp, H.B., Hess Ygil, K., Hels, O.H. (2009) *Danish Food Composition Databank, revision 7*. [Online]. Department of Nutrition, National Food Institute, Technical University of Denmark (DTU). Available from: [http://www.foodcomp.dk/v7/fcdb\\_default.asp](http://www.foodcomp.dk/v7/fcdb_default.asp) [Accessed 15 May 2014]
- Sen, A. (1981) *Poverty and famines: an essay on entitlement and deprivation*. Oxford: Oxford University Press.
- Sennhenn, A., Prinz, K., Gebauer, J., Whitbread, A., Jamnadass, R. and Kehlenbeck, K. (2013) Identification of mango (*Mangifera indica* L.) landraces from Eastern and Central Kenya using a morphological and molecular approach. *Genetic Resources and Crop Evolution*, **61**(1), 7-22
- Shaffer, D.N., Yebei, V.N., Ballidawa, J.B., Sidle, J.E., Greene, J.Y., Meslin, E.M., Kimaiyo, S.J.N. and Tierney, W.M. (2006) Equitable treatment for HIV/AIDS clinical trial participants: a focus group study of patients, clinical researchers, and administrators in western Kenya. *Journal of Medical Ethics*, **32**, 55-60
- Shamba Shape Up (2015) *Shamba Shape Up: practical advice on improving your shamba*. [Online]. Available from: <http://www.shambashapeup.com/> [Accessed 18 November 2015]
- Shrestha, P., Gautam, R., Rana, R.B. and Sthapit, B. (2002) Home gardens in Nepal: status and scope for research and development. [Online]. In: Watson J.W and Eyzaguirre P.B (eds) *Home gardens and in situ conservation of plant genetic resources in farming systems*, Proceedings of the second international home gardens workshop, Witzenhausen, Germany, 17-19 July 2001 Rome: IPGRI (International Plant Genetic Resources Institute), 105-118. Available from: [http://www.biodiversityinternational.org/uploads/tx\\_news/Home\\_gardens\\_and\\_in\\_situ\\_conservation\\_of\\_plant\\_genetic\\_resources\\_in\\_farming\\_systems\\_753.pdf](http://www.biodiversityinternational.org/uploads/tx_news/Home_gardens_and_in_situ_conservation_of_plant_genetic_resources_in_farming_systems_753.pdf) [Accessed 3 June 2013]
- Sibhatu, K.T., Krishna, V.V. and Qaim, M. (2015) Farm production diversity and dietary diversity in developing countries. [Online]. In: *Agricultural and applied economics and western agricultural economics association annual meeting*, San Francisco, California, 26-28 July 2015. Available from: [http://ageconsearch.umn.edu/bitstream/205286/2/AAEA\\_WAEA2015\\_6778.pdf](http://ageconsearch.umn.edu/bitstream/205286/2/AAEA_WAEA2015_6778.pdf) [Accessed 10 June 2015]
- Sikod, F. (2007) Gender division of labour and women's decision-making power in rural households in Cameroon. *Africa Development*, **32**(3), 58-71
- Smale, M., Cohen, M.J. and Nagarajan, L. (2009) *Local markets, local varieties: rising food prices and small farmers' access to seed*. IFPRI (International Food Policy Research Institute) Issue Brief 59. Washington, D.C.: IFPRI.
- Smale, M., De Groote, H. and Owuor, G. (2006) *Biodiversity of maize on farms in Kenya*. Policy Brief 25. Washington, D.C.: IFPRI (International Food Policy Research Institute).
- Smale, M., Diakite, L. and Keita, N. (2012) Millet transactions in market fairs, millet diversity and farmer welfare in Mali. *Environment and Development Economics*, **17**(5), 523-546

## References

- Smith, J., Sones, K., Grace, D., MacMillan, S., Tarawali, S. and Herrero, M. (2013) Beyond milk, meat, and eggs: role of livestock in food and nutrition security. *Animal Frontiers*, **3**(1), 6-13
- Stein, A.J., Nestel, P., Meenakshi, J.V., Qaim, M., Sachdev, H.P.S. and Bhutta, Z.A. (2007) Plant breeding to control zinc deficiency in India: how cost-effective is biofortification? *Public Health Nutrition*, **10**(5), 492-501
- Sthapit, B., Rana, R., Eyzaguirre, P. and Jarvis, D. (2008) The value of plant genetic diversity to resource-poor farmers in Nepal and Vietnam. *International Journal of Agricultural Sustainability*, **6**(2), 148-166
- Stocking, M., Fidelis, K. and Luohui, L. (2003) Agricultural biodiversity in East Africa - introduction and acknowledgements. In: F. Kaihura and M. Stocking (eds.). *Agricultural biodiversity in smallholder farms of East Africa*. Tokyo: United Nations University Press, 3-19.
- Tengberg, A., Ellis-Jones, J., Kiome, R. and Stocking, M. (1998) Applying the concept of agrodiversity to indigenous soil and water conservation practices in eastern Kenya. *Agriculture, Ecosystems and Environment*, **70**(2), 259-272
- The Health Communication Unit (2002) *Using focus groups*. Version 2.0. Toronto: University of Toronto.  
[http://www.sswm.info/sites/default/files/reference\\_attachments/THCU%202002%20Using%20Focus%20Group.pdf](http://www.sswm.info/sites/default/files/reference_attachments/THCU%202002%20Using%20Focus%20Group.pdf).
- Thierfelder, C. and Wall, P.C. (2010) Investigating Conservation Agriculture (CA) systems in Zambia and Zimbabwe to mitigate future effects of climate change. *Journal of Crop Improvement*, **24**(2), 113-121
- Thorne-Lyman, A.L., Valpiani, N., Sun, K., Semba, R.D., Klotz, C.L., Kraemer, K., Akhter, N., de Pee, S., Moench-Pfanner, R. and Sari, M. (2009) Household dietary diversity and food expenditures are closely linked in rural Bangladesh, increasing the risk of malnutrition due to the financial crisis. *The Journal of Nutrition*, **140**(1), 182S-188S
- Thornton, P. and Lipper, L. (2014) *How does climate change alter agricultural strategies to support food security?* IFPRI (International Food Policy Research Institute) Discussion Paper 01340. Washington, D.C.: IFPRI.
- Thornton, P.K., Ericksen, P.J., Herrero, M. and Challinor, A.J. (2014) Climate variability and vulnerability to climate change: a review. *Global Change Biology*, **20**(11), 3313-3328
- Thornton, P.K. and Herrero, M. (2014) Climate change adaptation in mixed crop-livestock systems in developing countries. *Global Food Security*, **3**(2), 99-107
- Thrupp, L.A. (2000) Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. *International Affairs*, **76**(2), 265-281
- Tilman, D., Balzer, C., Hill, J. and Befort, B.L. (2011) Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, **108**(50), 20260-20264
- Tittonell, P. and Giller, K.E. (2013) When yield gaps are poverty traps: the paradigm of ecological intensification in African smallholder agriculture. *Field Crops Research*, **143**, 76-90
- Tittonell, P., Muriuki, A., Shepherd, K.D., Mugendi, D., Kaizzi, K., Okeyo, J., Verchot, L., Coe, R. and Vanlauwe, B. (2010) The diversity of rural livelihoods and their

## References

- influence on soil fertility in agricultural systems of East Africa- a typology of smallholder farms. *Agricultural Systems*, **103**(2), 83-97
- Tittonell, P., Vanlauwe, B., Leffelaar, P., Rowe, E. and Giller, K. (2005) Exploring diversity in soil fertility management of smallholder farms in western Kenya: I. Heterogeneity at region and farm scale. *Agriculture, Ecosystems and Environment*, **110**(3), 149-165
- Toledo, A. and Burlingame, B. (2006) Biodiversity and nutrition: a common path toward global food security and sustainable development. *Journal of Food Composition and Analysis*, **19**(6), 477-483
- Trinh, L., Watson, J., Hue, N., De, N., Minh, N., Chu, P., Sthapit, B. and Eyzaguirre, P. (2003) Agrobiodiversity conservation and development in Vietnamese home gardens. *Agriculture, Ecosystems and Environment*, **97**(1), 317-344
- Tscharntke, T., Clough, Y., Wanger, T.C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J. and Whitbread, A. (2012) Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation*, **151**(1), 53-59
- United Nations Department of Economic and Social Affairs (2014) *World urbanization prospects: the 2014*. [Online]. Available from: [http://www.geohive.com/earth/pop\\_urban.aspx](http://www.geohive.com/earth/pop_urban.aspx) [Accessed 17 November 2015]
- Unruh, J. (2001) The dilemma of African agrobiodiversity: Ethiopia and the role of food insecurity in conservation. [Online]. In: *Proceedings of the international symposium managing biodiversity in agricultural ecosystems*, Montreal, Canada, 8-10 November 2001. Available from: <http://archive.unu.edu/env/plec/cbd/Montreal/papers/Unruh.pdf> [Accessed 20 January 2013]
- USDA (United States Department of Agriculture) Agricultural Research Service (2014) *USDA National Nutrient Database for Standard Reference, Release 27*. [Online]. Available from: <http://ndb.nal.usda.gov/ndb/search/list> [Accessed 27 November 2014]
- van Royen, K., Lachat, C., Holdsworth, M., Smit, K., Kinabo, J., Roberfroid, D., Nago, E., Orach, C.G. and Kolsteren, P. (2013) How can the operating environment for nutrition research be improved in sub-Saharan Africa? The views of African researchers. *PloS One*, **8**(6), e66355
- Vermeulen, S.J., Aggarwal, P.K., Ainslie, A., Angelone, C., Campbell, B.M., Challinor, A., Hansen, J.W., Ingram, J.S.I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G.C., Thornton, P.K. and Wollenberg, E. (2012a) Options for support to agriculture and food security under climate change. *Environmental Science and Policy*, **15**(1), 136-144
- Vermeulen, S.J., Campbell, B.M. and Ingram, J.S. (2012b) Climate change and food systems. *Annual Review of Environment and Resources*, **37**(1), 195-222
- von Grebmer, K., Saltzman, A., Birol, E., Wiesmann, D., Prasai, N., Yin, S., Yohannes, Y., Menon, P., Thompson, J. and Sonntag, A. (2014) *2014 Global hunger Index: the challenge of hidden hunger*. [Online]. Bonn, Washington, D.C. and Dublin: Welthungerhilfe, International Food Policy Research Institute and Concern Worldwide. Available from: <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128360> [Accessed 17 May 2015]

## References

- Waha, K., Muller, C., Bondeau, A., Dietrich, J.P., Kurukulasuriya, P., Heinke, J. and Lotze-Campen, H. (2012) Adaptation to climate change through the choice of cropping system and sowing date in sub-Saharan Africa. *Global Environmental Change*, **23**(1), 130-143
- Waithaka, M.M., Thornton, P.K., Herrero, M. and Shepherd, K.D. (2006) Bio-economic evaluation of farmers' perceptions of viable farms in western Kenya. *Agricultural systems*, **90**(1), 243-271
- Warner, M., Al-Hassan, R. and Kydd, J. (1997) Beyond gender roles? Conceptualizing the social and economic lives of rural peoples in sub-Saharan Africa. *Development and Change*, **28**(1), 143-168
- Waswa, L.M., Jordan, I., Herrmann, J., Krawinkel, M.B. and Keding, G.B. (2015) Community-based educational intervention improved the diversity of complementary diets in western Kenya: results from a randomized controlled trial. *Public Health Nutrition* DOI: <http://dx.doi.org/10.1017/S1368980015000920>.
- Waters-Bayer, A., Kristjanson, P., Wettasingha, C., van Veldhuizen, L., Quiroga, G., Swaans, K. and Douthwaite, B. (2015) Exploring the impact of farmer-led research supported by civil society organisations. *Agriculture & Food Security*, **4**(4), 1-7
- Weinberger, K. and Lumpkin, T.A. (2007) Diversification into horticulture and poverty reduction: a research agenda. *World Development*, **35**(8), 1464-1480
- Welch, R.M. and Graham, R.D. (2005) Agriculture: the real nexus for enhancing bioavailable micronutrients in food crops. *Journal of Trace Elements in Medicine and Biology*, **18**(4), 299-307
- WFP (World Food Programme) (2008) *Food consumption score: construction of the FCS*.
- Wheeler, T. and von Braun, J. (2013) Climate change impacts on global food security. *Science*, **341**(6145), 508-513
- White, P.J. and Broadley, M.R. (2009) Biofortification of crops with seven mineral elements often lacking in human diets - iron, zinc, copper, calcium, magnesium, selenium and iodine. *New Phytologist*, **182**(1), 49-84
- Whitehead, A. (2009) *The gendered impacts of liberalization policies on African agricultural economies and rural livelihoods*. UNRISD (United Nations Research Institute for Social Development).
- WHO (World Health Organization) (1995) *Physical status: the use and interpretation of anthropometry*. WHO Technical Report Series 854. Geneva: WHO. [http://whqlibdoc.who.int/trs/WHO\\_TRS\\_854.pdf?ua=1](http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf?ua=1).
- WHO (World Health Organization) (2006) *Global database on Body Mass Index*. [Online]. Available from: [http://apps.who.int/bmi/index.jsp?introPage=intro\\_3.html/](http://apps.who.int/bmi/index.jsp?introPage=intro_3.html/) [Accessed 21 January 2015]
- WHO (World Health Organization) (2010) *Indicators for assessing infant and young child feeding practices part 2: measurement*. Geneva: WHO Press.
- Wiehle, M., Goenster, S., Gebauer, J., Mohamed, S.A., Buerkert, A. and Kehlenbeck, K. (2014) Effects of transformation processes on plant species richness and diversity in homegardens of the Nuba Mountains, Sudan. *Agroforestry Systems*, **88**(3), 539-562

## References

- Wiersum, K. (2006) Diversity and change in homegarden cultivation in Indonesia. In: B. Kumar and P. Nair (eds.). *Tropical homegardens: a time-tested example of sustainable agroforestry*. Dordrecht: Springer, 13-24.
- Wiggins, S. (2012) *Small farm commercialisation in Africa: a guide to issues and policies*. Policy Brief 050. Brighton: Future Agricultures Consortium.
- Wong, L. (2008) Focus group discussion: a tool for health and medical research. *Singapore Medical Journal*, **49**(3), 256-261
- Wood, D. and Lenne, J.M. (1997) The conservation of agrobiodiversity on-farm: questioning the emerging paradigm. *Biodiversity and Conservation*, **6**(1), 109-129
- World Bank (2009) *Awakening Africa's sleeping giant: prospects for commercial agriculture in the Guinea Savannah zone and beyond*. [Online]. Washington, D.C.: World Bank. Available from: [http://siteresources.worldbank.org/INTARD/Resources/sleeping\\_giant.pdf](http://siteresources.worldbank.org/INTARD/Resources/sleeping_giant.pdf) [Accessed 12 April 2012]
- World Bank (2011) *Agriculture investment: investments in sustainable agricultural intensification*. [Online]. Available from: <http://go.worldbank.org/J4QTB50D10> [Accessed 13 May 2014]
- Xinhua (2014) *Craze for quail farming hits Kenya*. Standard Digital: 15 January. <http://www.standardmedia.co.ke/business/article/2000102356/craze-for-quail-farming-hits-kenya>.
- Yatich, T., Awiti, A., Nyukuri, E., Mutua, J., Kyalo, A., Tanui, J. and Catacutan, D. (2007) *Policy and institutional context for NRM in Kenya: challenges and opportunities for landcare*. ICRAF (World Agroforestry Centre) Working Paper 43. Nairobi: ICRAF.
- Ziervogel, G. and Ericksen, P.J. (2010) Adapting to climate change to sustain food security. *Wiley Interdisciplinary Reviews: Climate Change*, **1**(4), 525-540
- Zimmerer, K.S. (2003) Just small potatoes (and ulluco)? The use of seed-size variation in "native commercialized" agriculture and agrobiodiversity conservation among Peruvian farmers. *Agriculture and Human Values*, **20**(2), 107-123
- Zimmerer, K.S. (2014) Conserving agrobiodiversity amid global change, migration, and nontraditional livelihood networks: the dynamic uses of cultural landscape knowledge. *Ecology and Society*, **19**(2), 1
- Zimmerer, K.S., Carney, J.A. and Vanek, S.J. (2015) Sustainable smallholder intensification in global change? Pivotal spatial interactions, gendered livelihoods, and agrobiodiversity. *Current Opinion in Environmental Sustainability*, **14**, 49-60