Supplementary Material to: MacLaren C, Aliyu KT, Waswa W, Storkey J, Claessens L, Vanlauwe B and Mead A (2022) Can the Right Composition and Diversity of Farmed Species Improve Food Security Among Smallholder Farmers? *Front. Sustain. Food Syst.* 6:744700. doi: 10.3389/fsufs.2022.744700

Supplementary Material

Can the Right Composition and Diversity of Farmed Species Improve Food Security Among Smallholder Farmers?

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1 Modifications to RHoMIS for the purposes of this study

For the version of RHoMIS used in this study, we followed standard procedures to localise crop names, currencies, units, and the phrasing of some questions. We also made some additions to the survey (to meet our project goals) and edited and removed some parts (to keep the survey within to acceptable length of time).

1.1 Items added:

RHoMIS usually only asks detailed questions about the respondent's 5 most important crops. We added the following questions about all crops:

- which season(s) the crop was grown in
- the area of land on which the crop was grown in each season
- the yield in each season, and whether this was considered a good, bad or normal harvest
- whether the crop was intercropped, and if yes, with which other crop(s)
- whether the crop was fertilised and what proportion of fertiliser was attributed to the crop

1.2 Items removed:

Questions pertaining to:

- Who owns land/crops/livestock
- If land is flat, sloping, or steep
- If any crops were harvested early, and why
- If any crops are not grown that the farmer would like to grow
- Conversion of crops into products, and storage of crops and crop products
- Number of livestock purchased
- Livestock slaughter and uses of meat, and livestock natural deaths
    - ***Note:*** *This means that a complete household calorie budget cannot be calculated from our dataset, nor can total value of activities.*

- Uses of wool, skins and hides
- Medicines for livestock
- The proportion of food sourced from wild foods, gifts or aid
- Progress out of Poverty indicators
- Dietary diversity in the best season
- Items that income is spent on

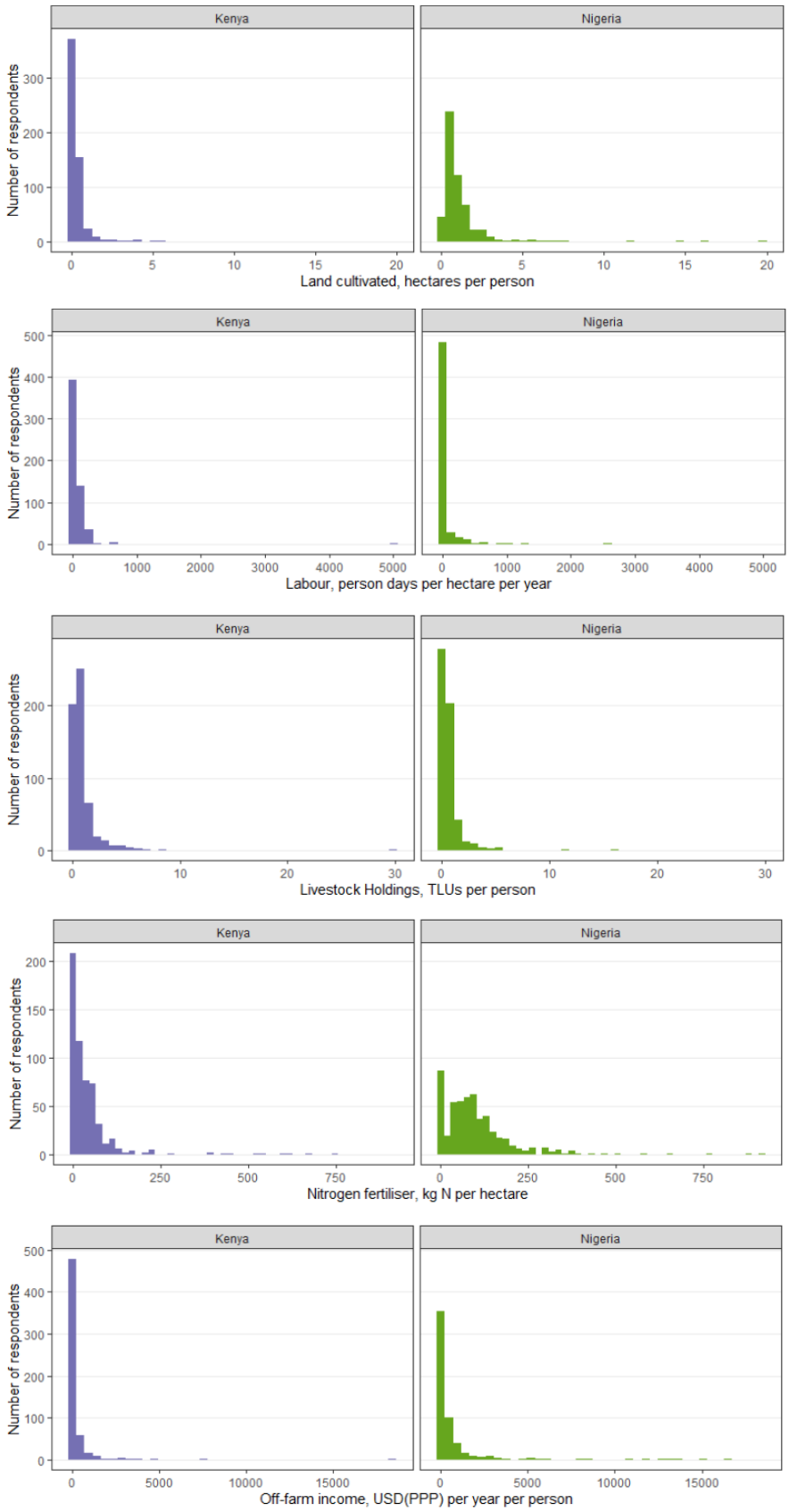
Questions about 'most important crops' that are not included under 'additions' were only asked of four crop species, while questions about the 'most important livestock' were only asked of three species (the default for both is six).

1.3 Items edited

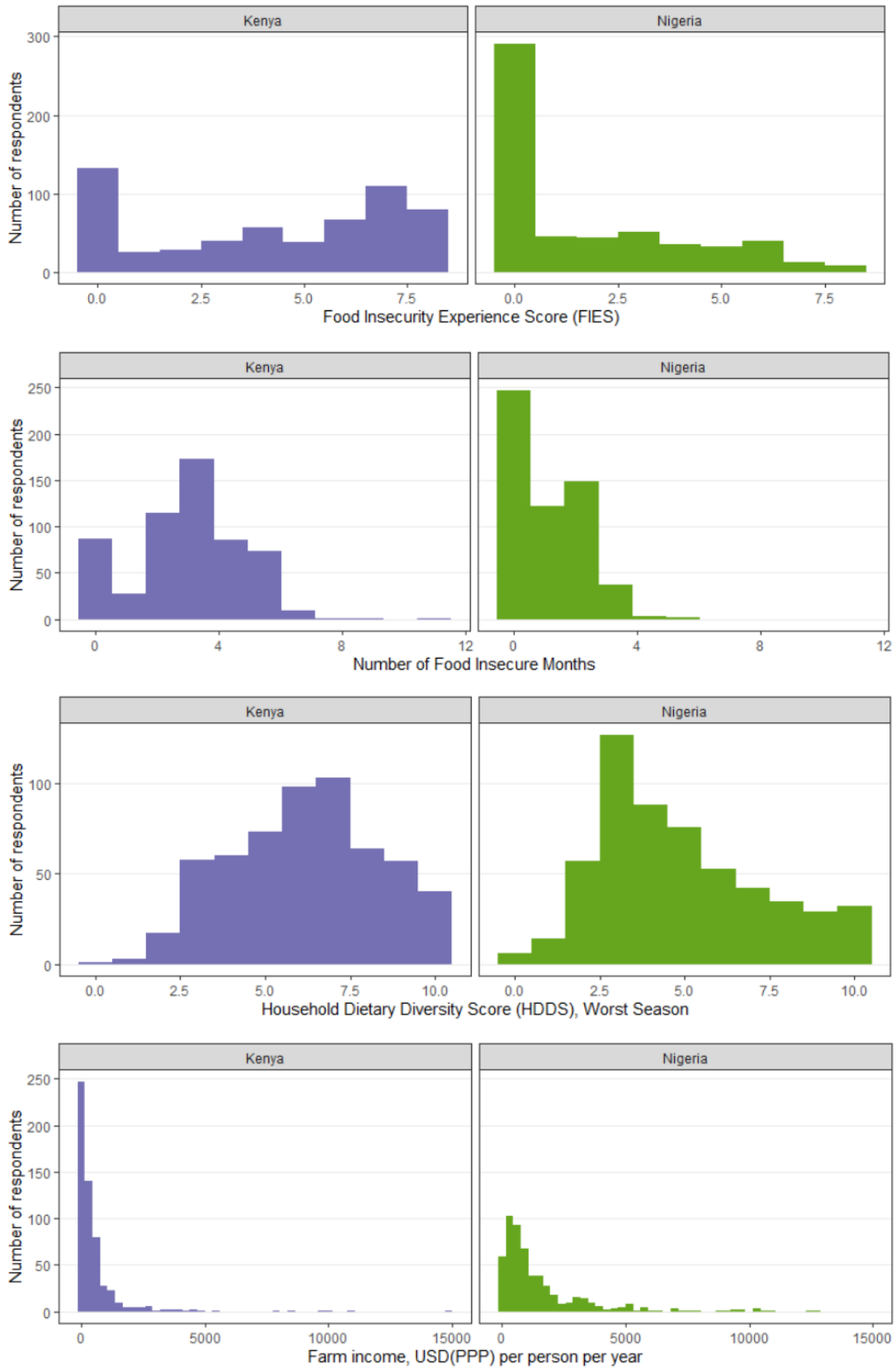
- Added a 'no answer' option to all questions
- In questions about the 'most important crops' we changed "What did you do with the main harvest of cropX during the last 12 months?" to "what do you usually do with your main harvest of cropX?", and the same for the crop residues question.
- Reduced questions about labour by each household member to ask 'approximately how many days does each woman on the house work on the farm?' and 'approximately how many days does each man on the house work on the farm?'
- Added 'purchased local seed' as a crop input option

2 Supplementary Figures and Tables

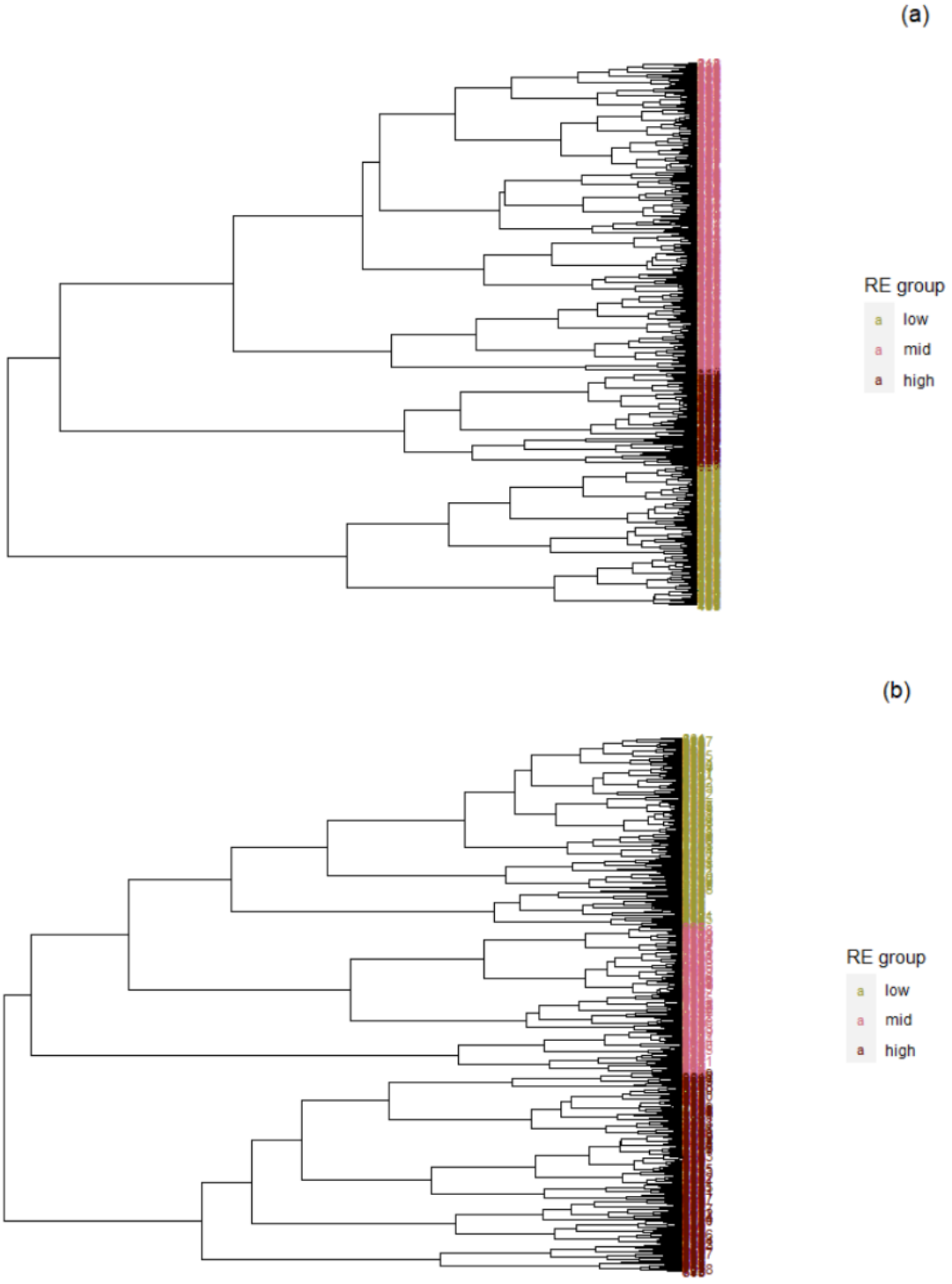
See following pages.



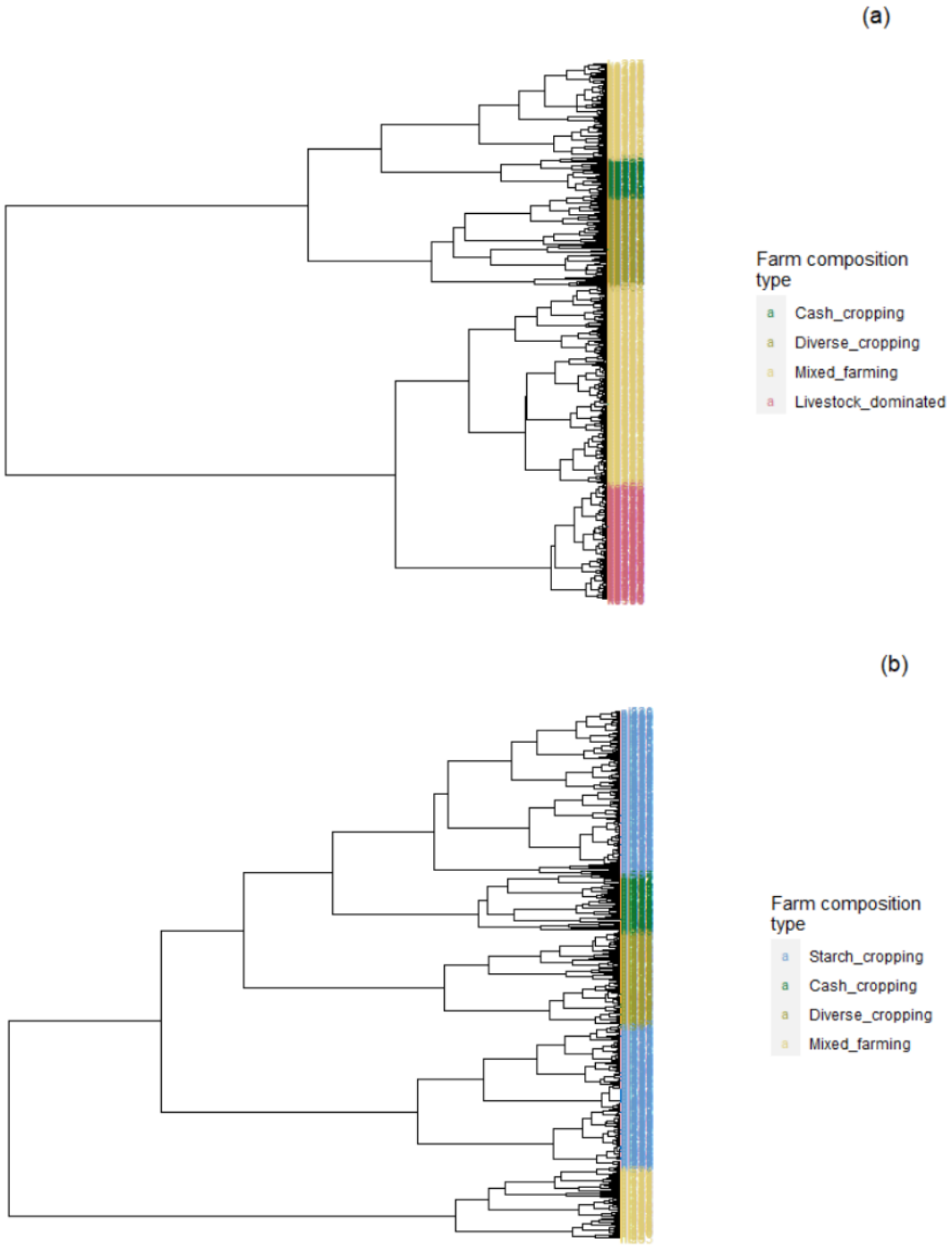
Supplementary Figure S1. The distributions of the five resource endowment variables.



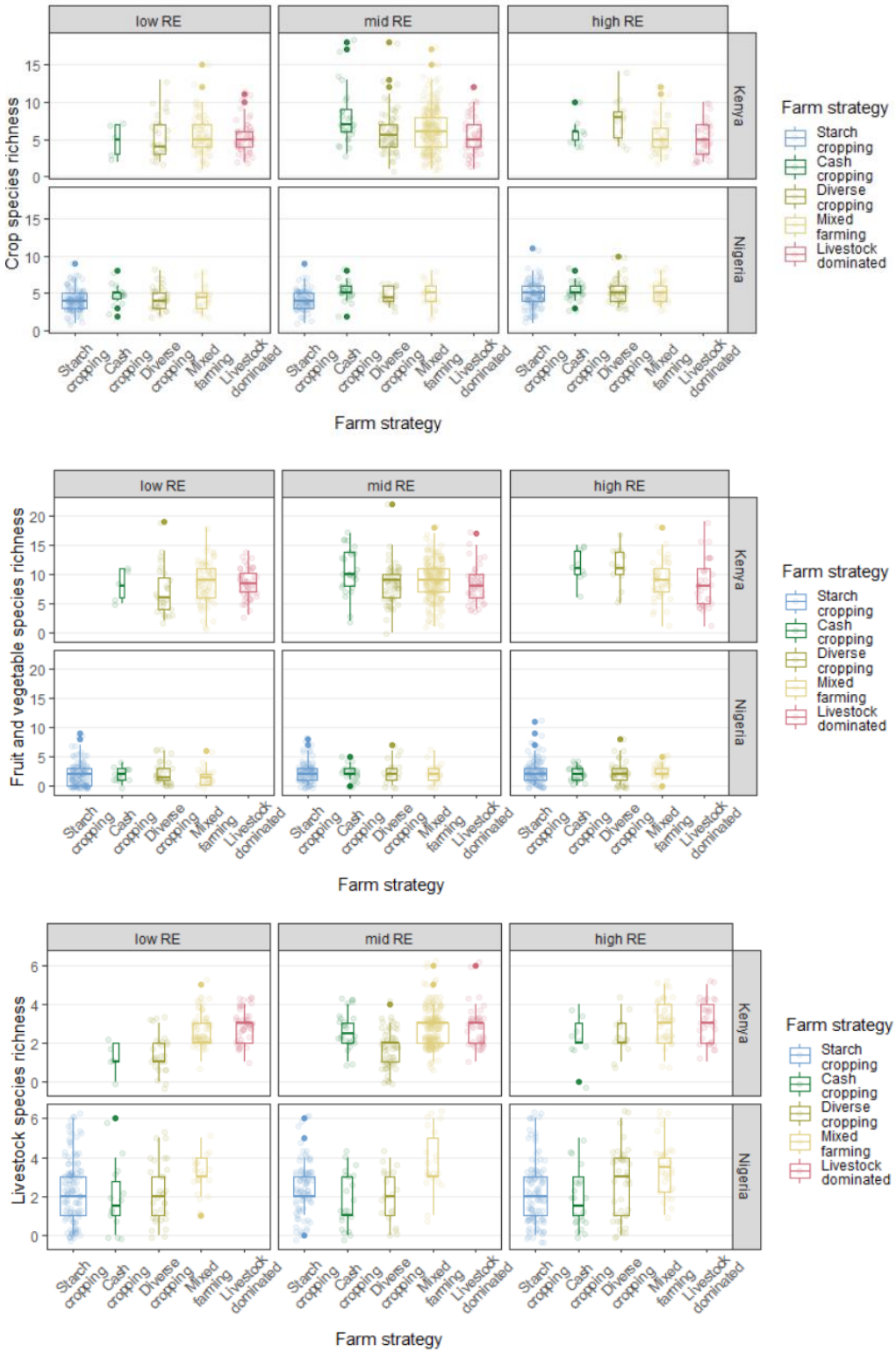
Supplementary Figure S2. Distributions of each of the four livelihood outcome variables in each country.



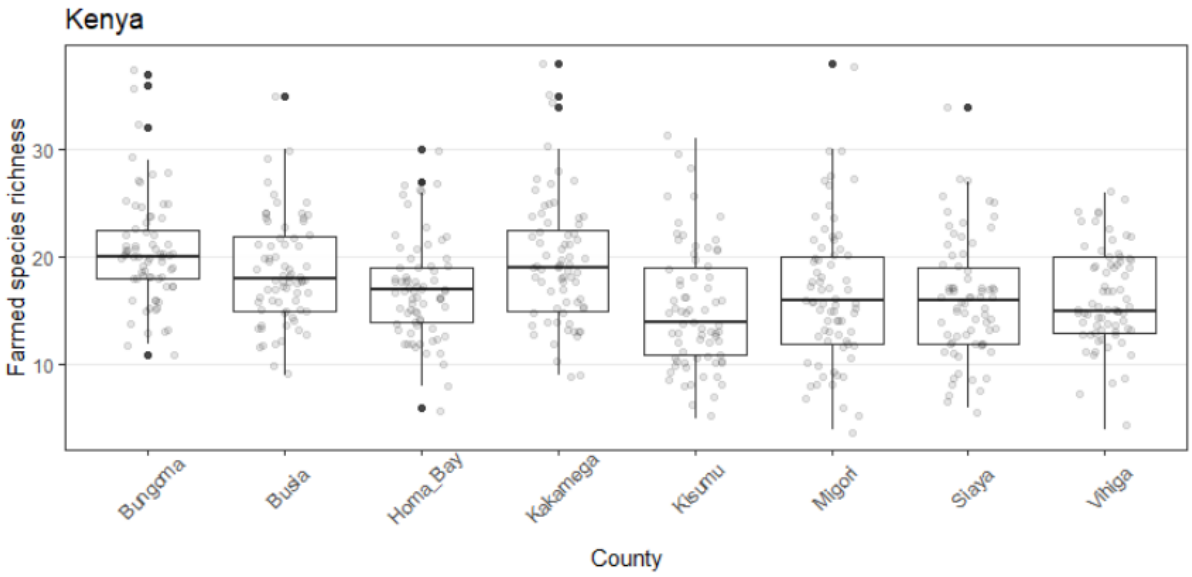
Supplementary Figure S3. The hierarchical clustering dendrograms identifying the farm composition (FC) groups in (a) Kenya and (b) Nigeria.

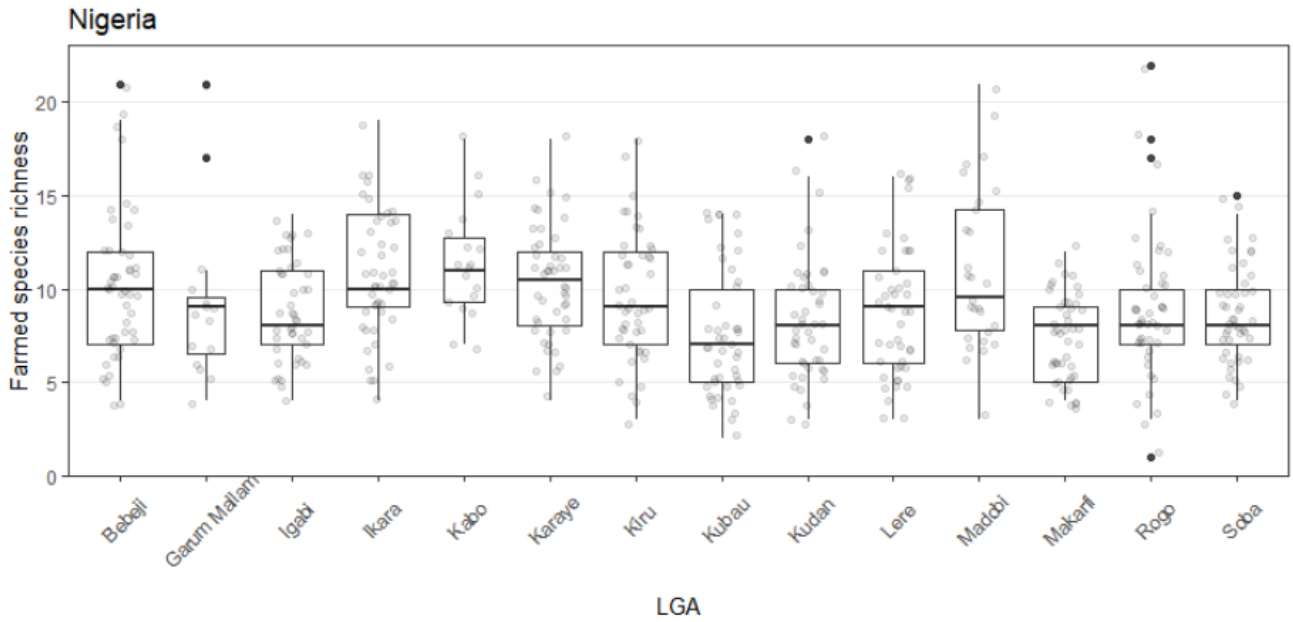


Supplementary Figure S4. The hierarchical clustering dendrograms identifying the farm composition (FC) groups in (a) Kenya and (b) Nigeria. In Kenya, The two mixed farming groups were combined as the main difference was in the weighted proportion of large livestock (medians of ~0.4 and ~0.6, respectively), but otherwise very similar weighted proportions of different crop and livestock types. In Nigeria, the two starch cropping groups were combined as the main difference between them was a median of ~0.6 starch crops vs ~0.4 starch crops. Proportions of other crops and livestock were similar.



Supplementary Figure S5. Richness of crop species (top), fruit and vegetable species (middle) and livestock species (bottom) farmed in different combinations of FC (x axis) and RE (panel columns) groups in each country (panel rows). Solid lines indicate medians, boxes indicate interquartile ranges, whiskers indicate points up to 1.5x the interquartile range while dots indicate outliers beyond that. Pale dots show the raw data (each point represents a farm).





Supplementary Figure S6: Boxplots illustrating that diversity varies more within regions (counties in Kenya, above; and LGAs in Nigeria, below) than between them, indicating no strong effect of geography on diversity within our study areas.

Supplementary Table S1. Model fitting results showing the fitted effects of RE and FC groups and species richness for the four livelihood outcome indicators, for the full models (although note that the full model and the reduced models for the FIES score and dietary diversity score are the same, as the AIC was not reduced by reducing the model for these outcome variables). Chi-square test statistics are shown for analysis of deviance summaries based on GLMs assuming binomially-distributed data and a logit link function and F-test statistics for ANOVA based on linear regression assuming normally distributed errors. All test statistics are for Type III tests for marginal contributions respecting the marginality of model terms. AIC values are presented for comparison of these full models with the corresponding reduced models presented in Table 5 (main text). Bold type highlights significance at the 5% level.

		FIES Score			Nr of Months Food Insecure			Dietary diversity (bad season)			Farm income per person		
Country	Variable	x^2	df	P	x^2	df	P	x^2	df	P	F	df	P
Kenya	RE	3.061	2	0.217	0.602	2	0.740	5.523	2	0.063	0.795	2	0.452
	FC	5.829	3	0.120	6.727	3	0.081	14.125	3	0.003	0.934	3	0.424
	RE:FC	34.357	6	<0.001	2.633	6	0.853	18.612	6	0.005	0.429	6	0.860
	SR	0.165	1	0.685	0.093	1	0.761	0.134	1	0.714	1.419	1	0.234
	RE:SR	1.823	2	0.402	0.088	2	0.957	3.456	2	0.178	0.682	2	0.506
	FC:SR	5.023	3	0.170	10.304	3	0.016	12.877	3	0.005	0.524	3	0.666
	RE:FC:SR	29.820	6	<0.001	5.699	6	0.458	17.992	6	0.006	0.320	6	0.926
	Residual		542			542			542			542	
	AIC	*3718.699*			*2178.835*			*2566.809*			*2402.910*		
Nigeria	RE	22.431	2	<0.001	3.740	2	0.154	4.181	2	0.124	7.991	2	0.000
	FC	1.634	3	0.652	1.389	3	0.708	1.044	3	0.791	0.711	3	0.546
	RE:FC	18.282	6	0.006	1.657	6	0.948	11.284	6	0.080	1.448	6	0.194
	SR	2.399	1	0.121	0.002	1	0.961	6.806	1	0.009	16.508	1	<0.001
	RE:SR	11.445	2	0.003	0.773	2	0.679	10.585	2	0.005	1.495	2	0.225
	FC:SR	4.919	3	0.178	1.214	3	0.750	1.333	3	0.721	0.334	3	0.801
	RE:FC:SR	28.462	6	<0.001	1.952	6	0.924	19.034	6	0.004	1.153	6	0.330
	Residual		509			509			509			509	
	AIC	*2679.444*			*1454.920*			*2628.334*			*1909.337*		

Supplementary Table S2. Model fitting results showing the fitted effects of RE and FC groups and species richness for the for the three dietary diversity sources (purchased, farm-based and 'other'/'free) for the full models (although note that the full model and the reduced models for other diversity in Kenya and for farm-based diversity in Nigeria are the same, as the AIC for these models was not reduced by removing variables). Chi-square test statistics are shown for analysis of deviance summaries based on GLMs assuming binomially-distributed data and a logit link function. All test statistics are for Type III tests for marginal contributions respecting the marginality of model terms. AIC values are presented for comparison of these full models with the corresponding reduced models presented in Table 5 (main text). Bold type highlights significance at the 5% level.

		Farm-based			Purchased			Other		
Country	Variable	x^2	df	P	x^2	df	P	x^2	df	P
Kenya	RE	2.312	2	0.315	5.437	2	0.066	3.017	2	0.221
	FC	3.111	3	0.375	11.080	3	0.011	15.172	3	0.002
	RE:FC	3.979	6	0.680	10.229	6	0.115	16.802	6	0.010
	SR	1.289	1	0.256	11.117	1	0.001	5.379	1	0.020
	RE:SR	1.027	2	0.598	5.449	2	0.066	5.760	2	0.056
	FC:SR	2.393	3	0.495	11.062	3	0.011	13.874	3	0.003
	RE:FC:SR	2.056	6	0.915	10.091	6	0.121	18.160	6	0.006
	Residual		542			542			542	
	AIC		*2291.766*			*2149.039*			*2979.144*	
Nigeria	RE	0.676	2	0.713	1.644	2	0.440	0.560	2	0.756
	FC	3.611	3	0.307	0.058	3	0.996	10.128	3	0.018
	RE:FC	8.029	6	0.236	7.228	6	0.300	8.909	6	0.179
	SR	6.657	1	0.010	38.253	1	<0.001	22.757	1	<0.001
	RE:SR	5.091	2	0.078	0.401	2	0.818	2.517	2	0.284
	FC:SR	6.221	3	0.101	0.613	3	0.894	8.547	3	0.036
	RE:FC:SR	13.710	6	0.033	8.629	6	0.196	8.608	6	0.197
	Residual		509			509			509	
	AIC		*1619.813*			*2319.564*			*1746.749*	

Supplementary Table S3: Pearson's correlation coefficients between RE variables and SR, within each RE group.

	Kenya			Nigeria		
	low	mid	high	low	mid	high
Land cultivated, ha pp*	0.02	0.06	0.17	0.21	0.07	-0.02
Labour/land ratio (person-days ha-1)	-0.02	-0.04	-0.08	-0.06	0.05	-0.01
N fertiliser (N kg ha-1)	-0.04	0.00	0.17	0.07	-0.07	-0.06
Livestock TLUs pp*	0.12	0.04	-0.05	0.50	0.46	0.23
Off-farm income, USD PPP pp*	-0.08	-0.01	-0.01	0.10	0.05	0.01

**pp = per person*