The Drylands Development Programme (DRYDEV)

A Farmer-led Programme to Enhance Water Management, Food Security, and Rural Economic Development in the Drylands of Burkina Faso, Mali, Niger, Ethiopia, and Kenya

Baseline Survey Report

September, 2016

Ministry of Foreign Affairs of the Netherlands

Core Baseline Survey Team Members:

Karl Hughes, Head of Monitoring, Evaluation and Impact Assessment, ICRAF
Judith Oduol, Agricultural Economist, ICRAF
Jeanne Coulibaly, Agricultural Economist, ICRAF
Joachim Binam, Policy Impact Scientist, ICRAF
Tor-Gunnar Vagen, Senior Geo-spatial Scientist, ICRAF
Niguse Hagazi, Agroforestry Scientist, ICRAF
Hilda Kigode, Research Officer, ICRAF

Table of Contents

Executive Summary 1

1. Introduction to the Drylands Development Programme (DryDev) 2

2. Impact Evaluation Strategy 3

3. Impact and Outcome Indicators 6

4. Baseline Data Collection and Analysis 8

5. General Respondent and Household Characteristics 11

5.1 Respondent Characteristics 11

5.2 General Household Characteristics 14

5.3 Household Productive Pursuits 16

6. Farming 18

6.1 Farm Land Holdings 18

6.2 Crop Production and Sales Estimates 19

7. Poverty Status 22

7.1 Household Consumption Expenditure 22

7.2 Household Asset Wealth 26

8. Dietary Diversity 29

9. Women's Empowerment in Agriculture Index (WEAI) 32

10. Multidimensional Poverty Index 37

11. Measures of Soil Health 40

12. Resilience Index 46

13. Field Characteristics & Management Practices 50

13.1 Field Tilling Practice 50

13.2 Soil Fertility Management Practice & Irrigation 51

13.3 Soil Erosion Control Practices 52

13.4 Trees in Crop Fields 53

14. Summary Indicator Table 56

Annexes 57

Annex 1: Country Maps of Impact Study Sites 58

Annex 2: Specific Names and Locations of DryDev's Impact Study Area Sites 63

Annex 3: Tests for Linear Trend 65

Annex 3: Details of the Women Empowerment in Agricultural Index (WEAI) Adapted for DryDev 67

Annex 4: Details of the Multidimensional Poverty Index (MPI) Adapted for DryDev 69

Annex 5: Details of the Resilience Index Adapted for DryDev 70

Executive Summary

The Drylands Development Programme (DryDev) is a five-year initiative (August 2013 to July 2018) funded by the Ministry of Foreign Affairs (MoFA) of the Netherlands, with a substantial contribution from World Vision Australia (WVA). The World Agroforestry Centre (ICRAF) is the overall coordinating agency, and National Lead Organizations (NLOs) are spearheading the programme's implementation in Kenya, Ethiopia, Mali, Niger, and Burkina Faso, with the active involvement of 16 other implementing partners. DRYDEV's strategy is informed by two complementary and overarching 'theories of change' developed during its Inception Year, which are presented in its Inception Report. One is focused on DryDev's direct development work with famers, while the other focuses on efforts being undertaken to promote the uptake of evidence and learning generated under the programme.

This report presents the results of a baseline survey focused on the impact and outcome indicators associated with this first theory of change. DryDev's impact evaluation strategy for its direct work with farmers will involve comparing changes in the status of these indicators between these farmers and others residing in neighbouring geographic areas that will not be supported. Statistical methods will also be used to control for measured non-programme related differences between the two. This quantitative impact evaluation design, more specifically, combines both the difference-in-differences and propensity score matching (PSM) causal impact evaluation strategies. Qualitative and participatory research methods will also be used to both triangulate and add depth to the quantitative results and interrogate the mechanisms of how and why the changes expected from the programme did or did not manifest.

A total of 7,901 randomly sampled female and male farmers from 71 intervention and comparison sub-watershed sites were interviewed across the five participating countries. Data were also captured via remote sensing from 7,887 randomly sampled fields farmed by these same farmers. The following table presents the survey's key findings, as per this report's primary section headings.

Section Heading	Key Summary Findings
Farming	• Crop production is generally very low for the vast majority of households across the five countries and much lower for crop-related income. • Crop production is strongly associated with landholding size, so alternative options for households with small landholdings are likely critically important.
Poverty Status	• Poverty, as measured by consumption expenditure, is more acute in Niger and Burkina Faso, with over 25% of the sampled households being below the USD $1.25 per capita 'ultra-poverty' line. • However, with respect to asset wealth, Burkina Faso is much better off, ranking second among the five counties. Kenya ranks first on both poverty measures.
Dietary Diversity	• Micronutrient adequacy is poor across all countries, with Ethiopia and, to a lesser extent, Burkina Faso being the worst off.
Women's Empowerment in Agriculture Index	• Scores for the WEAI are heavily biased in favour of men in all countries, save for Kenya; the pervasive nature of gender inequality appears undeniable.
Multi-dimensional Poverty Index	• Multidimensional poverty is high in all the five countries, but its depth is less in Kenya, primarily because it is better off with respect to the education dimension.
Measures of Soil Health	• Soil erosion is high in all countries, especially in Niger and Burkina Faso. • Considerably variability exists for other soil health measures, which is driven significantly by differences in soil types found within the DryDev sites.
Resilience Index	• Resilience is generally low but driven by varying factors across the countries.
Field Characteristics & Management Practices	• Field mgt. practices and characteristics vary considerably, and this variation should be carefully taken into account when promoting improved mgt. options.

1. Introduction to the Drylands Development Programme (DryDev)

The Drylands Development Programme (DryDev) is a five-year initiative (August 2013 to July 2018) funded by the Ministry of Foreign Affairs (MoFA) of the Netherlands, with a substantial contribution from World Vision Australia (WVA). The World Agroforestry Centre (ICRAF) is the overall coordinating agency. DryDev is designed to provide relevant, contextually appropriate support to smallholder farmers in selected dryland areas of Burkina Faso, Mali, Niger, Ethiopia, and Kenya. It is seeking to meaningfully contribute to the realization of a **vision** where households residing in such areas have transitioned from subsistence farming and emergency aid to sustainable rural development. This is to be achieved by increasing food and water security, enhancing market access, and strengthening the local economy for different categories of farmers.

DryDev is directly supporting 227,000 smallholders in selected semi-arid areas of five African counties to pursue contextually appropriate and inclusive options.

DRYDEV's strategy is informed by two complementary and overarching 'theories of change' developed during its Inception Year, which are presented in its Inception Report. One is focused on DryDev's direct development work with famers, while the other focuses on efforts being undertaken to promote the uptake of evidence and learning generated under the programme. These theories of change directly inform DRYDEV's logical framework analysis (LFA), which includes the following mutually reinforcing work packages, sub-outcomes, outcomes, and impacts:

Work Package	Sub-outcome	Outcome	Impact
1. Subcatchment level NRM	1. Appropriate subcatchment level NRM initiatives undertaken	1. Increased water capture & soil conservation/fertility at subcatchment & farm levels 2. Increased production of profitable, climate-smart commodities & food crops 3. Increased sales of targeted value chain commodities by male, female, and vulnerable farmers	1. Sustained improvements in food and water security, livelihoods, and resilience, and empowerment of women and disadvantaged groups
2. On-farm water & soil management	2. Improved & climate smart on-farm water & soil management practiced		
3. Agricultural commodity production	3. Improved, inclusive & climate-smart production options pursued		
4. Enhancing market access	4. Increased participation of male, female and disadvantaged farmers in lucrative value chains		
5. Financial services linking	5. Increased numbers of famers linked to credit/financial services		
6. Local governance & institutional strengthening	6. Increased capacity of local duty-bearers and farmer organizations & 'duty fulfilment' pressure applied	4. Improved local governance & farmer organization functioning	
7. Planning, M&E, and scaling of learning	7. Key 'scaling stakeholders' identified, find evidence & learning credible and relevant, and actively promote their uptake	5. Critical mass of development actors motivated, able, and resourced to support/directly implement evidenced options	2. Programme outcomes and impacts scaled out to other dry land areas
8. Policy analysis & influencing	8. Awareness raised and attitudes improved among key policy makers and other stakeholders, resulting in their taking desired action	6. More supportive/ appropriate policies & wider institutional environment conducive for wide uptake of evidence	

ICRAF, being a research-for-development organization, does not directly implement development interventions. Consequently, it is working closely with 21 implementing partners in the five countries to spearhead the programme's implementation. The following table presents both the lead and other participating partner organizations by country:

Country	National Lead	Other Implementing Partners
Burkina Faso	Reseau Marp	SNV; Tree Aid
Mali	Sahel Eco	OXFAM; AMEDD; AMEPPE
Niger	Care International	OXFAM; World Vision; KARKARA; AREN; RAIL; CRESA
Ethiopia	World Vision Ethiopia	EOC/DICAC; REST
Kenya	World Vision Kenya	SNV; CARITAS; ADRA

2. Impact Evaluation Strategy

DryDev's impact evaluation strategy comprises: (a) comparing famers directly supported with similar unsupported farmers; (b) structured planned comparisons; and (c) a final external evaluation.

Given that DryDev is seeking to achieve impact through both (a) directly supporting smallholder farmers; and (b) promoting the uptake of programme-generated evidence and learning by policy makers and other development actors for application elsewhere, its impacts will be assessed using several different, yet mutually reinforcing, approaches. The first involves comparing changes over the life of the programme in the status of key impact and outcome variables (e.g. household income and food security) experienced by smallholder farmers this programme is directly supporting with similar farmers in neighbouring geographic areas that will not be supported. This first strategy intends to estimate DryDev's impact on the smallholder farmers it is directly targeting and is elaborated further below.

The second strategy is to generate more nuanced learning about what specific interventions and development options work best under what conditions, for whom, how, and at what cost. DryDev, in particular, explicitly recognizes three things:

(a) the agro-ecological, sociocultural, and/or economic circumstances of the smallholder farmers DryDev is targeting vary considerably, both across and within the five participating countries;
(b) the most appropriate options for tackling key challenges they face are not always self-evident—either by external "experts" or these smallholders themselves; and
(c) one particular option (e.g. zai pits of a particular width, depth, and spacing) will not necessarily work and/or be taken up (i.e. adopted) in the same way across such varying circumstances.

It follows that promoting only one option in a uniform way within a particular intervention area or work package (e.g. on-farm soil and water conservation) will fail to maximize both impact (by failing to offer smallholders a range of options that are appropriate for their specific circumstances and needs) and learning (by failing to systematically compare the relative performance of different options across varying farmer circumstances). DryDev is, therefore, working with the participating smallholder farmers in all five countries to customize intervention options for their specific circumstances. In addition, where there is significant uncertainty about how to address a particular challenge or achieve a specific goal (e.g. reduce crop loss from pest attacks), implementing partners and farmers are being supported to implement several promising options alongside one another in such a way to enable their performance in relation to particular farmer circumstances to be

compared. **Planned comparison** is a term that refers to the systematic, prospective comparison of different ways of (i.e. options for) addressing specific problems or achieving desired goals. And such comparisons form an integral part of DryDev's Participatory Action Learning (PAL) agenda and broader Planning, Monitoring, Evaluation, and Learning (PMEL) cycle. See DryDev's Inception Report.

The final strategy for assessing DryDev's impact will involve the commissioning of an **independent evaluation** at the end of the programme. This will include a critical examination of its success in scaling out programme-generated evidence and learning and its contribution to influencing wider policy and practice. The programme will specifically seek to disseminate learning derived from its planned comparisons among policy makers and other development actors. It will also work to address key policy and institutional constraints that block the large scale promotion and uptake of such contextually appropriate options. The contracted consultant will use evaluation tools, such as those of contribution analysis and process tracing, to critically evaluate how successful DryDev's evidence dissemination and policy influencing efforts actually were.

For a large-scale programme such as DRYDEV, the most straightforward approach for executing the impact evaluation strategy's first component would involve comparing all smallholder households and other entities (e.g. fields and sub-watersheds) targeted by the programme with others that are similar (i.e. comparable) but were not, including by a similar programme. Impact could then be estimated by comparing the two groups with respect to key outcome and impact indicators of interest.[1]

DryDev's with and without comparison will focus on geographical areas it expanded into following its Inception Phase.

However, given that DryDev's implementing partners had already started implementing activities in particular geographical areas during the Inception Phase (called 'quick win' sites)—coupled by the fact that many of these sites had benefited from previous interventions spearheaded by these same implementing partners—including these areas would have been problematic. Consequently, DryDev's strategy to evaluate the programme's overall direct impacts focuses only on geographic areas the programme targeted following its Inception Phase.

From a quantitative impact assessment perspective and given its focus on both sub-watershed and farm levels, the ideal way to assess DryDev's effectiveness would be to first identify a large number of geographical units (e.g. sub-watersheds) that are independent from a hydrological perspective, separated by a reasonable degree of distance, and meet the programme's targeting criteria. These subcatchment units would then be randomly assigned into programme intervention and control groups, with representative baseline and endline data being collected and compared between the two. Better still, these geographic units would be randomly assigned to different programme components, thereby testing the relative effectiveness of each.

[1] Such impact evaluation designs are more robust when they compare both groups in relation to how the outcome indicators have changed over time (i.e. by comparing the difference in the differences) or, better still, when they ensure that programme participation takes place at random. If done properly, the latter ensures that both groups are statistically similar at baseline in terms of both the outcome variable itself and the various observable and non-observable factors unrelated to the programme that can affect its evolution over time. In short, the potential outcomes of both groups—irrespective of whether each is supported or not supported by the programme—would be the same.

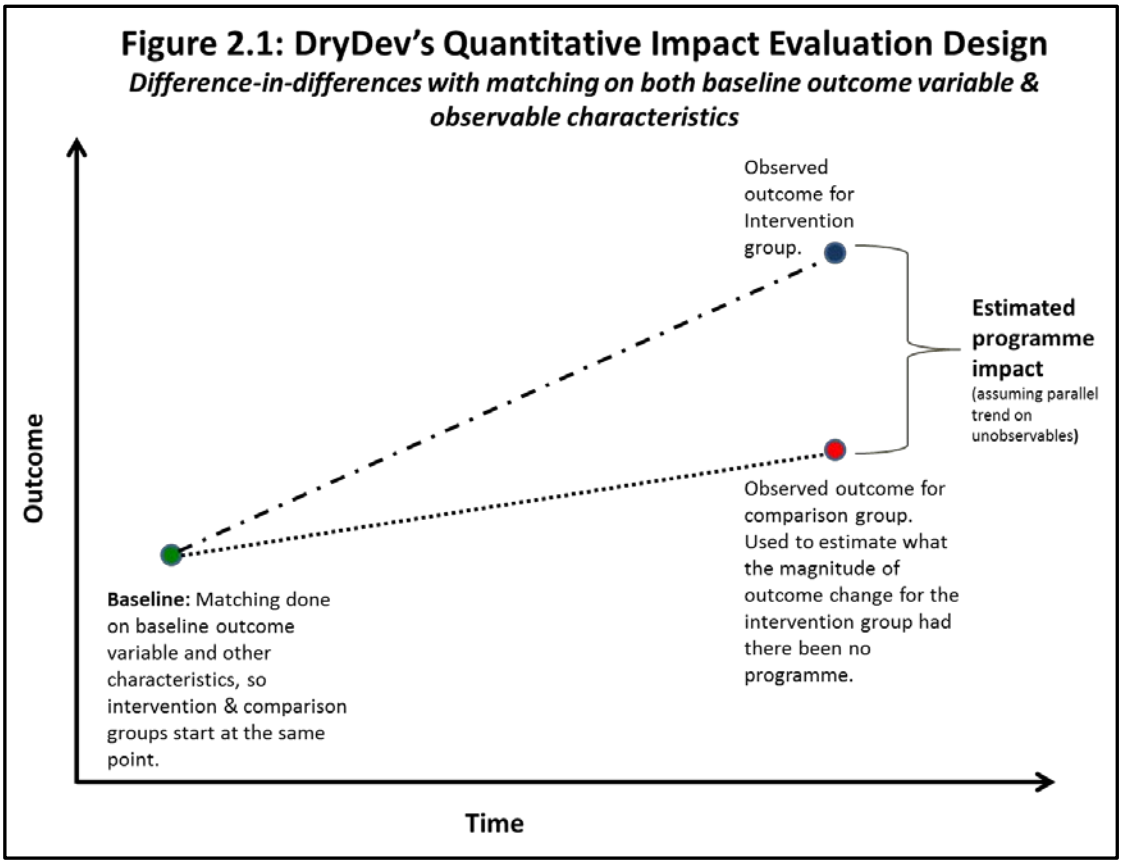
DryDev's direct impacts will be assessed by comparing the magnitude of change experienced by farmers in the intervention and comparison sites, coupled with the statistical control of measured differences between the two groups.

Unfortunately, pursuing such a cluster randomized control trial (RCT) was rendered infeasible. The primary reason: the sub-watershed is the unit of intervention, and the number of these units the programme expanded into during its full implementation phase is relatively small. The purpose of random assignment is to ensure that units (e.g. households) assigned to the intervention and comparison groups are statistically similar. This is in relation the baseline status of the outcome variable itself and both observable and unobservable factors that may affect the evolution of this variable over time. This only works when a large number of units are randomly assigned.

Consequently, a quasi-experimental impact evaluation design—based on the difference-in-differences method combined with propensity score matching (PSM)—is being pursued (Figure 2.1). This will be augmented by theory-based evaluation methods and complementary qualitative research. For the quantitative component, efforts were undertaken to purposively match each sub-watershed unit targeted for programme expansion to one comparison sub-watershed unit that is (a) relatively nearby but not so close that it could be influenced by significant programme spill over effects; (b) has similar biophysical characteristics (e.g. slope, rainfall patterns, and soil conditions) and socioeconomic characteristics (e.g. poverty levels and land use patterns); and (c) is part of the same larger watershed, yet independent from being affected by the programme's NRM interventions from a hydrogeological perspective.

Figure 2.1: DryDev's Quantitative Impact Evaluation Design

Difference-in-differences with matching on both baseline outcome variable & observable characteristics



The country maps presented in Annex 1 present the location of farmer fields that were sampled during the baseline survey and, therefore, indicate the location of DryDev's

impact study areas in general and the sub-watershed sites in particular. Annex 2 follows by presenting specific tables for each country with the names of each sub-watershed unit and the sample size of each, as well the higher level units for which they are a part. The data collection and analysis processes used during DryDev's baseline survey exercise are described in Section 4.

During DryDev's endline survey, efforts will be made to collect data from the same representative samples of farmers and farmer fields. The baseline and time invariant characteristics associated with these farmers and their fields will then be used to compute propensity scores, and those residing in the intervention and comparison sites will be subsequently matched on the basis of these scores. This strategy will ensure both groups are statistically balanced with respect to their observable characteristics. The two groups will then be compared in relation to the average and median changes each has experienced over time in relation to DryDev's outcome and impact indicators. Statistical interaction tests will also be used to assess whether particular groups (e.g. more prosperous farmers and female-headed households) were differentially affected by the programme.

Following the theory-based impact evaluation approach, the extent to which farmers in the targeted sub-watersheds have improved along the causal chain vis-à-vis their comparators will be assessed.[2] Qualitative and participatory research methods, as well as other quantitative approaches (e.g. mediation analysis), will also be used both to triangulate and add depth to these quantitative results and interrogate the mechanisms of how and why the changes expected from the programme did or did not manifest.

3. Impact and Outcome Indicators

DryDev's quantitative impact assessment strategy is focused on assessing progress in relation to the outcome and impact levels of the programme's theory of change for its direct work with smallholder farmers. Specific indicators are documented in DryDev's Inception Report for each corresponding impact and outcome statement, and efforts were made during DryDev's baseline survey to capture data on these. The extent to which relevant data were successfully captured for each particular indicator is presented in Table 3.1.

Baseline data were successfully captured on nearly all of the impact and outcome level indicators documented in DryDev's Inception Report.

As is evident, data were successfully collected for most of the indicators, save for crop water productivity. It may prove technically difficult to capture reliable data on this specific indicator, due to the nature of the targeted mixed smallholder farming systems. However, given that it is based on remote sensing data, ICRAF scientists are still assessing whether it can be meaningfully used, particularly to inform DryDev's endline evaluation. In addition, difficulties were encountered in differentiating food crops from market crops,

[2] See: White, Howard. (2009) *Theory Based Impact Evaluation: Principles and Practice*. International Initiative for Impact Evaluation, Working Paper 3.
http://www.3ieimpact.org/media/filer_public/2012/05/07/Working_Paper_3.pdf

given that many households both consume and sell the former. Consequently, indicators for (a) the cash value of food crops and (b) the cash value of market crops were merged together. The resulting indicator—the cash value of crops harvested during the previous farming season—estimates the total monetary value (using farm gate prices) of the crops a household produced during a given period (see Section 6).

TABLE 3.1: Impact and Outcome Indicators from Inception Report Versus Actual

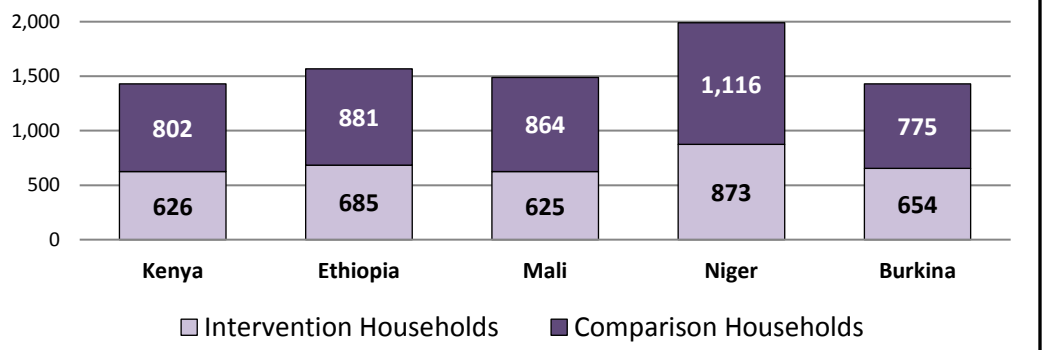
Outcome level	Indicator from Inception Report	Relevant data captured in baseline survey?
Impact Level		
Sustained improvements in food and water security, livelihoods, and resilience, and the empowerment of women and other disadvantaged groups	% of senior men and senior women in HH consuming 5 or more of the Minimum Dietary Diversity food groups	Yes
	% HHs predicted to be above the national poverty line	Yes, but World Bank poverty lines used
	% of HHs > median of comparison group on HH asset index	Yes
	% of HHs that are multi-dimensionally poor	Yes
	Women Empowerment in Agricultural Index (WEAI): % of men & women scoring positively on over 2/3 of weighted indicators	Yes
	% of HHs scoring positively on over 2/3 of weighted indicators of resilience index	Yes
Outcome Level		
1. Increased water capture & soil conservation/fertility at watershed & farm levels	Predicted soil organic carbon content (via remote sensing)	Yes
	Predicted erosion prevalence & root depth restriction (via remote sensing)	Yes
	Enhanced vegetation & herbaceous cover indices (via remote sensing)	Yes
	% of HH farm plot(s) serviced by irrigation in last growing season	Yes
2. Increased production of profitable, climate-smart commodities & food crops	Crop water productivity—yield (biomass)/ evapotranspiration (via remote sensing)	Still being explored; indicator technically challenging to implement in mixed farming systems
	Estimated cash value of main food crops last main harvest	Yes, but cash value of crops not differentiated between main food and market crops
	Estimated cash value of main market crops last main harvest	
3. Increased sales of targeted value chain commodities sold by male, female, and vulnerable farmers	Estimated cash value of agricultural commodities sold by male & female HH members in last 12 months	Yes
4. Improved local governance & farmer organization functioning	# of M&F farmers reporting improved agricultural local gov. services	Yes, as part of Resilience Index
	# of M&F farmers participating in & reporting benefits from FOs	Yes, as part of WEAI

4. Baseline Data Collection and Analysis

A total of 7,901 female and male farmers were interviewed, and data were captured via remote sensing from 7,887 randomly sampled fields.

To administer DryDev's baseline survey, population statistics were first compiled for each sub-watershed site and stratified proportionate sampling was used to calculate the sample size required for each. In this way, it was possible to obtain representative country-level statistics without employing sampling weights. Given that data were compiled on various impact and outcome variables—coupled by the fact that key parameters, such as the standard deviation and the inter-class correlation coefficient, were unavailable—statistical power calculations were not used to estimate each country's sample size. Rather, efforts were made to derive the largest sample size possible, as per the budgetary resources available.

Figure 4.1: Number of Farmers Interviewed by Country



Given the impact assessment's intended use of propensity score matching (PSM), more comparison households were sampled than intervention households. This is to mitigate the risk being forced to drop intervention households during DryDev's endline analysis, as efforts are made to statistically balance the two groups.[3] The resulting sample sizes used for each country by treatment group are presented in Figure 4.1, while the specific sample sizes for each sub-watershed unit are presented in Annex 2. The resulting sample sizes for each country appear adequate to detect at least moderate programme impacts. However, having greater numbers of sub-catchment sites falling under DryDev's impact study areas at the country level would have been preferable, given that outcomes tend to be significantly correlated within such sites (see below).

A draft survey instrument was developed to capture data on the indicators presented in Section 3, as well as relevant farmer and household characteristics. It was then reviewed, modified, translated, and formatted in Excel for application in the Open Data Kit (ODK)

[3] The comparison observations will be used to estimate what would have happened if DryDev had never been implemented (i.e. the counterfactual). If a number of these observations are excluded from the analysis (because they do not match well with the intervention observations, i.e. fall outside of the area of common support), generalizable impacts for the intervention sites of the impact study area can still be estimated. However, if intervention observations are excluded from the analysis, this will not be the case; the estimated effects will only apply to the subset of the farmers and households that have similar observable characteristics to the remaining subset of intervention observations. When using PSM, it is therefore generally preferable to have more comparison observations than intervention observations.

package by ICRAF scientists and a consultant in Ethiopia's Tigray Region. This was followed by field testing the survey instrument by two experienced enumerators, which led to further refinements. The survey instrument was then adapted for Jarso District in Ethiopia's Oromia Region and for each of the four other countries. Taking into account the linguistic context of each country, Tigrinya and Oromo versions of the survey instrument were used in Ethiopia, an English version in Kenya, and French versions in the three Sahelian countries.

In each country, efforts were made to recruit enumerator teams comprising of an even number of males and females with appropriate educational qualifications (e.g. preferably a university or college degree) and relevant enumeration experience. Those initially recruited were then trained for period of two to three days, which included practice run at administering the survey instrument. Their performance was critically reviewed during this time and corrective measures undertaken, including disengaging several underperforming enumerator trainees.

Lists of smallholder households located in each sub-watershed site were compiled (with the support of local leaders, local informants, and NGO field staff), and the requisite number of households were selected at random from these lists. Attempts were made to ensure that the lists only included smallholder farming households that farmed during the last farming season within the sub-watershed site in question.

DryDev is particularly interested in evaluating whether the programme will impact male and female smallholders differently. Consequently, interviewed male and female famers were each asked questions pertaining to both themselves and their households. Efforts were further made to ensure that (a) the same numbers of male and female smallholders were interviewed; and (b) the gender of the enumerator and each farmer they interviewed was the same. To achieve this, half of the sampling quota of each sub-watershed site was first randomly sampled (using Excel's random sort function). If an active female adult farmer was found residing in one of these sampled households, this household was put on the female farmer interview list. If not and an active male farmer resided in the household, this household was placed on the male farmer interviewee list. Once the quota for female farmers was achieved, the same exercise was repeated to make up the sample quota balance for the male farmers. Thereafter, reserve lists were created for both the female and male famers for resampling, in the event that doing so became necessary. The female enumerators, then, focused on the female farmer lists and vice-versa for the male enumerators.

To enable assessment of DryDev's differential impacts on female and male farmers, the household random selection process also included randomly selecting whether a female or male farmer was to be interviewed.

The enumerator protocol involved interviewing the farmers privately for the personalized questions first and then opening up the interview process to include other household members for the questions focusing on the broader household. The end of the interview involved randomly selecting one of the household's fields, followed by visiting this field. The visit included taking a geographical positioning system (GPS) reading from the centre of the field, as well as asking the farmer questions about the field and making specific complementary observations.

While the data were being cleaned and analysed, the GPS coordinates of the sampled fields were provided to ICRAF's Geospatial Lab, for the purpose of generating remote

sensing-based estimates for the specific soil health indicators presented in Section 3. These estimates are based on predictive models based on specific spectral signatures derived from field data associated with ICRAF's network of hundreds of Land Degradation Surveillance Framework sites throughout East and West Africa.

Particularly during the first few days of the survey, the completed questionnaires (in electronic form on the enumerators' smartphones or tablets) were checked on a daily basis by the assigned ICRAF scientist or consultant in question, prior to being uploaded onto an internet server (https://ona.io/home/). After each country survey exercise was completed, the completed survey data were then downloaded and imported into Stata for cleaning. Generally, the data were of reasonable quality, a fact largely attributable to the ODK-based survey instrument that was developed and used. Nevertheless, data cleaning is the norm for most data collection exercises. For this particular survey, the most common issues requiring correction included:

The quality of the "raw" baseline data was generally good, but mistakes were identified, necessitating corrective measures.

- **Geographical coding mistakes.** On a number of occasions, enumerators miscoded the location (e.g. district, sub-districts, or sub-watershed) of the respondent's household. Fortunately, these were relatively easily corrected, given that the GPS coordinates of these households were recorded. The coordinates, in particular, were placed onto maps and the data were decomposed by geographic category, allowing for such mistakes to be readily identified and corrected.

- **No one coded as household head**. Most of these errors were easily identifiable coding mistakes, e.g. the "parent of the head" code was used for parent of the respondent when it clear that this individual was indeed the household head. In the few cases where it was not overtly obvious what the mistake was and given the patriarchal nature of the societies in question, the oldest male adult in the household (or female adult when either there was no male adults in the households or when it was clear that the male adult(s) was the child of the oldest female) was coded as being the household head.

- **Food consumption errors.** As part of the household food consumption module, respondents were asked how many units (e.g. kilograms) of specific food items (e.g. maize flour) their households consumed during the previous week. In several cases, the number of consumed units was excessively high and implausible. Often, it was clear that the enumerator entered the monetary value for the unit, rather than the number of units consumed. In other cases, it was not clear what error had been made. Given that such errors were only confined to one or two of the many food items, rectifying the latter involved replacing the erroneous values with the median value of the other households in the country dataset in question.

- **Abnormally high monthly savings rates**. In the regular monthly expenditure module, the respondents were asked whether their household had saved any money during the previous four weeks and, if so, the amount. Savings, here, is seen as a type of expenditure, particularly given that household consumption expenditure is being used as a proxy for household income (see Section 7). However, particularly in Kenya, the amount indicated for several households was very high, i.e. the equivalent of over USD $1,000. While this is possible, it is unlikely that such high

rates of savings would take place on a monthly basis. Albeit arbitrary, the maximum amount allowable for household monthly savings was capped at USD $200.

- **Skipped modules.** Several of the modules that were set up in ODK (e.g. household consumption expenditure and assets) included the 'required option'. This resulted in the skipping of these modules on several occasions, resulting in missing data for the associated variables in question.

- **Likelihood of spill over effects, particularly in Kenya**. As explained in Section 2, the intention was to select intervention and comparison sub-watershed units separated by considerable distance (e.g. 5 kilometres) or, otherwise, by some kind of natural barrier, such as a mountain. However, in the case of Kenya, this proved difficult in negotiations with the implementing partners. Consequently, the intervention and comparison sites for this country are neighbouring sub-locations, and careful efforts will be needed to assess and, if needed, control for potential spill-over effects during DryDev's endline survey and data analysis.

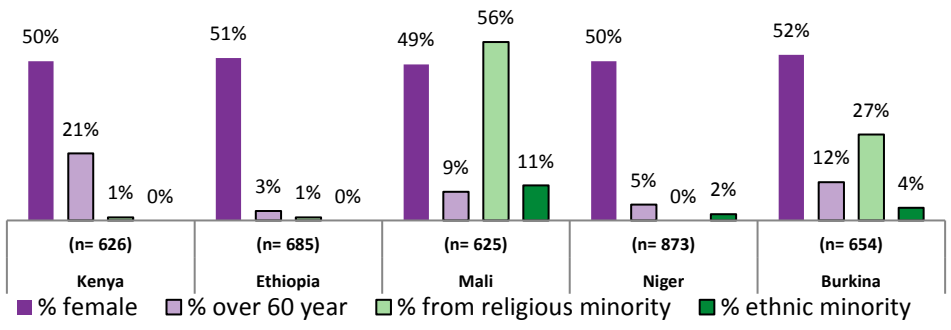
5. General Respondent and Household Characteristics

In addition to the impact and outcome indicators, information was also captured on the general characteristics of the respondents and their households.

5.1 Respondent Characteristics

To complement the indicators presented in Section 3, data were also captured on the characteristics of the respondents and their households. This includes 11 respondent characteristics and 23 household characteristics. For ease of presentation, Figure 5.1.1 presents only the first four of the respondent's characteristics and for DryDev's intervention sites only. The remaining characteristics are then presented in the proceeding graphs, while Table 5.1.1 presents all 11 respondent characteristics for both the intervention and comparison sites of each country, as well as the extent to which they statistically differ.

Figure 5.1.1: Characteristics of Interviewed Respondents (1)
(Intervention Respondents Only)



As indicated in Figure 5.1, approximately half of all the farmers interviewed are women. This is not surprising, given the sampling approach described in Section 4. While no statistically significant differences between the intervention and comparison sites were identified, a slightly higher proportion of female farmers were interviewed in Burkina Faso. Moreover, while far less than one-third of the interviewed farmers are over 60 years old and, again, no statistically significant differences were found between the intervention and comparison sites, there is significant variation across the five countries. This ranges from 21% for Kenya to 5% in Niger.

Several statistically significant differences between the farmers residing in the intervention and comparison sites were identified. However, the populations are similar for the most part.

The respondents were also asked about their religious and ethnic affiliations. For religion, very few of the respondents were identified as being from a religious minority group in Kenya, Ethiopia, and Burkina Faso. However, while Islam is the dominant religion in Mali, 56% and 44% of the respondents in the intervention and comparison sites, respectively, reported being non-Muslim. The same holds true for Burkina Faso, with 27% and 32% reporting themselves as non-Muslim for the intervention and comparison sites, respectively. The differences between respondents from the intervention and comparison sites in Mali for this variable are highly statistical significant. The differences are also statistically significant for Ethiopia and Burkina Faso, but to a lesser degree. Few respondents are from non-dominant ethnic groups vis-à-vis the regions in which they reside. However, 11% are from ethnic minority groups in Mali and 4% in Burkina Faso.

Figure 5.1.2: Characteristics of Interviewed Respondents (2)
(Intervention Respondents Only)

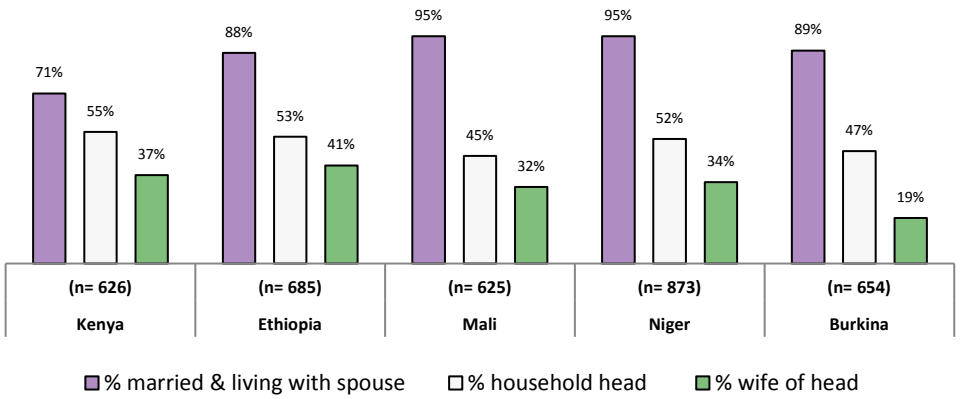


Figure 5.1.2 indicates the percentages of respondents who are married and living with their spouses, head their respective households, and who are the wife of the household head. For these three variables, there are no statistically significant differences between the intervention and comparison sites in any of the five countries, as indicated in Table 5.1.1. It is noteworthy that significantly fewer respondents are married in the case of Kenya, while Mali and Burkina Faso have the lowest proportion of respondents that head their respective households. The latter country also has the lowest percentage of respondents who are married to those that head their respective households.
Figure 5.1.3 presents the final graph on respondent characteristics. As is evident, there are significant differences across the five countries in terms of education levels. In Kenya,

Kenya stands out as an anomaly for respondent education and literacy levels, and there is significant inter-country variation for those who self-reported farming as their principal occupation.

85% are literate and 48% have completed at least primary school. Levels of literacy and education are considerably lower in the other four countries, with there being small—yet statistically significant—differences between the respondents of the intervention and comparison sites in three of these countries. The vast majority of the respondents further self-reported that they are in good health, and there are, again, small, but statistically significant, differences for this variable between the intervention and comparison respondents in Ethiopia and Mali. Finally, there is significant variation among the five countries in terms of respondents reporting that their principal occupation is farming. The percentages are relatively low for Kenya and Mali (66% and 62%, respectively) and as high as 96% in Ethiopia. Niger and Burkina Faso fall somewhere in between. Furthermore, significantly more respondents from the comparison sites stated that their principal occupation is farming in Mali, something that will need to be carefully controlled for during endline data analysis.

Figure 5.1.3: Characteristics of Interviewed Respondents (3)
(Intervention Respondents Only)

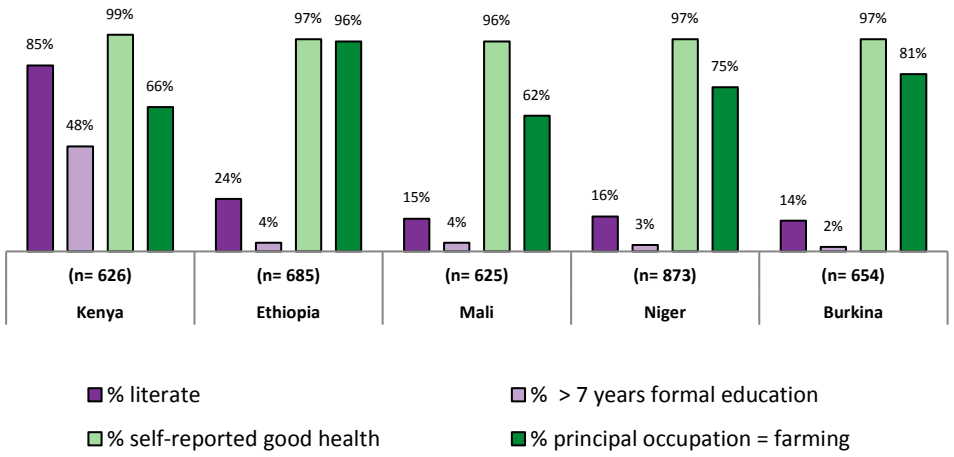


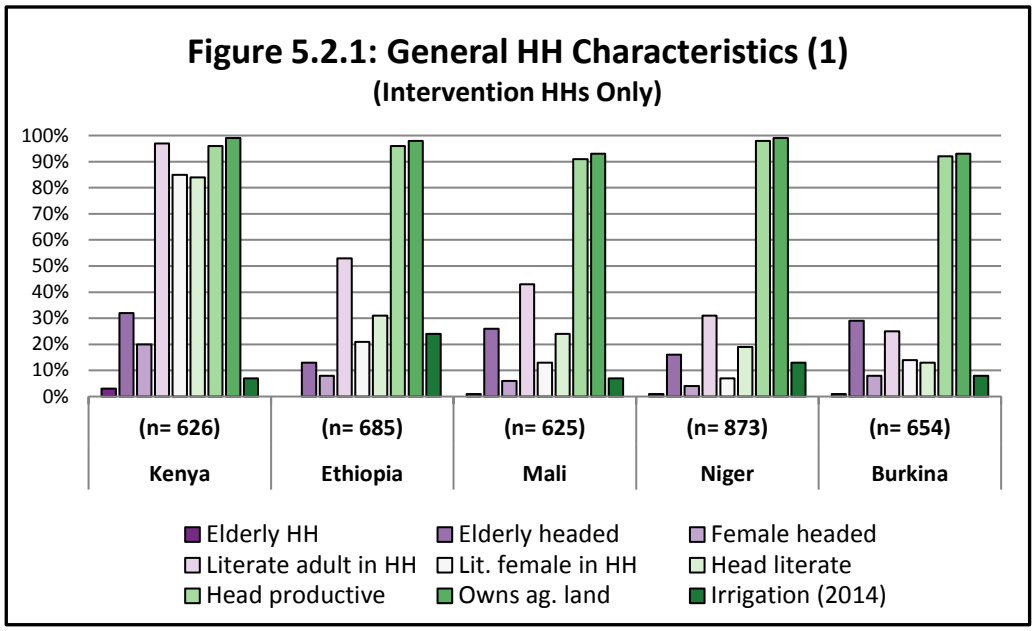
Table 5.1.1: Respondent Characteristics (Proportions): Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Female	0.50	0.50	-0.0050	0.51	0.50	0.015	0.49	0.50	-0.0021	0.50	0.51	-0.0075	0.52	0.53	-0.0083
Over 60	0.21	0.18	0.022	0.03	0.03	-0.0026	0.09	0.09	0.0018	0.05	0.04	0.0082	0.12	0.11	0.0068
Non-dominant religion	0.01	0.02	-0.0056	0.01	0.00	0.0058**	0.56	0.44	0.12***	0.00	0.00	-0.00090	0.27	0.32	-0.044*
Ethnic minority	0.00	0.01	-0.009**	0.00	0.00	-0.0023	0.11	0.10	0.0084	0.02	0.03	-0.0033	0.04	0.07	-0.023*
Married with spouse	0.71	0.70	0.0069	0.88	0.88	0.0022	0.95	0.97	-0.014	0.95	0.96	-0.014	0.89	0.90	-0.0066
Head of HH	0.55	0.57	-0.016	0.53	0.53	-0.00015	0.45	0.47	-0.020	0.52	0.51	0.016	0.47	0.48	-0.0047
Wife of HH head	0.37	0.35	0.020	0.41	0.40	0.0066	0.32	0.31	0.015	0.34	0.32	0.019	0.19	0.21	-0.016
Literate	0.85	0.86	-0.0080	0.24	0.25	-0.0040	0.15	0.14	0.0092	0.16	0.13	0.028*	0.14	0.11	0.032*
> 7 years of school	0.48	0.49	-0.0023	0.04	0.04	-0.0040	0.04	0.02	0.014*	0.03	0.02	0.0055	0.02	0.02	-0.000051
Health good	0.99	0.99	-0.0028	0.97	0.98	-0.018**	0.96	0.98	-0.022**	0.97	0.97	-0.0028	0.97	0.98	-0.013
Occupation=farmer	0.66	0.66	-0.0032	0.96	0.97	-0.010	0.62	0.71	-0.088***	0.75	0.73	0.021	0.81	0.81	-0.00040
Sample size	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; Inter. = Respondent comes from intervention, Com. = Respondent comes from comparison site.

5.2 General Household Characteristics

Figure 5.2.1 presents percentages for various household characteristics of the intervention sites of DryDev's impact study areas in each of the five countries. Table 5.2.1 further presents these same statistics but also includes those for the comparison sites and the extent to which these differ from intervention sites. Noteworthy observations include:



- Very few of the interviewed respondents' households are elderly, i.e. households where all adult members are over 60 years old. This may not reflect the overall situation in the targeted sub-watershed sites, however, given that only households that farmed during the past 12 months were targeted for interviews.
- Many of the households are, nevertheless, headed by elderly adults, but this varies considerably across the five countries, with the highest and lowest being 32% and 13% in Kenya and Ethiopia, respectively. Nevertheless, over 90% of the household heads in all five counties were reported as being productive, i.e. regularly engaged in productive work. There are slightly fewer elderly headed households in the Mali intervention sites vis-à-vis this country's comparison sites, and this difference is statistically significant.

While over 90% of the households across the five countries own land for farming, most of it is unirrigated.

- Kenya also comprises the highest numbers of female headed households at 20%, while the lowest is in Niger at 4%.
- As is the case for the respondents themselves, reported literacy levels of household members across the five countries also vary considerably. For example, at least one literate adult was reported to reside in almost all of the households in Kenya, while this drops to as low as 25% for Burkina Faso. Kenya is also the only country where significant numbers women were reported as being literate.
- While well over 90% of households reported owning agricultural land, far fewer reported that such land is irrigated, with this figure being as low as 7% for Kenya

and Mali and as high as 24% in Ethiopia. There are statistically significant differences in relation to both of these variables in several of the countries, which, again, will be important to control for during endline data analysis.

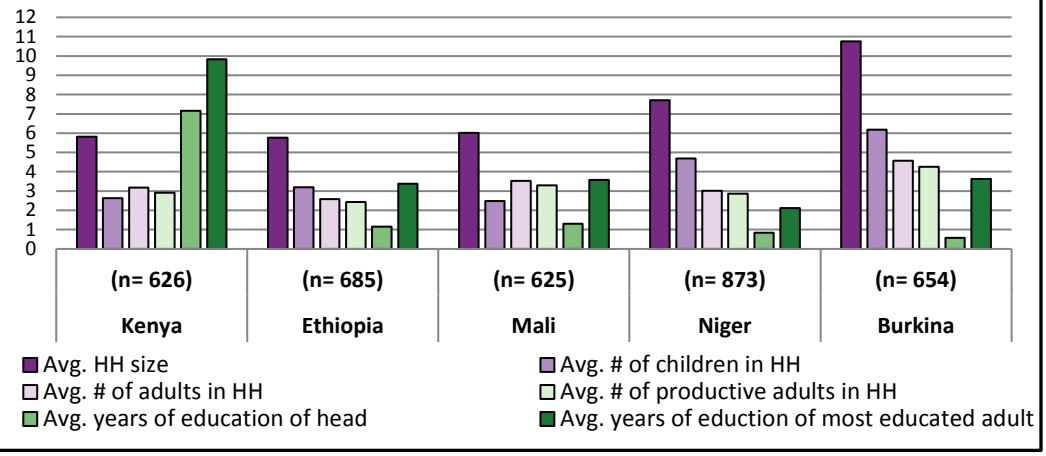
Table 5.2.1: HH Characteristics (Proportions): Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Elderly HH	0.03	0.02	0.0070	0.00	0.00	0.0032	0.01	0.01	0.0038	0.01	0.01	0.0038	0.01	0.01	-0.0027
Elderly headed	0.32	0.30	0.023	0.13	0.11	0.022	0.26	0.32	-0.058**	0.16	0.18	-0.016	0.29	0.27	0.020
Female headed	0.20	0.21	-0.010	0.08	0.09	-0.0076	0.06	0.05	0.0090	0.04	0.04	0.0026	0.08	0.08	0.0051
Literate adult in HH	0.97	0.97	0.0006	0.53	0.52	0.0055	0.43	0.41	-0.018	0.31	0.31	-0.0017	0.25	0.22	0.026
Lit. female in HH	0.85	0.86	-0.0082	0.21	0.23	-0.025	0.13	0.13	-0.0031	0.07	0.06	0.012	0.14	0.11	0.023
Head literate	0.84	0.84	0.0055	0.31	0.30	0.016	0.24	0.22	0.020	0.19	0.18	0.013	0.13	0.12	0.012
Head productive	0.96	0.96	0.0035	0.96	0.97	-0.0097	0.91	0.92	-0.0063	0.98	0.97	0.0040	0.92	0.94	-0.016
Owns ag. land	0.99	0.98	0.0100	0.98	0.96	0.014*	0.93	0.95	-0.027**	0.99	0.97	0.012**	0.93	0.92	0.0012
Irrigation (2014)	0.07	0.06	0.0051	0.24	0.30	-0.054**	0.07	0.17	-0.097***	0.13	0.14	-0.0093	0.08	0.06	0.015
Sample size	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01

Figure 5.2.2 present data for the intervention sites on six additional household characteristics, while Table 5.2.2 also presents them for the comparison sites and the differences between the two groups. Key observations include:

Figure 5.2.2: General HH General Characteristics (2)
(Intervention HHs Only)



Average household size is considerably greater in Burkina Faso and, to a lesser extent, in Niger.

- Household size varies considerably across the five countries, with Burkina Faso being a clear outlier.
- In Kenya and Mali the average number of adults exceeds that of the average number of children, with the reverse being the case in Ethiopia, Niger, and Burkina Faso.
- In all countries, the vast majority of adults are engaged in productive work.
- Kenya stands out as having significantly higher education levels with respect the household head and the most educated adult in the household. Average education levels are much lower for the four other countries.
- For the three Sahelian countries several statistically differences between the households in the intervention and comparison sites were identified. The average

household size, for instance, for the intervention sites is smaller and larger for Mali and Burkina Faso, respectively. While very low, household heads in the Mali sites also have, on average, higher education levels than their comparators.

Table 5.2.2: Other HH Characteristics (Averages): Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
HH Size	5.81	5.93	-0.12	5.77	5.68	0.096	6.01	6.30	-0.29**	7.70	7.88	-0.18	10.75	9.80	0.94***
No. of children	2.63	2.72	-0.091	3.19	3.12	0.075	2.48	2.62	-0.14	4.69	4.74	-0.058	6.18	5.48	0.70***
No. of adults	3.18	3.21	-0.032	2.58	2.56	0.021	3.52	3.68	-0.16*	3.01	3.14	-0.13*	4.57	4.32	0.24*
Productive adults	2.91	2.98	-0.072	2.44	2.46	-0.021	3.29	3.50	-0.20**	2.86	3.00	-0.14**	4.26	4.04	0.21*
Years educ. head	7.15	7.01	0.13	1.16	1.16	0.0043	1.30	0.83	0.47***	0.84	0.81	0.026	0.58	0.70	-0.12
Highest educ. adult	9.82	9.61	0.22	3.38	3.43	-0.055	3.58	3.51	0.083	2.12	2.29	-0.17	3.62	3.74	-0.14
Sample size	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**863**	**1489**	**873**	**1116**	**1989**	**653**	**774**	**1429**

* p<0.1, ** p<0.05, *** p<0.01

5.3 Household Productive Pursuits

Respondents were also asked whether anyone from their household participated in particular livelihood activities in 2014 from a pre-defined list. Figure 5.3.1 and Table 5.3.1 present the results. Noteworthy points include:

While almost all households engaged in farming in 2014, there is considerable variation across the five countries in their pursuit of other productive activities.

- Unsurprisingly, nearly all respondents reported that their household engaged in farming in 2014. However, several households in Niger's comparisons sites did not participate in farming during this particular year, resulting in a statistically significant difference between these households and their counterparts in the intervention sites. For Mali, while the difference is considerably less, the reverse is the case: several households in the intervention sites reported not having engaged in farming in 2014.
- Save for Mali, relatively few respondents reported that their household had processed crops or natural products (e.g. processing oil or extracting honey) in 2014. For Mali, this was nearly 50% for the intervention households compared with 57% for the comparison households, a difference which is highly statistically significant.
- Over half of the households in all five countries were reported as having had engaged in livestock rearing in 2014, with the highest being Kenya (88-89%) and the lowest Niger (53-55%). Statistically significant differences between the intervention and comparison households were found in Mali (8% difference) and Burkina Faso (4% difference).
- Large numbers of households in all five counties keep livestock. However, Kenya is the only country where a significant percentage (51% for the intervention sites) were reported as having had produced livestock products, such as milk and eggs. Ethiopia comes a distant second at 15% for the intervention households in particular. Statistically significant differences between the intervention and comparison household with respect to this variable were identified for Ethiopia, Niger and Burkina Faso.
- A number of households were also reported as having had been engaged in off-farm businesses (e.g. running a shop or buying and selling goods) during 2014. For

DryDev's interventions should take into account that many households complement farming with various off-farm livelihood activities.

the intervention sites, the highest was for Kenya at 29%, while the lowest was for Ethiopia at 10%. No statistically significant differences we found between the intervention and comparison households in all five DryDev countries.

- Significant differences across the countries were found with respect to engagement in casual labour. This is as high as 39% in Kenya and as low as 1% in Burkina Faso.
- Kenyan households are engaged in both unskilled and skilled formal paid work to a significantly greater extent than their counterparts in the other four countries, at 27% and 13%, respectively. However, 15% of the intervention households in Burkina Faso were reported to have been engaged in unskilled formal work, against 10% in the comparison sites—a difference that is highly statistically significant.

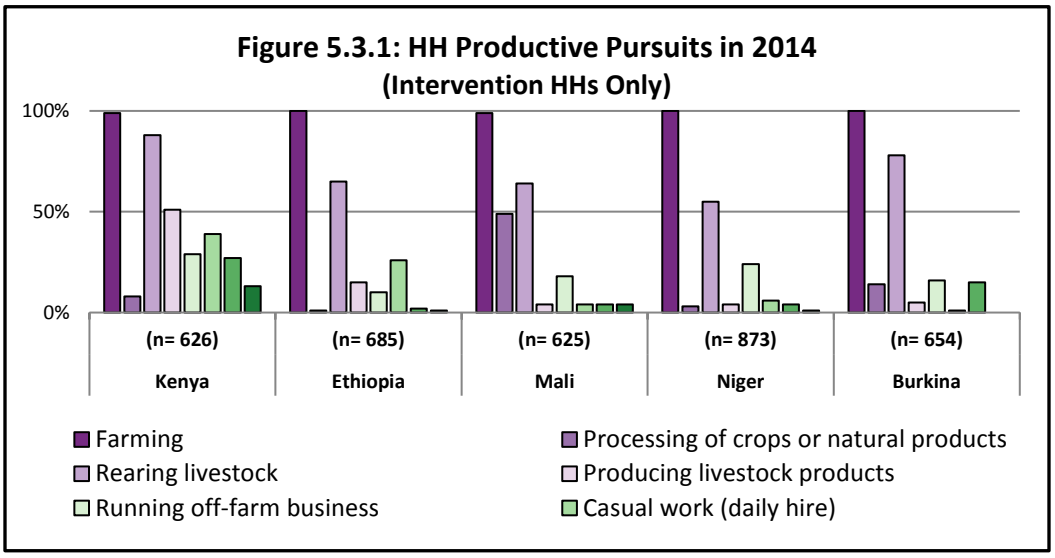


Table 5.3.1: HH Productive Pursuits in 2014 (Proportions): Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Farming	0.99	0.99	0.0009	1.00	1.00	-0.0029	0.99	1.00	0.0052*	1.00	0.98	0.012***	1.00	1.00	-0.00024
Processing of crops	0.08	0.07	-0.0035	0.01	0.00	0.0071	0.49	0.57	0.077***	0.03	0.03	0.0040	0.14	0.12	0.015
Rearing livestock	0.88	0.89	0.0078	0.65	0.63	0.018	0.64	0.72	0.074***	0.55	0.53	0.029	0.78	0.74	0.039*
Livestock products	0.51	0.50	-0.016	0.15	0.11	0.048***	0.04	0.05	0.0077	0.04	0.02	0.015**	0.05	0.02	0.032***
Off-farm business	0.29	0.28	-0.0057	0.10	0.11	-0.0094	0.18	0.20	0.019	0.24	0.26	-0.022	0.16	0.15	0.0039
Casual work	0.39	0.39	-0.0023	0.26	0.25	0.0058	0.04	0.05	0.00034	0.06	0.06	-0.00022	0.01	0.00	0.0081*
Unskilled paid work	0.27	0.26	-0.011	0.02	0.02	-0.0019	0.04	0.03	-0.013	0.04	0.04	0.0039	0.15	0.10	0.046***
Skilled paid work	0.13	0.14	0.016	0.01	0.01	0.0034	0.04	0.02	-0.019**	0.01	0.01	-0.00030	0.00	0.01	-0.0036
Sample size	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01

6. Farming

6.1 Farm Land Holdings

Table 6.1.1 presents statistics for the intervention and comparison households residing in DryDev's impact study sites on average agricultural land holding size, as well as the average hectares of land farmed in 2014 overall and the average hectares irrigated more specifically. As is clear, there is significant variation across the five countries. This variation is displayed visually by Figure 6.1.1's horizontal box plots[4], which show the distribution of hectares of land farmed in 2014 by country. The area of land farmed in 2014 is considerably lower in the two East African counties compared with the three Sahelian countries. Mali is clearly an exception in the Sahel as well, both in terms land area farmed and variation with respect to this variable. The average size of land farmed in 2014 is more than double that of Niger and Burkina Faso and over seven times larger than that of the two East African countries.

Mali is a clear outlier for both land holding size and variation in land holding size.

Other noteworthy observations include:

- The average area under irrigation in 2014 was much higher in Mali and Niger, with Kenya being lowest by a large margin.
- In Mali, statistically significant differences between the households of the intervention and comparison sites exist for all the three variables presented in Table 6.1.1. The intervention households own more farm land and farmed more in 2014, but the comparison households reported having had irrigated a greater area of land during this same year. This was also the case in Ethiopia.
- Ethiopia is the only country where the average size of land farmed in 2014 is greater than the average size of farm land households own. This is likely because more households in this country rent land to farm than in the other countries.

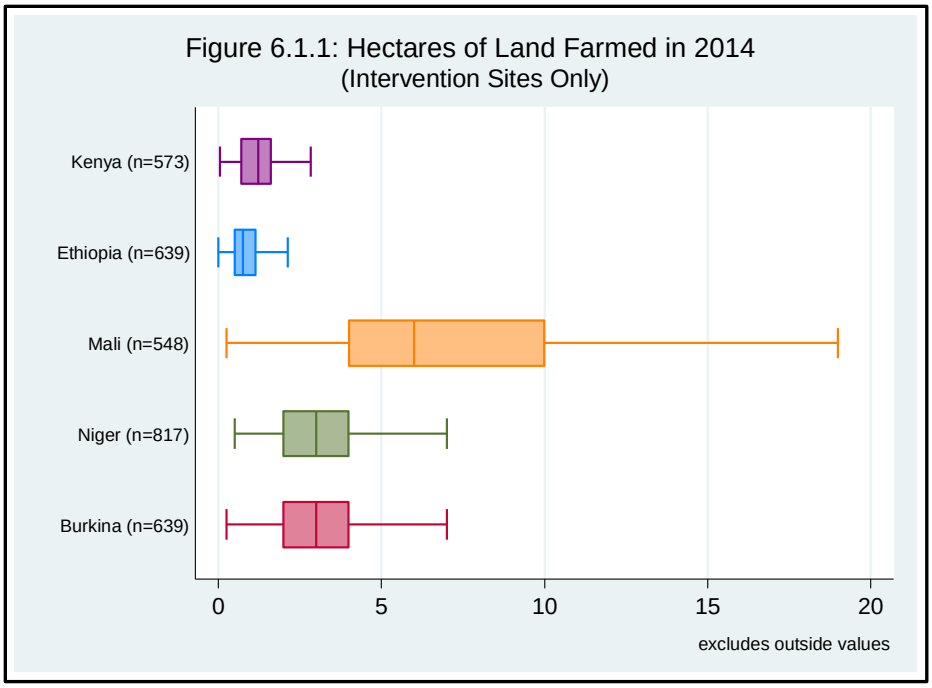
Table 6.1.1: Farm Land Characteristics (Averages): Intervention & Comparison Sub-watersheds

	Kenya			**Ethiopia**			**Mali**			**Niger**			**Burkina Faso**		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Ha. of farming land	1.775	1.747	0.028	0.72	0.70	0.014	9.85	8.65	1.196***	3.91	3.71	0.2013	3.85	4.09	-0.246
Sample size	**619**	**785**	**1404**	**672**	**847**	**1519**	**579**	**825**	**1402**	**862**	**1084**	**1946**	**605**	**716**	**1321**
Ha. farmed in 2014	1.356	1.321	0.0350	0.87	0.83	0.042	8.10	7.07	2.843***	3.58	3.48	0.0935	3.31	3.10	0.212*
Sample size	**573**	**746**	**1319**	**639**	**818**	**1457**	**548**	**790**	**1338**	**817**	**1055**	**1864**	**639**	**753**	**1392**
Ha irrigated (2014)	0.0014	0.0016	-0.000	0.058	0.077	-0.020**	0.21	0.37	-0.164**	0.251	0.220	0.0304	0.09	0.07	0.020
Sample size	**574**	**748**	**1322**	**637**	**818**	**1455**	**549**	**790**	**1339**	**819**	**1053**	**1864**	**636**	**751**	**1387**

* p<0.1, ** p<0.05, *** p<0.01

[44] From left to right, the first whisker to the box represents the first quartile (25th percentile), the start of the box to the median (middle line) represents the second quartile (50th percentile), the median to the end of the box represents the third quartile (75th percentile), and the end of the box to the end of the last whisker is the fourth quartile (100th percentile). However, for ease of presentation, extreme (outside) values are excluded from the presentation.

Significantly less land was farmed in 2014 in the two East African countries vis-à-vis their counterparts in the Sahel.



6.2 Crop Production and Sales Estimates

One of DryDev's key objectives is to increase the sustained production and marketing of particular agricultural crops for which each targeted site has a comparative advantage in producing. To capture data on baseline crop production levels, the interviewed farmers were asked: (a) the specific crops their households grew in 2014; (b) the quantity of these crops harvested and their cash value at the time of harvest (i.e. farm gate prices); (c) the expenses incurred in producing and/or marketing each crop: and, finally, (d) the quantity sold, if any.

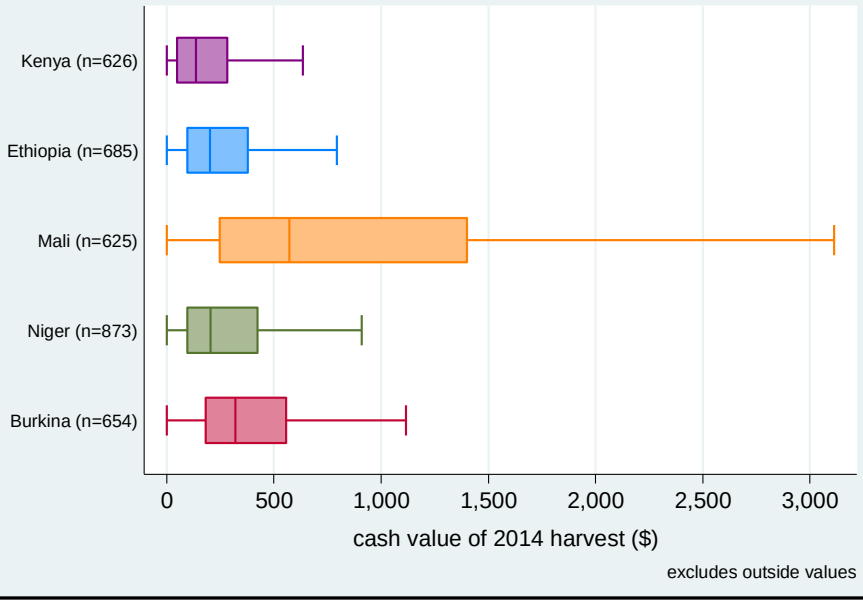
Rather than analysing results for each specific crop, the data were aggregated for all crops to generate four variables: (1) gross harvest value, i.e. the total cash value of all crops each household harvested in 2014 at the time of their harvest; (2) net harvest value, i.e. the total cash value of all crops harvested in 2014 minus all relevant expenses (e.g. fertilizer, pesticides, labour, and transport); (3) gross crop sales, i.e. the gross amount received from all crops harvested and sold in 2014; and (4) net crop sales, i.e. cash received from all crops harvested and sold in 2014 minus all expenses incurred to produce and/or market them.

Table 6.2.1 presents the average and median values of these four variables for the sampled households in the intervention and comparison sites, as well as the differences between these two groups. Figure 6.2.1 and Figure 6.2.2 present box plots to visually illustrate the distribution for two of these variables (gross harvest value and gross crop sales) for households in the intervention sites only. An examination of both the Table 6.2.1 and these boxplots clearly reveals that levels for all four variables are low for most of

households. However, Mali stands out from the other countries, with many households better off with respect to all four variables. Nevertheless, the Mali boxplots indicate that there is significant variation among the participating households. For the intervention sites, for example, the gross cash value and gross sales for 25% of the households in the intervention sites was under $300 and $20, respectively. Indeed, both the gross and net crop sales are very low in all five countries, particularly in relation to their median values, with these being zero for Kenya, Ethiopia, and Niger.

The cash value of the crops harvested in 2014 and revenue resulting from their sale appears to be very low for the vast majority of households in all the five countries.

Figure 6.2.1: Gross $ value of 2014 harvest (Intervention sites only)



It is noteworthy that the patterns of the boxplots for the gross value harvest indicator (Figure 6.2.1) resembles that of the box plots for the hectares of land farmed in 2014 (Figure 6.1.1). One possible explanation, then, for why the cash value of harvested crops is significantly higher for Mali is simply because households in this country's targeted sites, on average, cultivate more land. This raises a key question: To what extent is farm land holding size a factor that influences crop productivity in the DryDev sites? While a simple correlation between farm landholding size and the cash value of crops harvested is insufficient to evidence a causal relationship (i.e. one or more other factors associated with both could be reasonable), its absence would indicate that such a relationship is unlikely.

Table A3 in Annex 3 presents results of several statistical tests on the extent to which land cultivated in 2014 and the gross cash value of crops harvested in this same year are associated. Unsurprisingly, the tests reveal that these two variables are highly associated in all five countries. In addition, grouping the households into four levels of landholding size[5] and implementing tests for linear trend reveal that the association is linear and

[5] Such levels were constructed by grouping the households into four even groups by country according to the size of land each reportedly farmed in 2014.

monotonic; that is, the cash value of crops harvested generally increases to the same extent with each subsequent level of landholding size. This is visually illustrated by the landholding level specific boxplots presented in Figure 6.2.3. Given that households with relatively smaller farm landholdings produce significantly less than their larger landholding counterparts, it likely that the agricultural options for these households need to be tailored accordingly, e.g. by supporting them to produce higher value/yielding and/or less "land hungry" commodities.

While the estimated cash value of crops harvested in 2014 are clearly low, an equally grave cause for concern is that large numbers of households either did not sell any of this produce or, if they did, earned very little from doing so.

Figure 6.2.2: Gross Crop Sales ($) in 2014 (Intervention Sites Only)

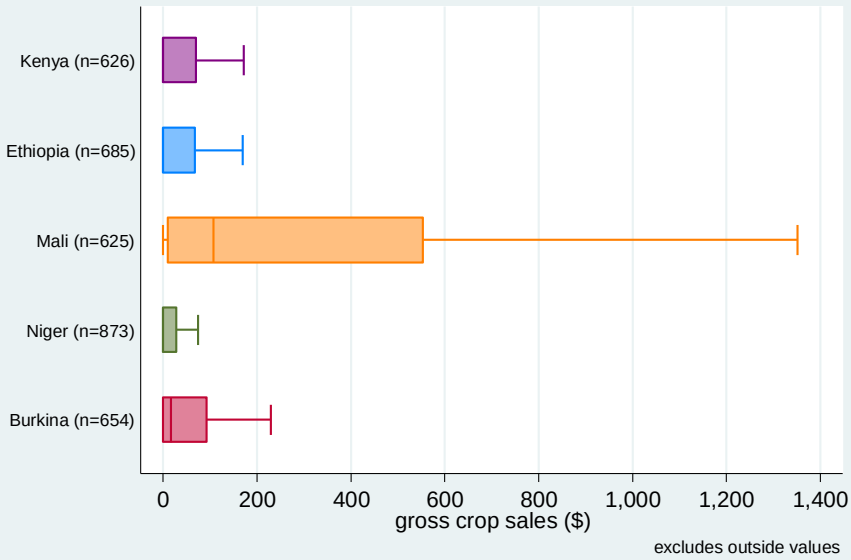


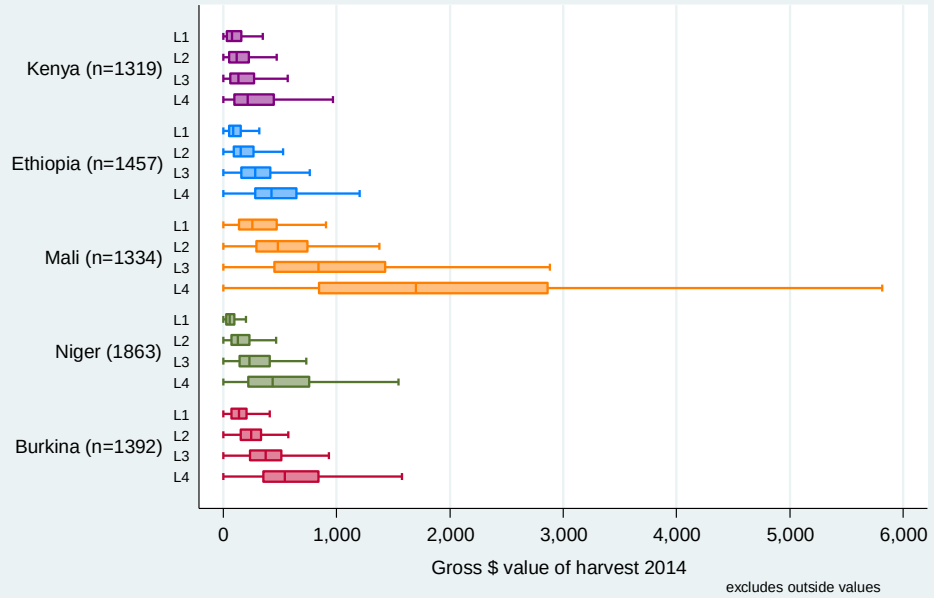
Table 6.2.1: Agriculture—mean ($\bar{x}$) & median ($\tilde{x}$) differences in USD: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Gross harvest value (total cash value of all crops harvested)															
$\bar{x}$	338.68	289.28	49.41	366.73	308.60	58.12	1249.28	1089.33	159.96	409.98	394.35	15.63	457.23	411.72	45.51
$\tilde{x}$	135.89	131.13	4.63	201.26	222.55	-21.29	570.18	637.55	-64.084	205.40	200.82	4.231	319.70	274.41	46.00
Net harvest value (total cash value of all crops harvested minus expenses)															
$\bar{x}$	246.72	204.61	42.11	299.10	249.62	49.48	1013.76	921.06	92.706	359.62	351.81	7.794	397.59	356.66	40.94
$\tilde{x}$	82.55	79.17	3.53	149.98	164.49	-14.51	448.42	506.92	-61.619	187.32	183.13	4.108	282.74	230.04	52.75
Gross crop sales (gross cash received from all crops sold)															
$\bar{x}$	107.26	116.91	-9.65	67.49	84.70	-17.21	602.78	396.85	205.93	103.99	117.04	-13.06	83.35	66.99	16.36
$\tilde{x}$	0.00	4.78	-4.90	0.00	19.35	-19.35	106.81	123.24	-16.432	0.000	0.000	0.000	16.23	6.408	10.02
Net crop sales (cash received from all crops sold minus expenses incurred to produce them)															
$\bar{x}$	89.71	94.90	-5.19	58.84	75.52	-16.68	472.07	301.89	170.18	89.40	103.68	-14.28	73.00	55.98	17.02
$\tilde{x}$	0.00	0.58	-.784	0.00	12.86	-12.86	82.16	80.12	1.888	0.000	0.000	0.000	2.90	4.11	9.037
n	**626**	**802**	**1428**	**685**	**881**	**1566**	**624**	**862**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

The more land a household has, the greater the cash value its harvest is likely to be. Well devised options conducive for households with little land are critical to generate inclusive outcomes and impacts.

Figure 6.2.3: Gross Cash Value of 2014 Harvest by Level of Landholding Size
(Intervention and Comparison Sites)



7. Poverty Status

7.1 Household Consumption Expenditure

Measuring household wealth or socioeconomic position in low and middle income countries is not straightforward, particularly in rural areas where respondents tend to be self-employed. Self-reported measures of total income are unreliable, given the wide variety of endeavours such populations engage in to generate income and meet their consumption needs more generally.[6] However, given that there is a widely recognised and strong association between household income and consumption,[7] one popular proxy measure used by the World Bank and other international institutions is household consumption expenditure.[8] It is through such data that the percentages of households living above and below the poverty line are estimated.

To capture these data, several modules were incorporated into the household survey. The respondents were asked what types of food they consumed over the previous seven day period, as well as the particular quantities. The quantities of each food item consumed were then converted into a monetary value. This was done by asking the respondent how

[6] Morris, Saul, Calogero Carletto, John Hoddinott, and Luc J. M, Christianensen. (1999) *Validity of Rapid Estimates of Household Wealth and Income for Health Surveys in Rural Africa: FCND Discussion Paper No. 72*. Washington: International Food Policy Research Institute.

[7] See Gujarati, Damodar N. (2003) *Basic Econometrics: Fourth Edition*. New York: McGraw Hill.

[8] Deaton, A and S. Zaidi. (2002) "Guidelines for constructing consumption aggregates for welfare analysis," Working Paper No. 135. The World Bank, Washington, D.C.

much was paid for the food item in question or, if the food item was sourced through the household's own production, how much it would have cost if it was purchased from the local market. The respondents were also asked how much they spent on particular non-food items and services from a detailed list, such as soap, toothpaste, and minibus fares, over the past four weeks (regular non-food expenditure). Finally, they were asked about particular "big ticket" expenditures over the previous 12 months from another pre-defined list, such as school and healthcare expenses, clothes, and home repair, over the last 12 months (non-regular non-food expenditure).

Given that households in DryDev's sites earn income from multiple sources—coupled by the fact that they produce much of the food they consume—the consumption expenditure was one key measure used to ascertain poverty status.

The basic per capita measure was calculated as follows for each household:

- The weekly cash value of each food item consumed during the past seven days were added together and divided by seven, thereby estimating the daily cash value of food consumed by the household.
- Household expenditure on items from both the regular monthly non-food expenditure list and annual non-food expenditure list were added together and divided by 30 and 365, respectively, thereby estimating the household's average daily expenditure on regular and non-regular non-food items.
- The daily consumption expenditure estimated for food and the regular and non-regular non-food items were then added together and converted into US dollars, while adjusting for purchase power parity (PPP).[9]
- Finally, to derive each household's per capita consumption expenditure, its PPP adjusted dollar value was divided by the number of its members (household size), with another adjustment being made for assumed lower consumption among children and economies of scale.[10]

Figure 7.1.1 presents horizontal box plots for the resulting variable by country. Table 7.1.1 complements by presenting the average and medium values for both the intervention and comparison households, as well as the differences between the two. The latter also displays figures of this variable placed on a logarithmic scale (to normalize the distribution and reduce the influence of outliers); the values prior to adjustment for household size; and the proportion of total household expenditure on food items. Table 7.1.1 and Figure 7.1.3 further present this variable in two binary forms, representing the per capita USD $1.90 poor and USD $1.25 ultra-poor cut-offs. It is clear that Kenya is better off than the other countries, with Niger and Burkina Faso being the worst off.

However, recall both that the household size differs considerably across the five countries and household size is used to construct the per capita consumption expenditure indicator.

[9] Adjusting to PPP was undertaken to take into account each country's idiosyncratic purchasing power, i.e. the quantity of currency required to purchase a given basket of goods and services. The PPP conversion rates used were taken from the World Bank's website: http://data.worldbank.org/indicator/PA.NUS.PPPC.RF

[10] While dividing the above by household size as the overall denominator is recommended in the literature, it is considered important to avoid underestimating expenditure for larger sized households relative to their smaller counterparts. A recommended formula for computing household size for this purpose is: HH size $= (A + \alpha K)^{\theta}$ where *A* is number of adults in the household; *K* is the number of children; α is the cost of a child relative to an adult; and θ adjusts for economies of scale. For low income countries, it is recommend that α be set at .25 or .33 and θ be set at .9. See: Deaton, A and S. Zaidi. (2002) "Guidelines for constructing consumption aggregates for welfare analysis," Working Paper No. 135. The World Bank, Washington, D.C.

It is therefore useful to examine how sensitive the results are to such variation in household size. Figure 7.1.2, therefore, presents box plots for estimated consumption expenditure prior to adjusting for household size. The relative differences among the most of the countries appear similar. However, in Burkina Faso, the level of per household consumption expenditure is now both above that of Niger and comprises significantly greater variability than before.

Households in Kenya sites are generally better off in relation to consumption expenditure, but there is significant variability among household of all countries.

Figure 7.1.1: Daily Household Consumption Expenditure Per Capita (USD PPP)
(Intervention Sites Only)

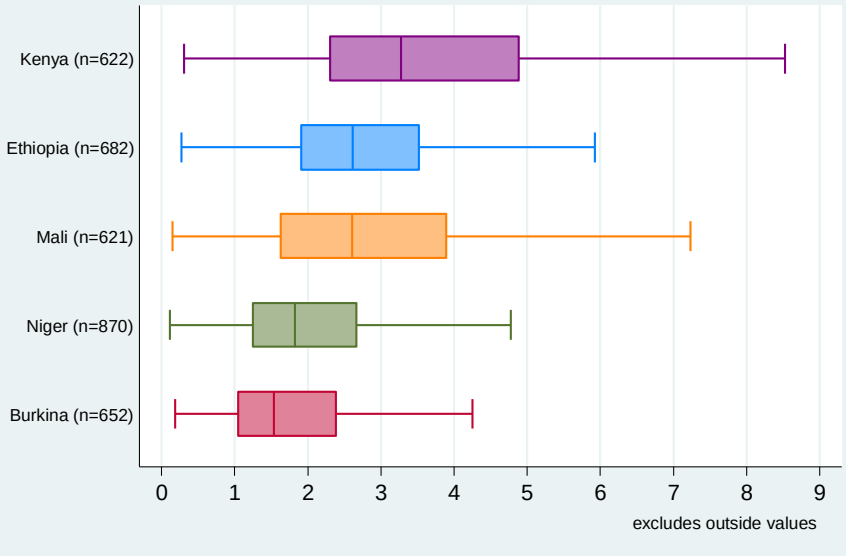
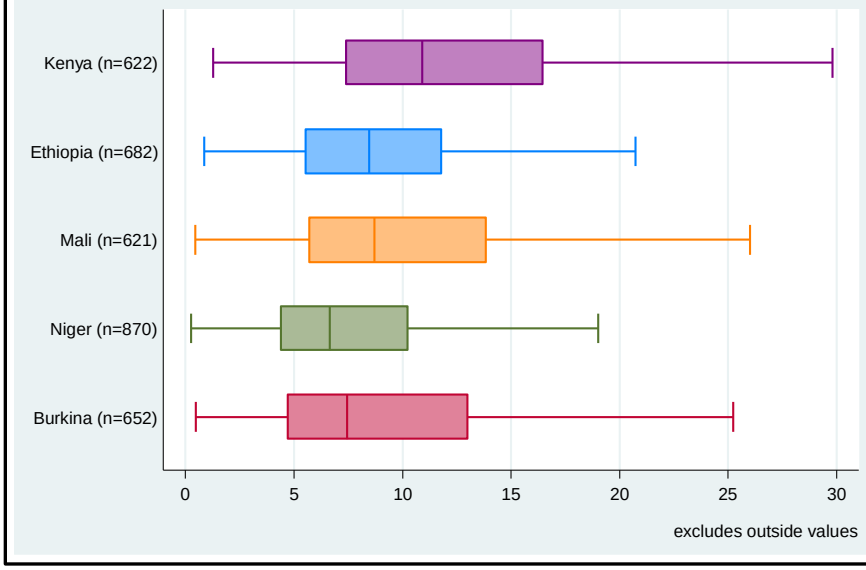


Figure 7.1.2: Daily Household Consumption Expenditure (USD PPP)
(Intervention Sites Only; Not Adjusted for Household Size)



It is further noteworthy that no statistically significant differences were found for any of the average and medium values of the various manipulations of the consumption

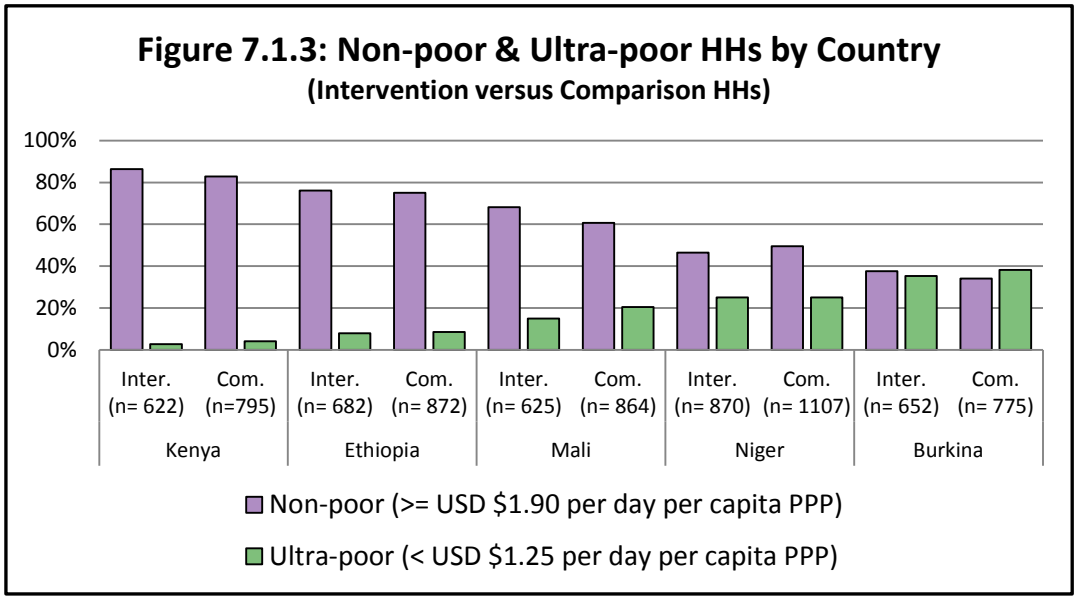
expenditure data in all five countries, save for Burkina Faso with respect to household consumption expenditure unadjusted for household size. (Incidentally, the statistical significance of this difference disappears after controlling for household size.) The differences for Mali also stand out as being significantly large. The reason why these differences are statistically insignificant is largely because the standard errors for this variable (as well as all other outcome and impact indicators in this report) were intentionally clustered at the sub-watershed level. Doing this is recommended in the literature because this is the equivalent of the "unit of assignment" in a randomized control trial, which DryDev's quasi-experimental impact evaluation design is attempting to mimic. For Mali, it is clear that a household's poverty status and its respective sub-watershed are significantly correlated. This is also true for the four other countries.

Table 7.1.1: Household Consumption Expenditure Per Capita per Day in USD Purchase Power Parity (PPP)—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Daily HH Consumption Expenditure Per Capita (USD PPP)															
$\bar{x}$	4.651	4.216	0.435	3.054	3.066	-0.0122	3.306	2.997	0.3090	2.250	2.389	-0.1386	1.982	1.825	0.160
$\tilde{x}$	3.276	3.083	0.198	2.626	2.713	-0.0828	2.609	2.268	0.3416	1.826	1.885	-0.0536	1.534	1.448	0.087
Daily HH Consumption Expenditure Per Capita (PPP) – logarithmic scale (to normalize distributions & downplay influence of outliers)															
$\bar{x}$	1.268	1.195	0.073	0.9637	0.9582	0.006	0.928	0.815	0.117	0.606	0.620	-0.0135	0.476	0.405	0.071
$\tilde{x}$	1.187	1.126	0.062	0.9655	0.9981	-0.034	0.959	0.825	0.140	0.602	0.634	-0.0288	0.428	0.370	0.058
Daily HH Consumption Expenditure (USD PPP) – unadjusted for household size															
$\bar{x}$	15.873	14.169	1.704	9.604	9.681	-0.077	12.228	10.863	1.365	8.197	8.978	-0.781	10.589	8.970	1.620*
$\tilde{x}$	10.904	10.231	0.692	8.470	8.367	0.103	8.691	8.460	0.235	6.650	7.050	-0.393	7.451	6.992	0.461
Proportion of non-poor HHs (>=USD $1.90 per day per capita [PPP])															
$\bar{x}$	0.863	0.828	0.036	0.761	0.750	0.014	0.681	0.607	0.074	0.464	0.495	-0.0307	0.376	0.341	0.035
Proportion of Ultra Poor HHs (< USD $1.25 per day per capita [PPP])															
$\bar{x}$	0.027	0.041	-0.014	0.080	0.085	-0.005	0.150	0.205	-0.056	0.251	0.251	0.0000	0.353	0.382	-0.029
Proportion of HH Expenditure on Food															
$\bar{x}$	0.511	0.513	-0.003	0.651	0.666	-0.015	0.626	0.649	-0.0223	0.676	0.672	0.0045	0.552	0.561	-0.009
$\tilde{x}$	0.534	0.528	0.005	0.672	0.679	-0.007	0.660	0.676	-0.0157	0.693	0.689	0.0032	0.571	0.563	0.007
n	**622**	**795**	**1417**	**682**	**872**	**1554**	**621**	**857**	**1478**	**870**	**1107**	**1977**	**652**	**775**	**1427**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

The prevalence of consumption poverty appears greatest in the Burkina Faso and Niger sites.



7.2 Household Asset Wealth

As explained above, a household's wealth status in low and middle income countries is often measured using consumption expenditure data. An alternative way is by analysing the assets a household owns and other wealth indicators, e.g. the material of a household's roof and/or floor. Consumption expenditure data are generally recognised as being more sensitive to recent changes in household income, while asset based measures typically reflect a household's more established wealth status.[11] This is because increases in household income generally need to be sustained for some time before they translate into significant increases in household asset ownership. In other words, after a household's income has been sustainably increased, it will take time for it to accumulate assets, make improvements to the home, and so forth.

Poverty status was also assessed by analyzing data on household ownership of over 90 asset items and other wealth indicators.

During the survey, respondents were asked whether they or anyone in their household currently owns particular assets and other wealth indicators from long list of over 90 items. The inter-item correlation among these assets was subsequently tested.[12] Assets that were not sufficiently correlated with the main pool of assets were dropped, leaving streamlined set of household wealth indicators. The inter-item correlation (measured with Cronbach's alpha statistic) among these indicators varies by country (0.901 for Kenya; 0.72 for Jarso District, Ethiopia; 0.75 for Samre District, Ethiopia; 0.82 for Mali; 0.76 for Niger; and 0.84 for Burkina Faso).[13]

A wealth index for each country (or district for Ethiopia) was constructed from a tetrachoric matrix, which is used to measure the degree to which binary variables are statistically associated. Principal component factor analysis was then run on this matrix. This is a data reduction technique that was used to narrow in on the variation in household asset ownership, which is assumed to represent wealth status. The more an asset is correlated with this variation, the more weight it is given. Hence, each household's weighted index score is determined by both (a) the number of assets it owns; and (b) the particular weight assigned to each asset. This enables the *relative* wealth status between defined groups of households to be compared.

The first section of Table 7.2.1 presents a comparison between the intervention and comparison households of each county. Note that this is index is a relative (rather than absolute) measure, so comparisons are only valid between the intervention and comparison groups, rather than across countries. Note that the only statistically significant differences are for the median values of this variable for Niger and Burkina

---

[11] Moser, C. F. 2007. *The Construction of an Asset Index: Measuring Asset Accumultion in Ecuador*. Washington: The Brookings Institution.

[12] When items are used in a scale or index, they should all measure the same underlying latent construct (e.g. household wealth status). The items, therefore, must be significantly correlated with one another. Cronbach's alpha is a measure of this inter-item correlation. The more the variables are correlated, the greater is the sum of the common variation they share. If all items are perfectly correlated, alpha would be 1 and 0 if they all were independent from one another. For comparing groups, an alpha of 0.7 or 0. 8 is considered satisfactory. See: Bland, M. J. & Altman, D. G. 1997. Statistics notes: Cronbach's alpha. *BMJ,* 314, 572.

[13] For Ethiopia, the analysis was done separately for each of the two districts that make up this country's impact study area for the DryDev programme. This is because these districts are located in two district regions and socio-cultural, economic, and political settings.

Faso. For Niger, the comparison households are slightly more asset rich, while the opposite is the case for Burkina Faso

Table 7.2.1: Household Asset Wealth—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

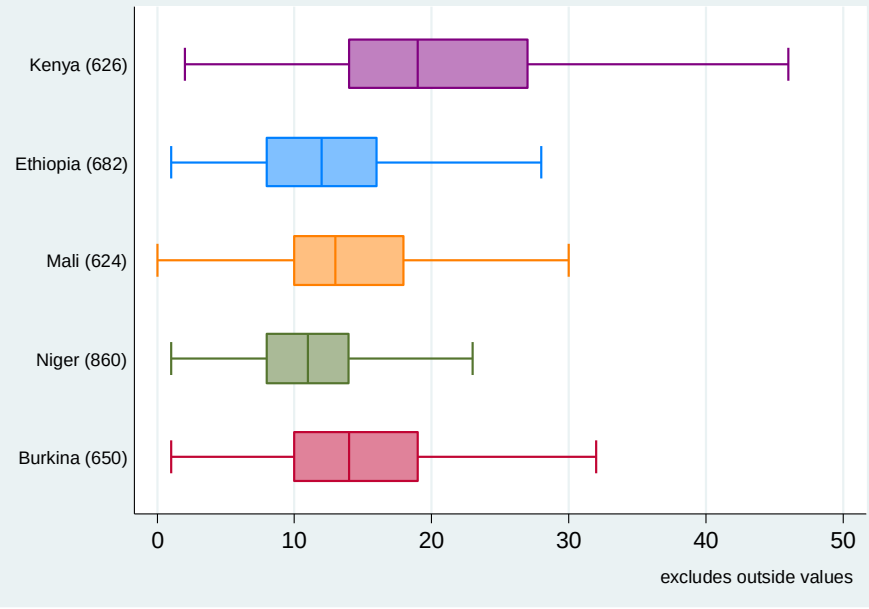
	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Wealth Index (constructed from tetrachoric matrix with principal component factor analysis)															
$\bar{x}$	0.437	0.399	0.0375	0.612	0.609	0.004	0.660	0.731	-0.0708	0.2530	0.2825	-0.0295	0.490	0.436	0.055
$\tilde{x}$	0.358	0.334	0.0248	0.604	0.606	-0.001	0.666	0.748	-0.0828	0.2439	0.2806	-0.0366*	0.449	0.395	0.056*
Wealth Indicator Score (constructed by adding binary wealth indicator scores together)															
$\bar{x}$	20.95	19.67	1.28	12.58	12.47	0.109	13.95	14.84	-0.886	11.35	11.58	-0.226	15.00	13.59	1.402*
$\tilde{x}$	19.00	18.00	1.00	12.00	12.00	0.000	13.00	15.00	-2.000	11.00	11.00	0.000	14.00	13.00	1.000
n	**626**	**802**	**1,428**	**682**	**879**	**1561**	**624**	**860**	**1484**	**860**	**1105**	**1965**	**650**	**769**	**1419**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

The second part of Table 7.2.1 presents wealth indicator scores that were derived simply by adding all the individual binary wealth indicator scores together. Given that the asset lists used for each country were nearly identical, it is possible to compare the resulting wealth scores both between the intervention and comparison household and across the five countries. Figure 7.2.1 presents the resulting scores visually in the form of box plots for the intervention households across the five countries. Consistent with the consumption and expenditure data, Kenya clearly stands out on top followed by Burkina Faso and Mali. The Kenyan intervention sites also display the greatest variation in wealth asset ownership. However, while Burkina Faso is the lowest ranking country for consumption expenditure, it ranks second for asset wealth.

The relative country ranking for Burkina Faso changes from fifth for consumption expenditure to second for asset wealth.

Figure 7.2.1: Wealth Indicator Scores (Intervention Sites Only)

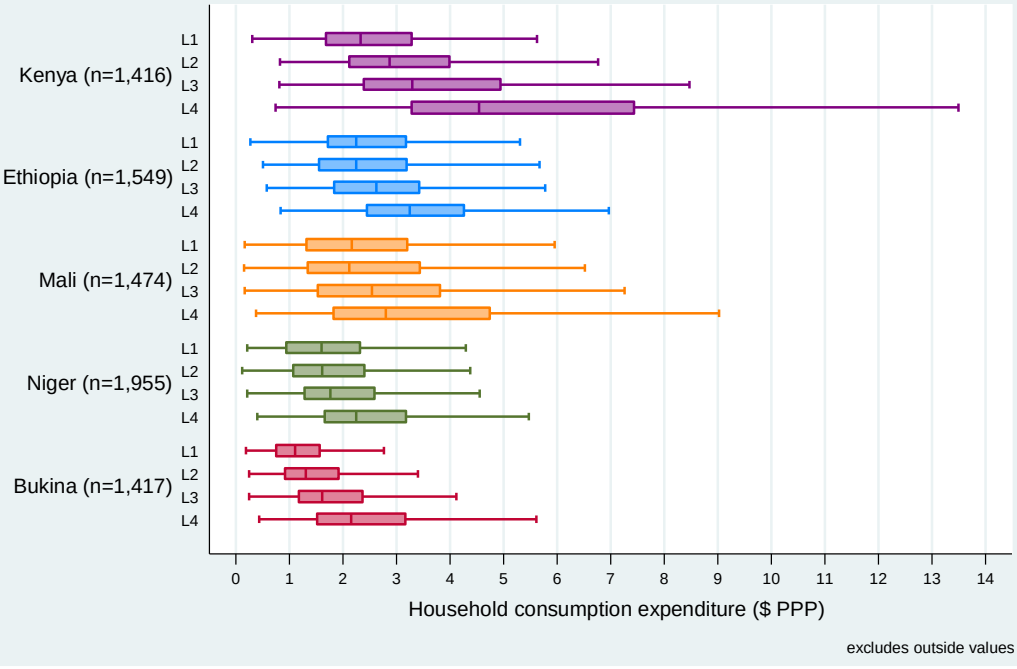


Given that the relative country ranking for the consumption expenditure and asset wealth measures differ, one may question the extent to which the latter is a good proxy for the former. One point to bear in mind (as explained above) is that they are measuring slightly different constructs: the asset index measures longer term wealth status, while the consumption expenditure measure is more sensitive to recent changes in household income and consumption. Nevertheless, further analysis was undertaken to examine the extent to which they are associated. Table A3 2 in Annex 3 presents the results on tests performed to assess the extent to which they are correlated in general and linearly associated in particular. While neither measure perfectly predicts the other, the correlation between the two is highly significant across all countries. Moreover and as is presented visually in Figure 7.2.2, the relationship is linear; households with higher levels of asset wealth are more likely to have higher levels of consumption expenditure.

The association between consumption expenditure and asset wealth is imperfect but linear and highly statistically significant.

Figure 7.2.2: HH Consumption Expenditure by Level of Wealth Indicator Score

(Intervention and Comparison Households)



8. Dietary Diversity

Another key aim of the DryDev programme is to improve household food security. Capturing and analysing data on anthropometric measures, such as weight-for-height, height-for-age, and weight-for-age of under-five children and body mass index (BMI) for adults, is recognized as a valid approach for assessing the nutritional and food security status of a population.[14] However, such measures are costly and time consuming to administer, and, consequently, a number of alternative measures have been proposed. The Women's Dietary Diversity Project (WDDP) was launched, in particular, to address the need for simple, yet valid, measure of women's diet quality, with a specific focus on micronutrient adequacy. This culminated in the development and 'adoption' of the Minimum Dietary Diversity–Women (MDD–W) indicator.[15]

The baseline survey captured data on a new measure for measuring women's micronutrient adequacy.

To capture data on this indicator during DryDev's baseline survey, both the female and male respondents were asked whether they consumed particular food items during the previous day, which fall under the 10 categories presented in Figure 8.1. While this indicator is specifically designed for women, the corresponding survey module was also administered to men.

Figure 8.1: Food Types Consumed by Respondents During Previous Day
(Intervention Respondents Only)

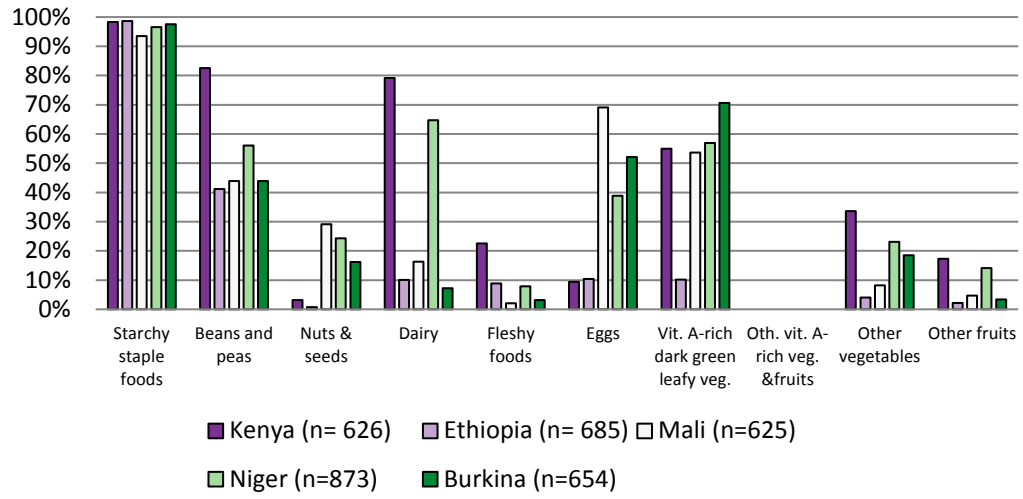


Figure 8.1 presents pooled results for both men and women for each of the 10 food groups by country. Well over 90% of the respondents reported that they had consumed staple carbohydrate foods during the previous day. For the other food groups, there is significant variation across the five countries, however. Kenya, for example, appears to

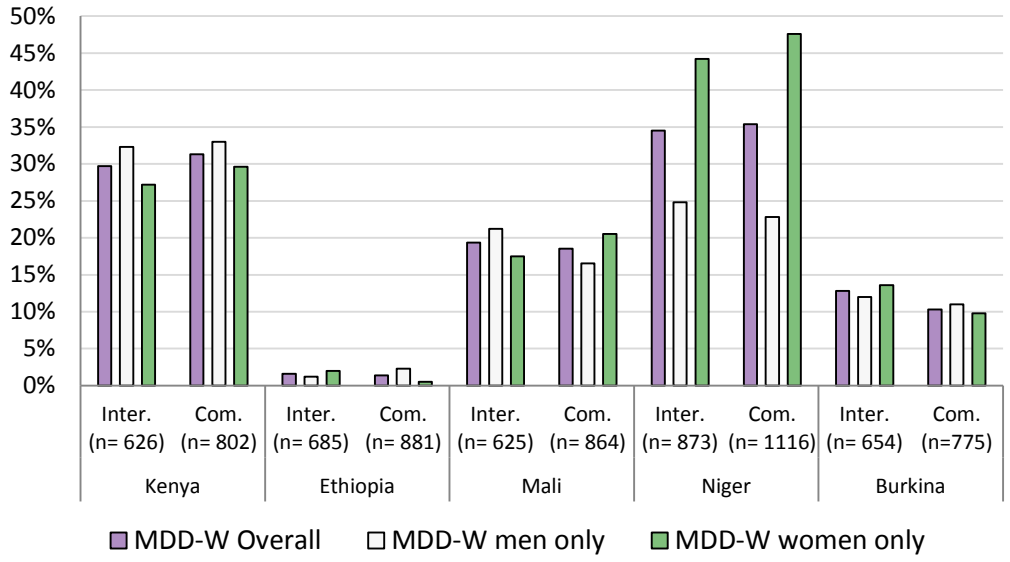
[14] See, for example: WFP. (2005) *A Manual: Measuring and Interpreting Malnutrition and Mortality*. Nutrition Service, World Food Programme, Rome.
[15] See: http://www.fao.org/3/a-i5486e.pdf

be better off in terms of the consumption of protein rich foods, such as beans/peas, dairy products, and animal meat products.

This variation across the five countries is even more pronounced for the binary MDD-W indicator itself, where a respondent was coded with 1 if s/he had reported having had consumed at least five of the 10 food groups during the previous day and 0 if otherwise. Niger is better off overall, but this is only for the female respondents. In fact, this is the only country where there is a large gender-based difference—and this difference is biased in favour of women. However, even within this country, less than half of the women interviewed surpassed MDD-W's binary threshold. It is particularly important to also note that both the interviewed women and men of the Ethiopian sites are significantly worse off in comparison with their counterparts in the other four countries, with very few consuming more than five of the 10 food groups.

Micronutrient adequacy is poor across all countries but is particularly pronounced in Ethiopia and, to a lesser extent, Burkina Faso.

Figure 8.2: Minimum Dietary Diversity-Women (MDD-W) by Sex of Respondent & Country



The MDD-W indicator data were also analysed as a continuous score out of 10. Figure 8.3 presents horizontal box plots for this score by country and by gender. It interesting to observe that the median value for men and women is the same in four out of the five countries, yet the variation around these values differs in three countries. In Ethiopia and Mali, there is less variation for women, while in Burkina Faso it is greater.

Table 8.1 presents more detailed statistics for the MDD-W indicator and its associated raw score out of 10. Note that no statistically significant differences were found between the male and female respondents of the intervention and comparison sites across all five countries.

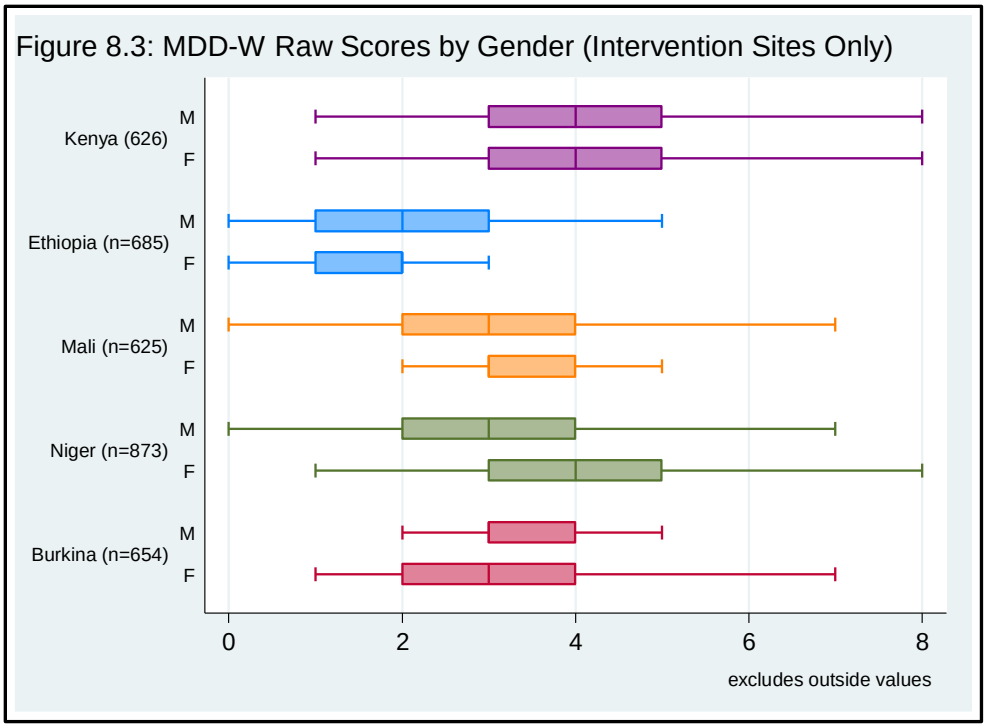


Table 8.1: Minimum Dietary Diversity, Women (MDD-W)—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter	Com	Dif.	Inter	Com	Dif.	Inter	Com	Dif.	Inter	Com	Dif.	Inter	Com	Dif.
MDD-W raw score out of 10 (male & female respondents combined)															
$\bar{x}$	4.02	4.00	0.016	1.86	1.83	0.032	3.20	3.36	-0.158	3.83	3.96	-0.1385	3.13	3.11	0.019
$\tilde{x}$	4.00	4.00	0.00	2.00	2.00	0.00	3.00	3.00	0.00	4.00	4.00	0.000	3.00	3.00	0.000
n	**626**	**802**	**1,428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**
MDD-W raw score out of 10 (male respondents only)															
$\bar{x}$	4.03	3.98	0.051	1.89	1.89	0.004	3.15	3.31	-0.162	3.36	3.54	-0.1800	3.36	3.29	0.0759
$\tilde{x}$	4.00	4.00	0.00	2.00	2.00	0.00	3.00	3.00	0.00	3.00	3.00	0.000	3.00	3.00	0.000
n	**313**	**397**	**710**	**335**	**444**	**779**	**316**	**435**	**751**	**436**	**549**	**985**	**316**	**368**	**684**
MDD-W raw score out of 10 (female respondents only)															
$\bar{x}$	4.01	4.03	-0.018	1.84	1.78	0.062	3.26	3.41	-0.154	4.28	4.37	-0.0849	2.91	2.95	-0.041
$\tilde{x}$	4.00	4.00	0.00	2.00	2.00	0.00	3.00	3.00	0.00	4.00	4.00	0.000	3.00	3.00	0.000
n	**313**	**405**	**718**	**350**	**437**	**787**	**309**	**429**	**738**	**437**	**567**	**1004**	**338**	**407**	**745**
MDD-W binary score--5 or more points out of 10 (male & female respondents combined)															
$\bar{x}$	0.297	0.313	0.016	0.016	0.014	-0.002	0.194	0.185	0.008	0.345	0.354	-0.009	0.128	0.103	0.025
n	**626**	**802**	**1,428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1116**	**1989**	**654**	**775**	**1429**
MDD-W binary score--5 or more points out of 10 (male respondents only)															
$\bar{x}$	0.323	0.330	0.007	0.012	0.023	0.011	0.212	0.166	0.047	0.248	0.228	0.020	0.120	0.110	0.012
n	**313**	**397**	**710**	**335**	**444**	**779**	**316**	**435**	**751**	**436**	**549**	**985**	**316**	**368**	**684**
MDD-W binary score--5 or more points out of 10 (female respondents only)															
$\bar{x}$	0.272	0.296	0.025	0.02	0.005	-0.015	0.175	0.205	-0.030	0.442	0.476	-0.0345	0.136	0.098	0.038
n	**313**	**405**	**718**	**350**	**437**	**787**	**309**	**429**	**738**	**437**	**567**	**1004**	**338**	**407**	**745**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

9. Women's Empowerment in Agriculture Index (WEAI)

In addition to bolstering livelihoods and food security, DryDev is also seeking to empower women and disadvantaged groups. An adapted version of the Women's Empowerment in Agricultural Index (WEAI) was, therefore, administered to both the female and male respondents. The WEAI was developed by the Oxford Poverty and Human Development Initiative (OPHI), the United States Agency for International Development (USAID), and the International Food Policy Research Institute (IFPRI). It is designed to measure the empowerment, agency, and the inclusion of women in the agricultural sector.[16]

The WEAI has become a popular tool for measuring women's empowerment and has undergone several iterations of adaptation and refinement.

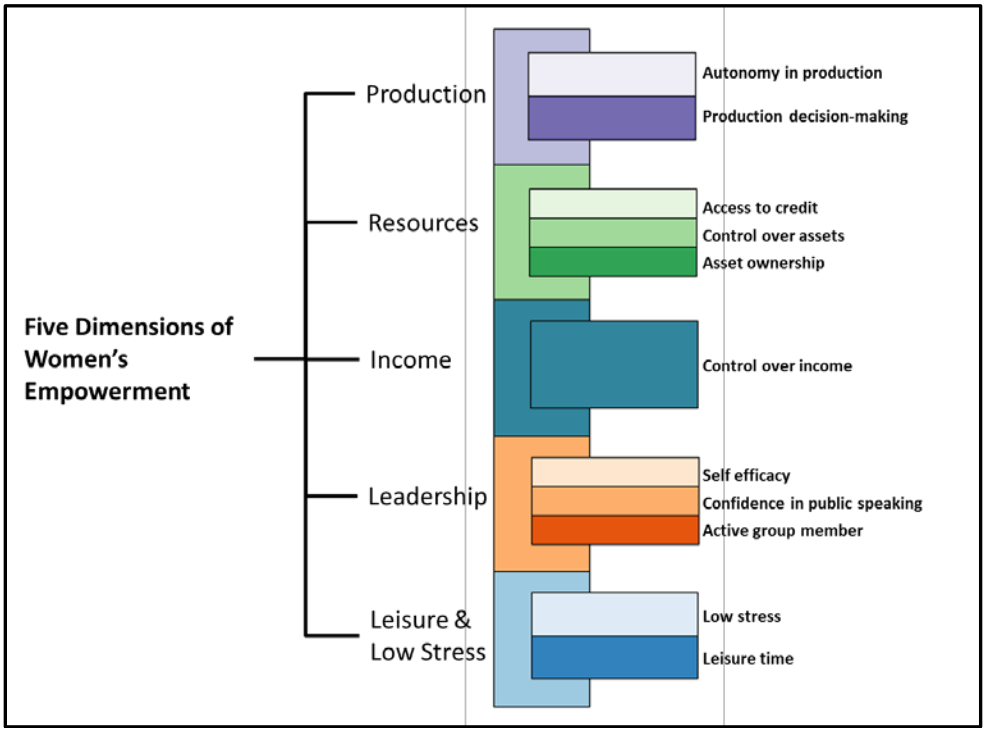


Figure 9.1: WEAI Dimensions and Indicators Used for DryDev's Baseline Survey

The WEAI measures women's empowerment in five dimensions or areas: production, resources, income, leadership, and time use. The original WEAI comprises of 10 indicators that fall under these five dimensions. For the most part, this original framework was followed, albeit with several adaptations. One adaption was in relation to the autonomy in production indicator. In the original WEAI survey, capturing data on this indicator involves asking the respondent their motivation for their actions in four areas of agricultural activity. However, recent reviews of the WEAI have concluded that this particular module is too abstract and have experimented with using vignettes (descriptions of hypothetical farmers) as a substitute. After reading out the vignette, the respondent is asked to report how much they are like the particular character. Vignettes such as these were adapted and used in DryDev's baseline survey.

[16] See: http://www.ophi.org.uk/policy/national-policy/the-womens-empowerment-in-agriculture-index/

Several adaptions to the original WEAI were made, so that it is more amenable to DryDev's operational context.

Another indicator was also added for the leadership dimension—self efficacy. Simply being confident in public speaking and actively participating in groups was considered inadequate to fully capture leadership potential. Being confident in one's ability to achieve personal goals and overcome problems was also considered important. To this end, an internationally recognized module for measuring self-efficacy—the Generalized Self Efficacy Scale[17]—was included in the WEAI module.

The original WEAI also measures the leisure indicator by asking the following question: "How satisfied are you with your available time for leisure activities like visiting neighbours, watching TV, listening to the radio, seeing movies or doing sports?" References to watching TV, seeing movies, and playing sports are likely contextually inappropriate for the DryDev sites. Moreover, this single subjective question is likely inadequate for meaningfully measuring time available for leisure. Consequently, WEAI's 24 hour activity profile exercise to measure the "workload" indicator was maintained but was renamed as the "leisure" indicator. In addition, the Perceived Stress Scale[18] was included in the survey an alternative way of assessing the extent the interviewed respondents perceive themselves as being overburdened. Consequently, instead of the fifth WEIA dimension being Time, it was redefined in the DryDev adapted version as Leisure and Low Stress.

The final adaptation of the DryDev version of the WEAI is how differences between men and women in relation to the index are compared. In some WEAI surveys, both women and men from the same household are interviewed. This enables relative differences between women and men within the same household in relation to the WEAI to be compared and can be used to construct something called the Gender Parity Index (GPI). However, there are two key reasons why both women and men from the same household were not interviewed in DryDev's baseline survey: (1) it was foreseen that there would be difficulties in organizing for both the senior male and senior female of the same household to be interviewed at the same time, with the risk of there being significant missing data; and (2) the DryDev household survey was already long and interviewing both women and men would take considerable time.

Nevertheless, an innovative alternative to compare differences between women and men in relation to the WEAI was pursued. As explained in Subsection 4, this involved randomly selecting whether an active male or active female farmer from each household was to be interviewed. This gender-based random selection process enables statistical differences between women and men in relation to the WEAI to be compared.

The WEAI is a weighted index that ranges from 0 to 1. Each of its constitutive indicators is binary, taking a value of 1 if the respondent scores positively in relation to it and 0 if otherwise. These binary cut-offs are arbitrary but reflect the fact that the respondent must reach a minimum level in order to be given a positive score. The 11 indicators that

[17] Schwarzer, R., & Jerusalem, M. (1995). Generalized Self-Efficacy scale. In J. Weinman, S. Wright, & M. Johnston, Measures in health psychology: A user's portfolio. Causal and control beliefs (pp. 35- 37). Windsor, England: NFER-NELSON.

[18] Cohen, S., Kamarck, T., & Mermelstein, R., (1983) "A Global Measure of Perceived Stress," *Journal of Health and Social Behavior. 24,* 385-396.

make up DryDev's adapted version of the WEAI were all weighted equally within each of the five dimensions, and each of these dimensions was also weighted equally. Annex 3 presents details on how data for each of the 11 indicators was obtained from the interviewed respondents, as well as the specific binary cut-offs that were used and the specific weights applied.

The WEAI is based on a weighted index ranging from 0 to 1. Individuals scoring 80% or more on this index are considered empowered and are, therefore, given the maximum score of 1.

The WEAI is calculated using the Alkire Foster (AF) method.[19] Here, the weighted indicators are added together to derive a "counting vector" or what is referred to in this report as WEAI's base index. Individuals who reach a particular cut-off on the base index are "discounted". For the WEAI, the scores of individuals that reach 80% or more on the base index are replaced with the maximum score of 1. This increases the sensitivity of the WEAI (and other indices using the AF method) to individuals reaching the threshold. The WEAI, for example, will always be higher than the base index provided that both (a) at least one individual surpasses the 80% threshold; and (b) at least one individual does not obtain the maximum possible score of 1 on the base index.

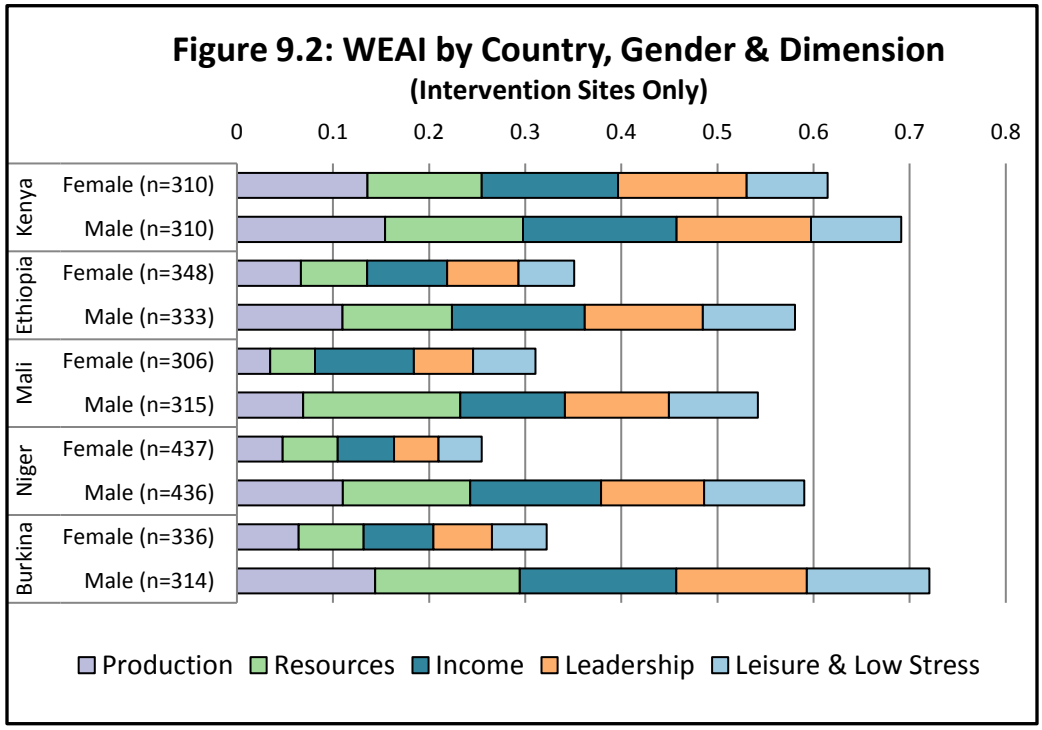


Figure 9.2 presents the baseline results of DryDev's adapted version of the WEAI by country, gender, and each of the five dimensions. For all the countries, save for Kenya, the differences between the interviewed female and male respondents are very significant and, perhaps unsurprisingly, biased towards the latter. The differentials for Burkina Faso and Niger are particularly striking, with the average WEAI score of the male respondents being over twice that of the female respondents. In addition, the Kenya

[19] See: http://www.ophi.org.uk/research/multidimensional-poverty/alkire-foster-method/

female respondents scored significantly better in comparison with their counterparts in the other four countries, while the female respondents from Niger scored the lowest.

The differences between women and men in relation to the WEAI are very large in four out of the five DryDev countries.

Figure 9.3: WEAI by Country, Gender & Weighted Indicator (Intervention Sites Only)

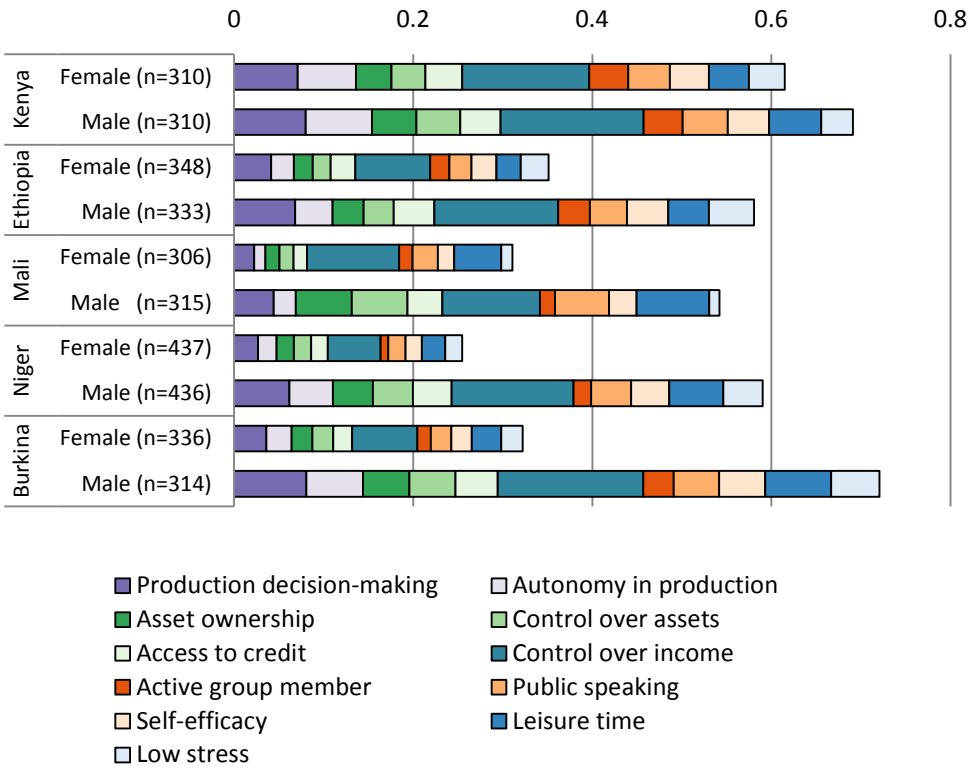


Figure 9.3 presents the WEAI again, but this time showing the average contribution of each of the weighted indicators. It is important to note that the indicators cannot be compared with each other within a particular group, particularly those that are weighted differently. However, the same weighted indicators can be compared across the groups, and the variability here is noteworthy. In Mali, for example, there are relatively lower levels of empowerment among women in the production and resources dimensions. However, these same women are doing relatively well with respect to the control over income and leisure indicators.

Figure 9.2 and Figure 9.3 present average statistics for each country and gender groups. Figure 9.4 complements this with the presentation of horizontal box plots, so that the extent of variation in the WEIA within these same groups can be examined. It is clear that this variation is significant, and the differences between women and men within each country appear as equally, if not more, pronounced.

Viewing the WEAI as box plots further illustrates the disparity between women and men, as well as the variation both within and across the five countries.

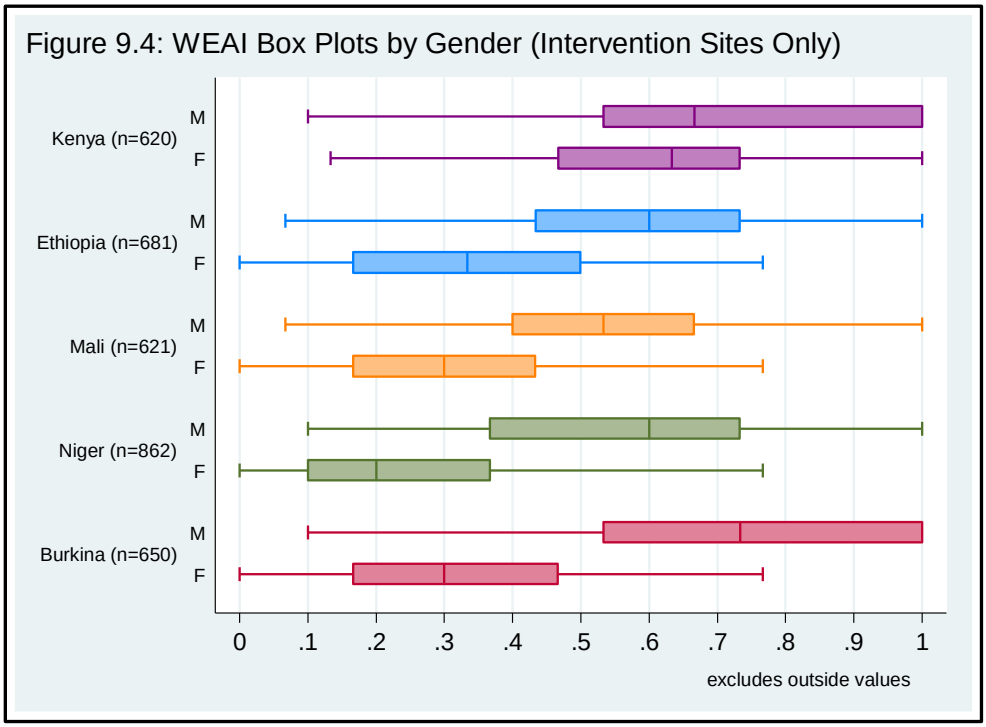


Table 9.1 concludes this section on the WEAI by presenting the mean and median values for DryDev's adapted version of the WEAI, as well the differences between the male and female respondents from the intervention and comparison sub-watersheds. While there are small differences between the intervention and comparison respondents, only one of these is statistically significant (the median values of male and female respondents combined for Mali) and this is only at a 10% level of confidence. Moreover, the difference is driven by the fact that ratio for women and men in both groups is not the same; when a dummy variable for respondent sex is controlled for, the difference is no longer statistically significant.

Table 9.1: Women's Empowerment in Agriculture Index (WEIA)—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
WEIA (male & female respondents combined)															
$\bar{x}$	0.653	0.638	0.015	0.463	0.443	0.020	0.435	0.418	0.0172	0.422	0.423	-0.0011	0.515	0.506	0.009
$\tilde{x}$	0.667	0.633	0.033	0.467	0.433	0.033	0.433	0.366	0.0667*	0.367	0.400	-0.0333	0.500	0.467	0.033
N	**620**	**794**	**1,414**	**681**	**877**	**1558**	**621**	**860**	**1481**	**862**	**1101**	**1963**	**650**	**770**	**1420**
WEIA (female respondents only)															
$\bar{x}$	0.615	0.625	-0.011	0.351	0.350	0.001	0.311	0.324	-0.015	0.255	0.267	-0.0127	0.322	0.310	0.012
$\tilde{x}$	0.633	0.600	0.033	0.333	0.333	0.00	0.300	0.300	000.0	0.200	0.233	-0.0333	0.300	0.300	000.0
N	**310**	**401**	**711**	**348**	**434**	**782**	**306**	**428**	**734**	**433**	**563**	**996**	**336**	**403**	**739**
WEIA (male respondents only)															
$\bar{x}$	0.691	0.651	0.040	0.580	0.535	0.046	0.557	0.511	0.0461	0.590	0.585	0.0048	0.720	0.720	000.0
$\tilde{x}$	0.667	0.667	0.000	0.600	0.533	0.067	0.533	0.500	0.0333	0.600	0.566	0.0333	0.733	0.700	0.033
N	**310**	**393**	**703**	**333**	**443**	**776**	**315**	**432**	**747**	**429**	**538**	**967**	**314**	**367**	**681**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

10. Multidimensional Poverty Index

The MPI has been used in over 100 countries for measuring both income and non-income related manifestations of poverty.

The Alkire Foster (AF) method for formulating the WEAI is also used in a particular approach for measuring multi-dimensional poverty. Also developed by the Oxford Poverty and Human Development Initiative (OPHI), the global Multidimensional Poverty Index (MPI) is designed to complement income-based measures of poverty by also simultaneously capturing several of its other dimensions.[20] Drawing on existing sources of country-level data, it has been applied to over 100 low and middle income countries.

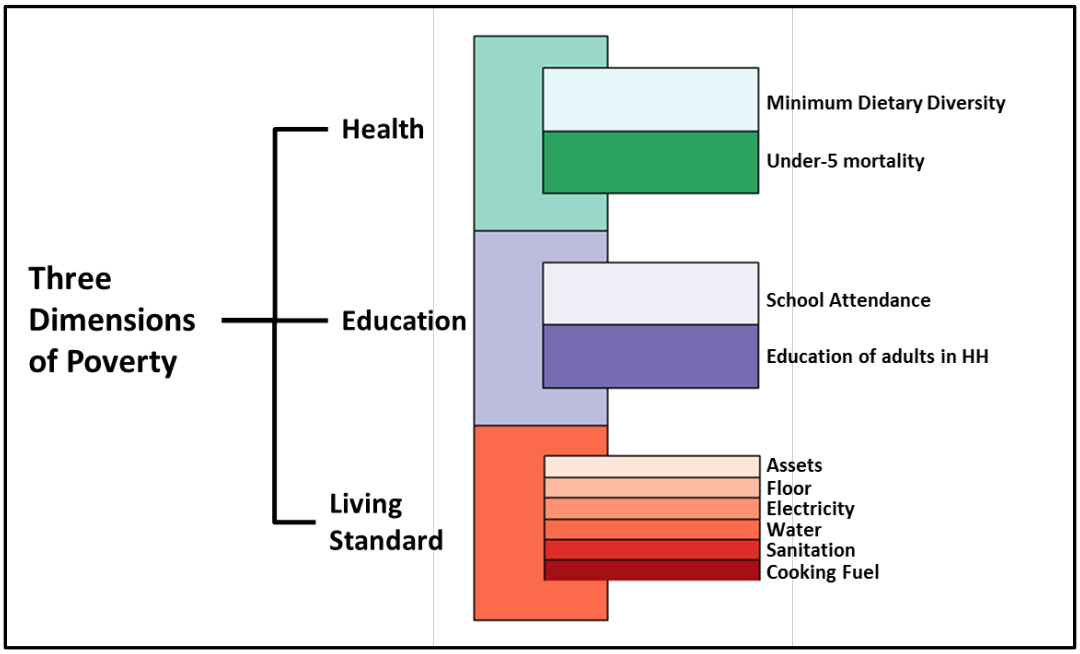


Figure 10.1: Dimensions and Indicators of the Multi-dimensional Poverty Index Used in DryDev's Baseline Survey

Figure 10.1 presents the three dimensions and 10 specific indicators for a slightly adapted version of the global MPI that was used for DryDev's baseline survey. Similar to the WEAI, each of the indicators falling under each of the three dimensions are weighted equally, as are each of these three dimensions. For the purposes of DryDev's baseline survey, there was only one significant modification from the original global MPI. For this global measure, women's body mass index (BMI) is used to inform its nutrition indication. Given that such anthropometric baseline data were not captured by DryDev's baseline survey, the MDD-W binary indicator was used as a substitute. Annex 4 presents specific details on how each of the above indicators was measured, as well as the specific binary cut-offs and weights associated with each. As per the Alkire-Foster method, calculating the MPI involves "discounting". In particular, if an individual or household is deprived on one-third or more of the weighted indicators, the weighted indicator score is replaced with 1, given that the multi-dimensional poverty threshold has been surpassed.

Figure 10.2 presents the baseline results for DryDev's adapted version of the global MPI by country and the specific weighted contribution of each dimension. The index ranges

[20] See: http://www.ophi.org.uk/multidimensional-poverty-index/

Multidimensional poverty is high across all the DryDev impact study area sites. However, Kenya is better off, particular because it is less deprived on the education dimension.

from 0 to 1, with 1 indicating that the multi-dimensional poverty threshold (one-third of the weighted indicators) has been surpassed. The Kenyan intervention and comparison sites are clearly better off in relation to this indicator than those of the other four countries. The dimensional breakdown reveals that this is primarily because they are less deprived on the education dimension.

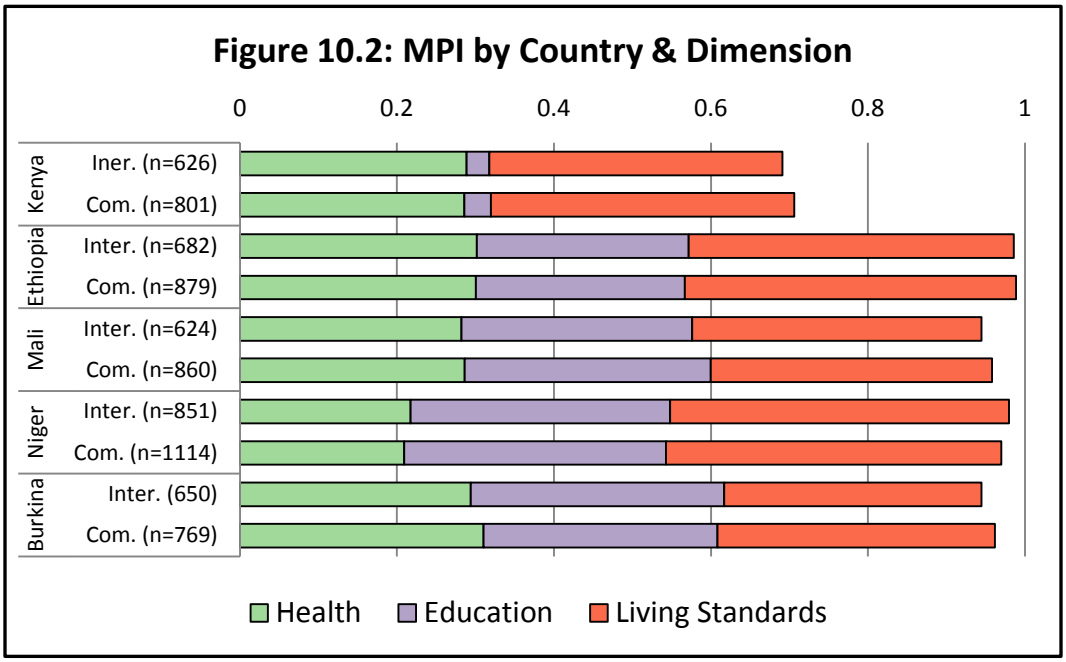


Figure 10.3 presents the same average MPI scores but this time with the weighted contribution of each specific indicator. Here, further differences between the countries can be seen. The three Sahel countries, for example, were more likely to report the death of an under-five child during the previous five years, as compared with the East African countries. In addition, Ethiopia is more deprived with respect to the assets indicator, followed by Niger. Finally, as already highlighted in Section 8, Niger is better off in relation to the MDD-W (minimum dietary diversity) indicator.

Table 10.3: Multi-dimensional Poverty Index (MPI)—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Base of MPI (counting vector)															
$\bar{x}$	0.334	0.334	-0.001	0.613	0.603	0.010	0.590	0.591	-0.004	0.644	0.638	0.0061	0.563	0.567	-0.004
$\tilde{x}$	0.333	0.333	0.000	0.611	0.611	0.000	0.611	0.611	0.000	0.667	0.667	0.0000	0.556	0.556	0.000
MPI															
$\bar{x}$	0.691	0.706	-0.015	0.986	0.989	-0.003	0.945	0.958	-0.014	0.980	0.970	0.0098	0.945	0.962	-0.017
$\tilde{x}$	1.000	1.000	0.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000	1.000	0.0000	1.000	1.000	0.000
Proportion of HHs multi-dimensionally poor (suffering deprivations in 33% or more of the weighted indicators)															
$\bar{x}$	0.615	0.6377	0.022	0.982	0.985	-0.003	0.928	0.945	-0.0175	0.973	0.960	0.0131	0.928	0.951	-0.023
n	**626**	**801**	**1427**	**682**	**879**	**1561**	**624**	**860**	**1484**	**860**	**1105**	**1965**	**650**	**769**	**1419**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

Viewing the MPI by weighted indicator enables a comparison of how indictor specific depravation varies across the intervention and comparison sites and countries.

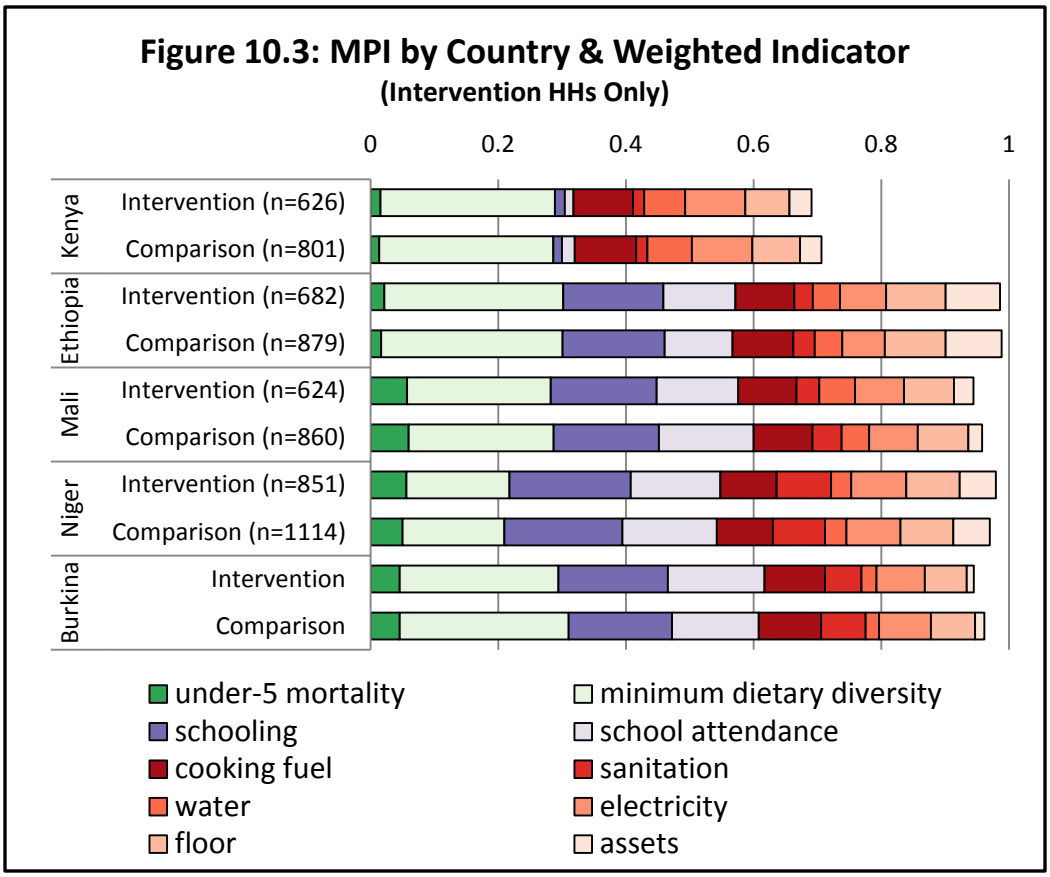
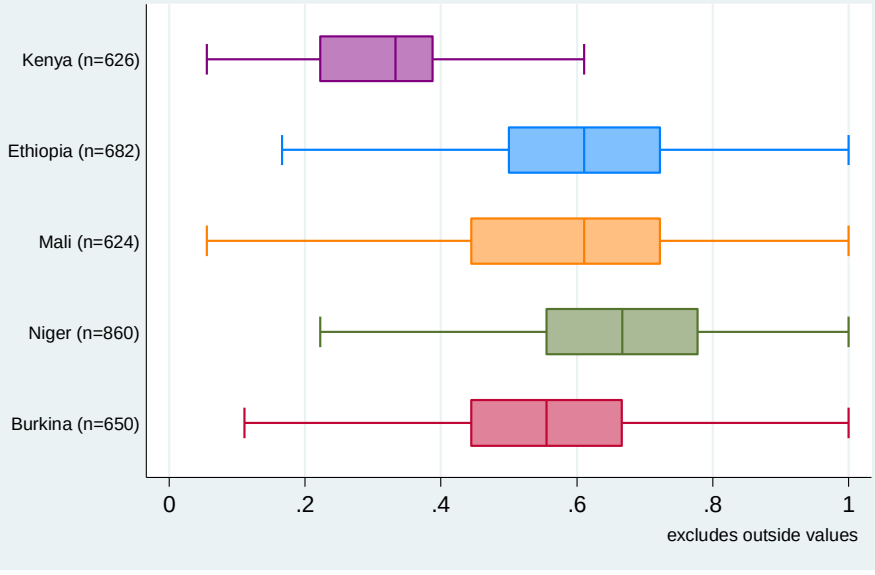


Table 10.3 presents specific statistics associated with the MPI, as well as differences between the households of the intervention and comparison sites in relation to these. The first section of the table presents the mean and median values of the counting vector (base MPI index). The counting vector is arguably more useful for comparing groups, given that it comprises of more variation in the data. Nevertheless, mean and medium values for the MPI are also presented, as well proportions of households that can be considered as multi-dimensionally poor, i.e. those assessed as suffering deprivations in one-third or more of the weighted indicators. It clear from the various statistics presented in the table that the households in both Kenya's intervention and comparison sites appear to experience significantly less multi-dimensional poverty. It is further worth noting that there are no statistically significant differences in relation to any of the point estimates between the households of the intervention and comparison sub-watersheds in all five countries.

Figure 10.4 concludes this section on the MPI by presenting horizontal box plots for the base index of the MPI (counting vector) for the intervention sites only by country. While it is true the vast majority of households in four of the five DryDev countries, surpassed the 33% multi-dimensional poverty cut-off, these box plots reveal that there is considerably variability in the depth of multi-dimensional poverty, with a significant number of households being deprived in two-thirds or more (rather than simply one-third) of the weighted indicators.

Figure 10.4: Box Plots of Counting Vector for Multi-dimensional Poverty Index (Intervention Sites Only)



11. Measures of Soil Health

During the baseline survey, GPS coordinates were captured from sampled fields to ascertain their status on five measures of soil health.

Recall from Section 1 that DryDev's first expected outcome involves increasing water capture and soil conservation and fertility at the sub-watershed and farm levels. The indicators to assess the status of this outcome are primarily derived via the analysis of 30 meter resolution satellite imagery. During the baseline survey, the enumerators worked with the respondents to randomly select one of the fields the latter farmed in 2014 within the sub-watershed in question. While making various observations about the fields, the enumerators also went to their centre to capture geographical information systems (GPS) coordinates using their smartphones/tablets. These coordinates were then provided to ICRAF's Geosciences Lab, which hosts high level expertise in mapping and monitoring of ecosystem health and other biophysical parameters around the globe.

Five complementary measures were subsequently computed for soil erosion, soil organic carbon (SOC), soil pH, fractional vegetation cover, and root depth restriction.[21] These measures are based on predictive models for mapping land health based on systematically collected field and lab measurements from about 150 Land Degradation Surveillance Framework (LDSF) sites across the global tropics. The LDSF framework[22] consists of a set of methods for capturing data on various ecosystem health metrics, including soil condition, vegetation structure and cover, landform, land use, and land degradation (e.g. soil erosion). The LDSF is developed for integrated landscape analysis,

[21] The point estimates take into account the size of the fields where the GPS coordinates were captured. To mitigate the possibility of satellite imagery pertaining to areas outside of the sampled fields convoluting the results, estimates closer to where the GPS points were taken were given greater weight.

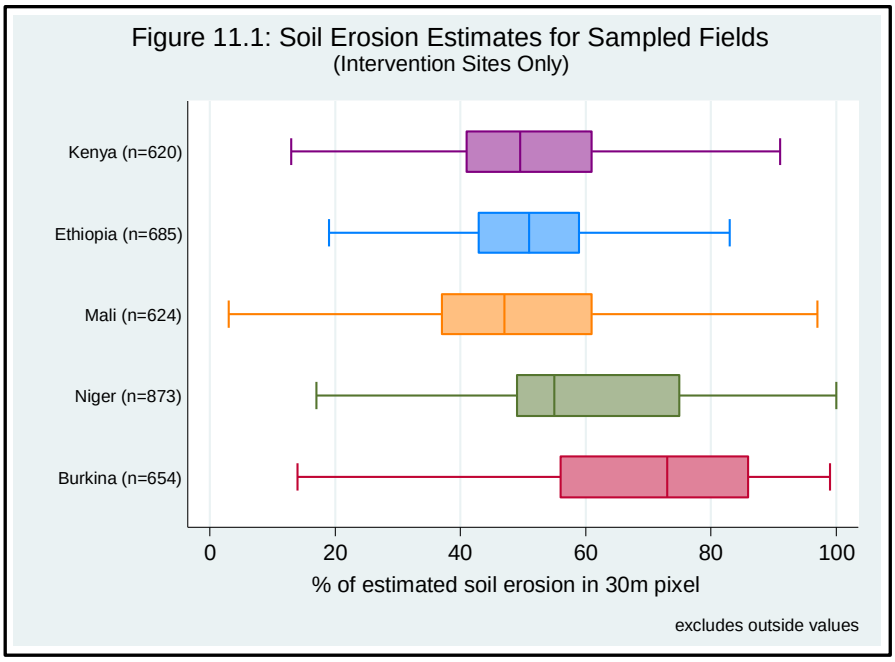
[22] http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/

using a spatially balanced hierarchical sampling design based on 10 by 10 kilometre (100 km^2) sites (or landscapes), with each site consisting of 16 clusters, each 1 km^2, with 10 randomly generated 1,000 m^2 plots per cluster.[23]

Table 11.1 presents the resulting mean and medium values for each of the five measures, including differences between the fields located in the intervention and comparison sub-watersheds. While only one statistically significant difference was identified for all the estimates across the five countries (i.e. median soil pH for Mali), it is important to note again that standard errors were clustered at the sub-watershed level in these comparisons. If such clustering were not used, a number of these differences would also be statistically significant, e.g. estimated soil erosion in Mali. This is because, understandably, many fields located within a particular sub-watershed have more biophysically in common with other fields within this same sub-watershed, as compared with fields in other sub-watersheds.

It is informative to examine box plots for each of the five soil health measures. Figure 11.1 focuses on the percentage of estimated soil erosion prevalence in a given 30 meter pixel. It is clear the prevalence of soil erosion is significantly high, with the sampled fields of Niger and, to a much larger extent Burkina Faso, being the worst off.

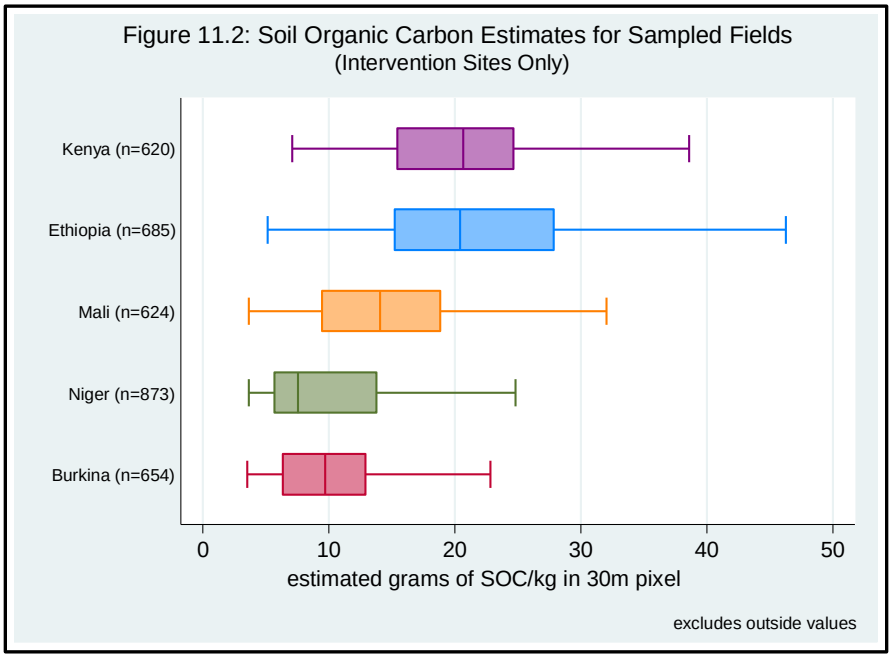
The prevalence of soil erosion is particularly high in all countries, with it being the severest in Niger and Burkina Faso.



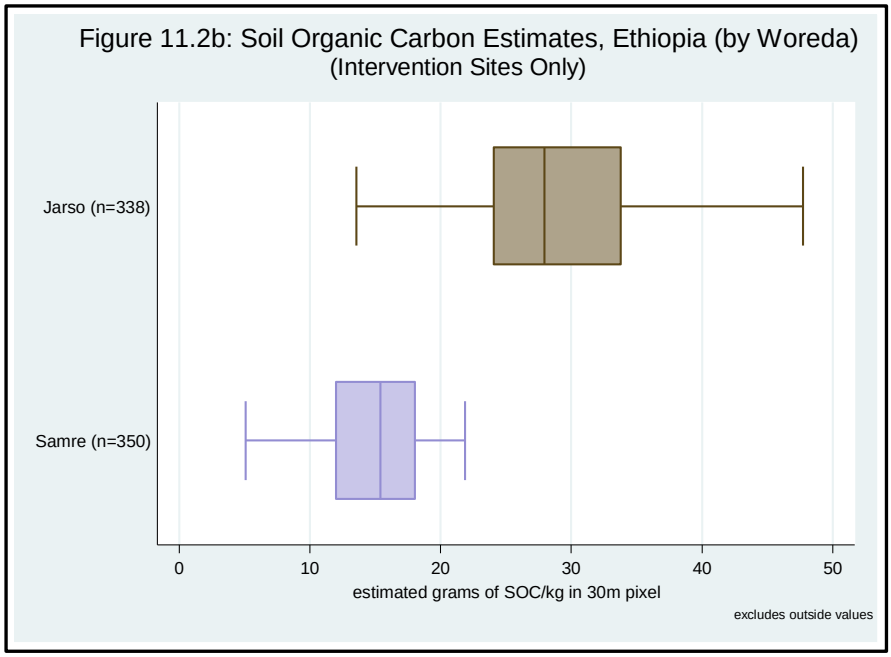
Soil organic carbon (SOC) is a measure of carbon contained within soil organic matter, which plays a critical role in the physical, chemical, and biological functioning of

[23] See, for example: Vågen, T.G. et al., 2013. Landsat-based approaches for mapping of land degradation prevalence and soil functional properties in Ethiopia. *Remote Sensing of Environment*, 134(August), pp.266–275.

agricultural soil and its ability to support crop growth. Box plots presenting estimated grams of SOC per kilogram are presented in Figure 11.2. An estimate of 10 is equivalent to 1% organic carbon, 20 2%, and so forth. Estimates below 10 (1% SOC) are generally considered to be low, adversely impacting crop production potential. These figures can also be converted into the percentage of organic matter (which includes elements of the soil other than carbon, such as hydrogen, nitrogen, and oxygen) using a factor of 1.72. Hence, 20 grams of SOC per kilogram is equivalent to approximately 3.44% of soil organic matter (20/10 x 1.72).



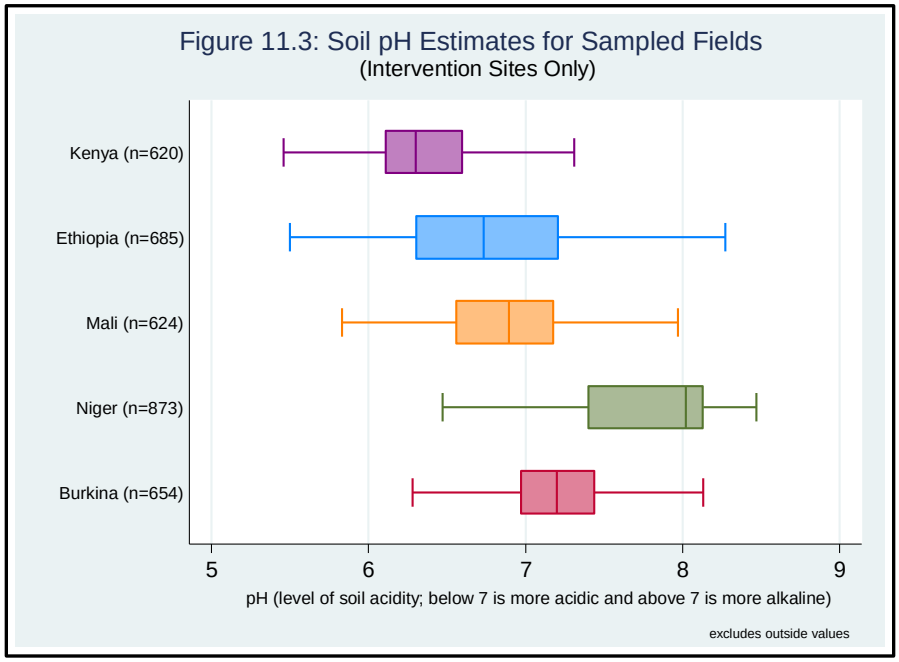
There is considerable variability in SOC across (and, to a certain extent, within) the five countries. Much of this is due to the differing nature of the sampled fields' soils.



It is clear from Figure 11.2 that there is significant variability in SOC both across and within the five countries. Niger and Burkina Faso clearly have the lowest estimated levels, but more fields of the former country are below the 10 estimated grams per kilogram threshold. Ethiopia also displays the greatest variability. However, the two districts that make up its impact study area are from different sides of the country, and Figure 11.2b presents district specific box plots. It is clear that the fields sampled in Jarso District comprise considerably more SOC. This is largely due to the differing nature of the dominant soil type of this district, i.e. Vertisols, a type of clay-rich soil that shrinks and swells with changes in soil moisture content.

Figure 11.3 presents pH estimates—a scale that measures the level of acidity and alkalinity—for the sampled fields of the intervention sites for each of the five countries. Soils below seven on the scale are more acidic, while those above are more alkaline. It is clear from the box plots that the soils of Kenya, Ethiopia, and Mali are generally more acidic, while those of Niger and Burkina Faso are more alkaline. There again appears to be significant variation in the Ethiopian sites. However, much of this variation is driven by the differing nature of the soils of the two districts that make up this country's impact study area: The soils of Jarso District (*Woreda*) are significantly more acidic, while those of Samre District tend to be more neutral to alkaline.

The soils are clearly different across the five countries, necessitating different management strategies.

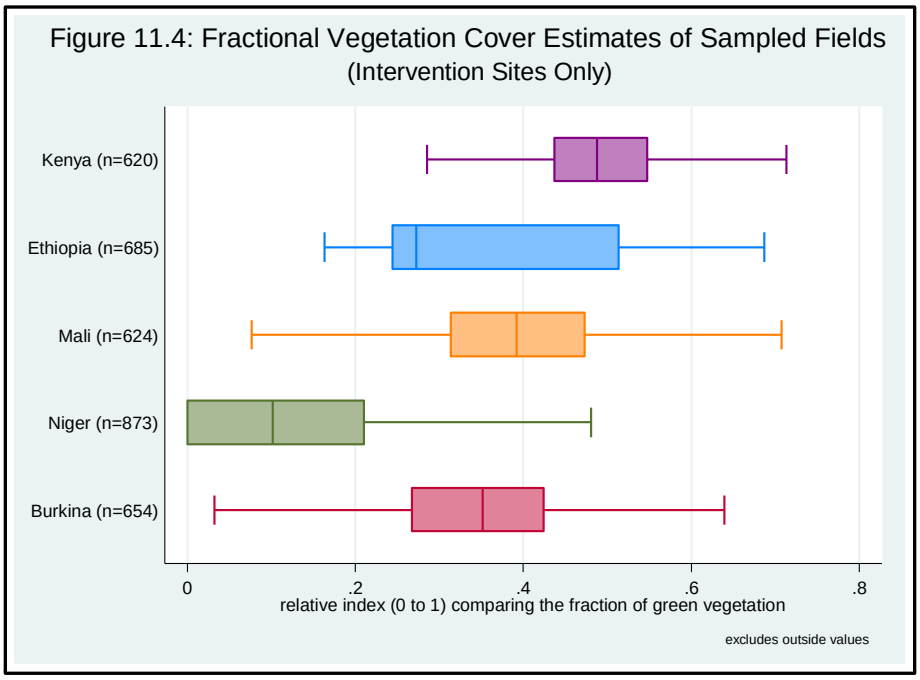


Soil pH ranging between 5.5 and 8 is generally amenable for crop and pasture production. It appears that the vast majority of all the sampled fields in all five countries are above the 5.5 threshold. If there were farmers with soils below this threshold, this can be managed with the application of agricultural lime every few years. Unfortunately, however, significantly more of the sampled fields surpass the alkalinity threshold, where remedial measures are more challenging to implement. This is particularly in Ethiopia

(Samre District), Burkina Faso, and—most extensively—in Niger, where over 50% of the sampled fields are significantly alkaline.

Figure 11.4 presents the distribution of values pertaining to a fractional vegetation cover index for the sampled fields. This is a relative index that indicates the extent to which the sampled fields are covered by green vegetation. As is apparent, there are considerable differences both within and across the five countries. Kenya is generally higher in relation to the index, while the sampled Niger fields have the lowest levels of green vegetation cover, with approximately 25% scoring 0 on the index. While there appears to be significant variation within the Ethiopian sites, this is again driven by district-related differences: significantly more vegetative cover was identified for the sampled fields of Samre district.

There is significant variability across (and to a certain extent within) the five countries in relation to the fraction of sampled fields with green vegetation cover.



The final soil health indicator derived from remote sensing that informs DryDev's baseline survey is root depth restriction. Following Vågen et al. (2016), this pertains to the extent to which restrictions preventing root penetration are estimated in the top 50 centimetres of soil. Given that many crops (e.g. wheat and maize) grow optimally when their roots penetrate more than 50 centimetres below the surface, the presence of crop rooting restrictions within this top layer may have adverse implications for plant growth and, hence, crop yields. Such restrictions may further indicate poor water infiltration and retention capacity.[24] Figure 11.5 presents the resulting box plots for this indicator. It is clear that high percentages of the sampled fields across all the five countries are

[24] Vågen, T.G. et al., 2016. Mapping of soil properties and land degradation risk in Africa using MODIS reflectance. *Geoderma*, 263, pp.216–225.

estimated to have significant crop rooting and water infiltration and retention restrictions within the first 50cm of soil.

The promotion of new crop varieties under DryDev should take into account the inherent root depth restrictions associated with a large share of the targeted sub-watersheds.

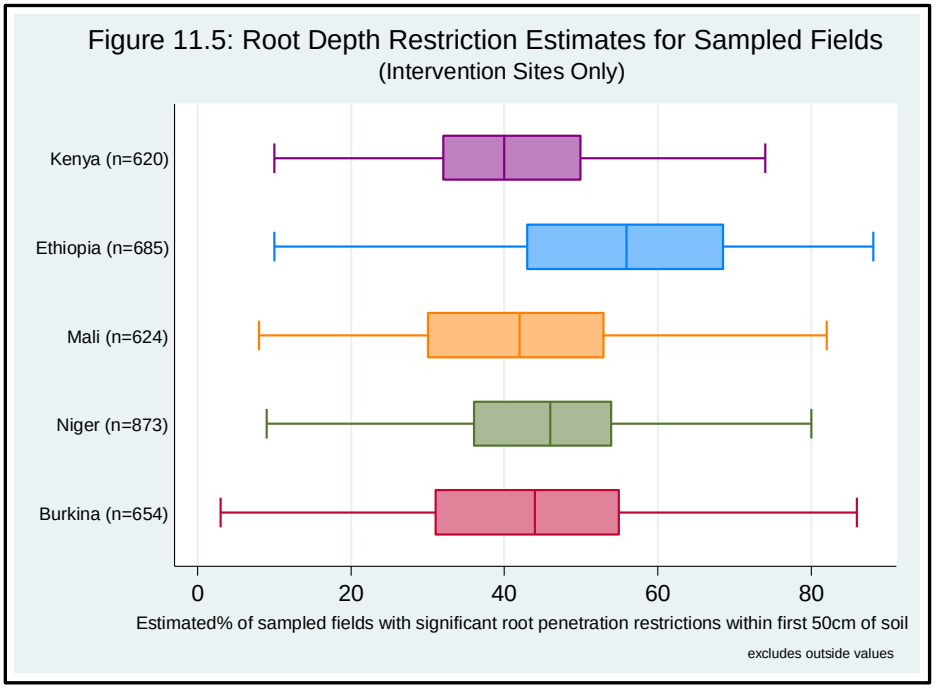


Table 11.1: Soil Health Parameters Derived from Remote Sensing—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Soil Erosion (% of estimated soil erosion per 30m pixel)															
$\bar{x}$	51.64	54.67	-3.036	50.84	51.78	-0.940	49.25	53.68	-4.425	62.00	64.84	-2.834	69.71	71.56	-1.864
$\tilde{x}$	49.50	55.00	-5.00	51.00	52.00	-1.000	47.00	52.00	-5.000	55.00	63.00	-8.000	73.00	75.00	-2.000
Soil Organic Carbon (estimated grams/kilogram in 30m pixel)															
$\bar{x}$	20.31	22.09	-1.778	21.94	20.95	0.999	14.60	13.10	1.511	9.93	8.93	1.003	10.03	09.58	0.446
$\tilde{x}$	20.66	22.43	-1.780	20.36	18.82	1.540	14.06	13.14	0.940	7.52	6.82	0.700	9.68	8.65	1.030
Soil pH (measure of soil acidity; below 7 is acidic and above 7 is alkaline)															
$\bar{x}$	6.380	6.358	0.022	6.749	6.872	-0.1231	6.89	7.00	-0.108	7.79	7.75	0.034	7.20	7.31	-0.107
$\tilde{x}$	6.300	6.270	0.030	6.739	6.940	-0.2005	6.90	7.07	-0.180*	8.02	7.81	0.210	7.20	7.29	-0.09
Fractional Vegetative Cover (relative index to compare the fraction of green vegetation within a pixel between groups)															
$\bar{x}$	0.495	0.510	-0.014	0.371	0.341	0.0303	0.380	0.375	0.005	0.125	0.160	-0.034	0.350	0.328	0.022
$\tilde{x}$	0.488	0.511	-0.022	0.275	0.261	0.0137	0.392	0.388	0.004	0.102	0.154	-0.053	0.351	0.330	0.022
Rooting Restriction Depth (measure of extent root penetration is inhibited due to physical and chemical characteristics of the soil)															
$\bar{x}$	41.27	39.15	2.116	55.01	52.08	2.934	41.99	42.42	-0.426	45.16	43.28	1.879	43.06	42.95	0.108
$\tilde{x}$	40.00	40.00	0.000	56.70	53.94	2.111	42.00	42.00	0.000	46.00	43.00	3.000	44.00	43.00	1.000
n	**620**	**801**	**1421**	**685**	**880**	**1565**	**624**	**864**	**1488**	**873**	**1111**	**1984**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

12. Resilience Index

While DryDev is ultimately seeking to bolster household income and food security, as well as empower women and disadvantaged groups, it is also working to ensure that these results will be sustained and augmented for the long term. In the face of climate change and external drivers of change affecting the drylands, it is therefore also critical for the programme to promote resilience building among the households and communities it is targeting. However, given that resilience is another complex multidimensional concept, measuring it is particularly challenging.

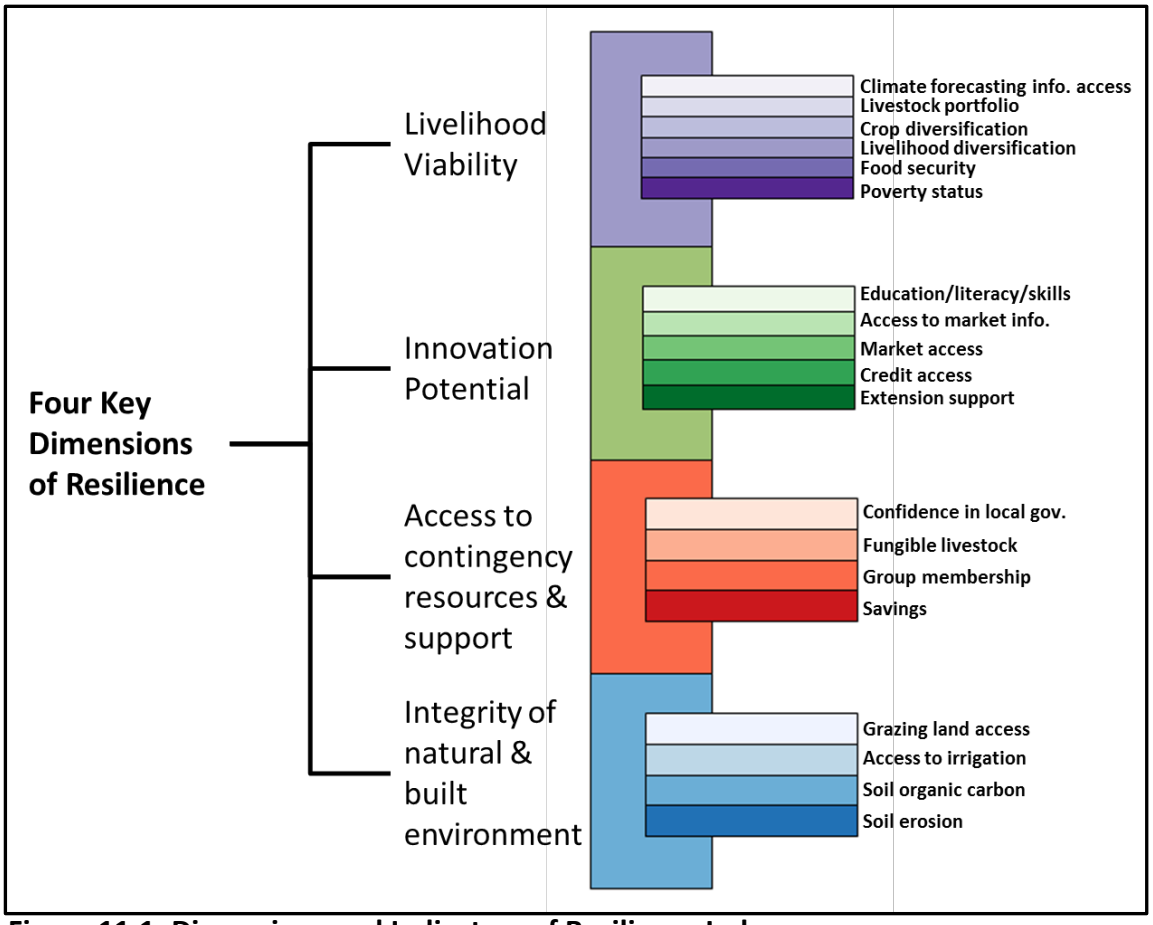


Figure 11.1: Dimensions and Indicators of Resilience Index

DryDev is following Oxfam GB's approach for measuring resilience.[25] One of the complexities associated with measuring resilience is that the success of a household, community, organization, or any system for that matter in bouncing back from a shock or adapting to change more generally can only be ascertained after the fact.[26] Characteristic approaches for measuring resilience, such as Oxfam GB's, attempts to overcome this by

[25] Hughes, K. and Bushell, H. (2013), A Multidimensional Approach for Measuring Resilience. *Oxfam GB Working Paper*, Oxford.

[26] Dodman, D., Ayers, J. and Huq, S. (2009), 'Building Resilience', Chapter 5, in World Watch Institute (ed), *'2009 State of the World: Into a Warming World'*, Washington D.C: World Watch Institute, pp. 151-168.

hypothesizing that there are particular characteristics of households (and systems more generally) that affect how well they are able to cope with shocks and positively adapt to change. The dimensions and specific characteristics (indicators) that make up DryDev's adapted version of the resilience index are presented in Figure 11.1.

DryDev's resilience index is adapted from an approach developed by Oxfam GB that, like the WEAI and MPI, is based on the Alkire-Foster method.

Livelihood viability is the first dimension. Here, it is assumed that if a shock takes place, a poor household dependent on only one or two precarious livelihood activities is more likely to be adversely impacted than a richer household dependent on a more diverse portfolio of more robust livelihood activities. The second dimension, **innovation potential**, focuses on a household's ability to positively adjust to change, whether anticipated or not. It is hypothesized that such potential is dependent on factors such as access to extension, credit, markets, and market information, as well as the education levels and skills of household members.

However, there will likely be times when even households with resilient livelihood strategies and high adaptive capacity will find it difficult to get by. **Access to contingency resources and external support**—e.g. savings, food and seed reserves, social protection, kin and non-kin support networks, emergency services, and so forth—are, therefore, also assumed to be critically important for coping with shocks and positively adjusting to change. The final dimension of DryDev's resilience index pertains to the **integrity of the natural and built environment**. This dimension is assumed to be particularly important, given that it is recognised that healthy ecosystems are better able to cope/adjust to climatic shocks/change than those that are relatively more degraded.[27] It is therefore hypothesized—again with all other things being equal—that households with livelihoods dependent on healthier ecosystems will be in a better position to adjust to climatic shocks/change than those that are not. The presence of appropriate infrastructure (e.g. irrigation facilities) resilient to shocks and stresses (e.g. flooding) is equally important; if critical infrastructure no longer functions or collapses following an extreme climatic event, the livelihoods and/or health of community members can be negatively affected.

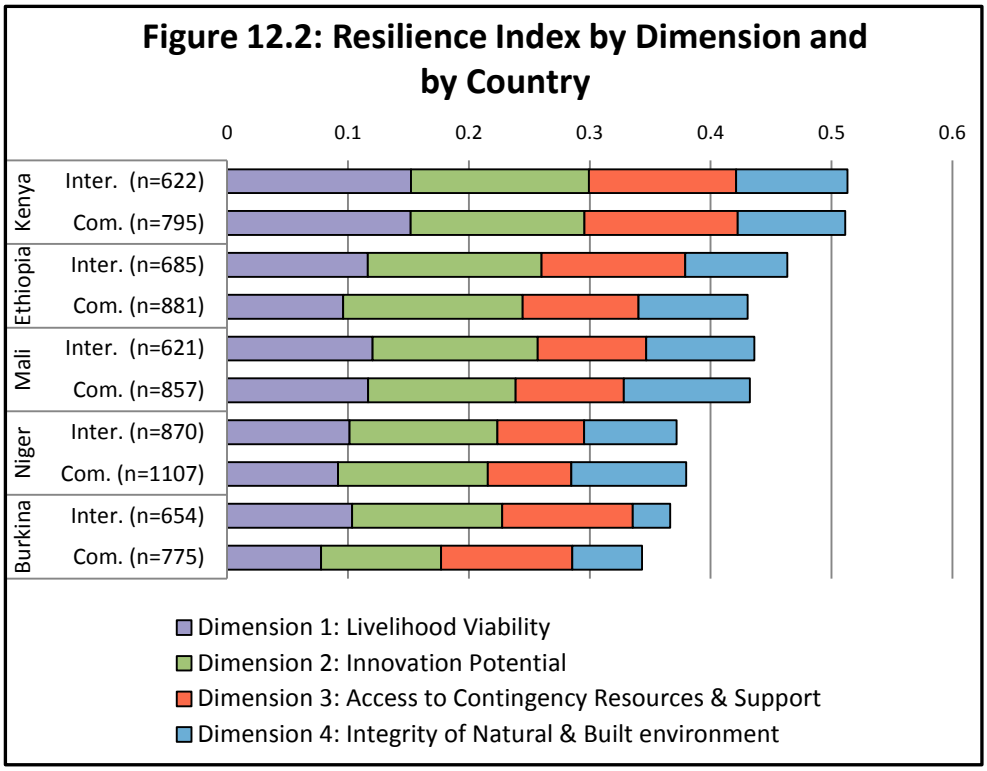
Figure 11.1 presents the indicators used for measuring each particular dimension. These are certainly not exhaustive but are believed to be many of the key household characteristics relevant for (i.e. associated with) resilience for the households DryDev is targeting. Moreover, a number pertain to several of the indicators already presented in this report, given that these are also believed to be key components of resilience as well.

As is the case for the WEAI and MPI, Annex 5.4 presents specific details on how each of the above indicators was measured, as well as the specific binary cut-offs and weights associated with each. DryDev's resilience index also makes use of the Alkire-Foster method. Here, the index is set on a scale ranging from 0 (very low resilience) to 1 (significantly high resilience), and each indicator is weighted equally under each of the four dimensions, which are also equally weighted. Moreover, each weighted indictor score was replaced with the maximum possible score of 1 if the household in question scored positively in relation to at least two-thirds of the weighted indicators.
Figure 12.2 presents the resulting resilience indices by country and the intervention and comparison sites within each country. The Kenya sites, again, are better off in relation to

[27] Ibid.

the index in comparison with those of the other four countries, with Niger and Burkina Faso being the worst off. The overall indices for the intervention and comparison sites appear to be about the same within each country, save for Ethiopia and Burkina Faso. However, these differences are not statistically significant, as revealed in Table 12.1. Nevertheless, it is interesting to note that when the data are analysed separately for Ethiopia by district, the difference for Samre District is statistically significant with a 10% level of confidence.

There are significant opportunities to promote greater resilience and adaptive capacity among the households DryDev is targeting.



To understand how household resilience scores vary within and among the countries, Figure 12.3 presents displays box plots for the 'uncensored' base of the resilience index. As is clear, the variability is considerable for all five countries. This variability is, again, most significant in Ethiopia, but disaggregating the data by district reveals that much of this is being driven by differences between the two districts. Samre District is actually considerably better off in relation to the index, as compared with Jarso District.

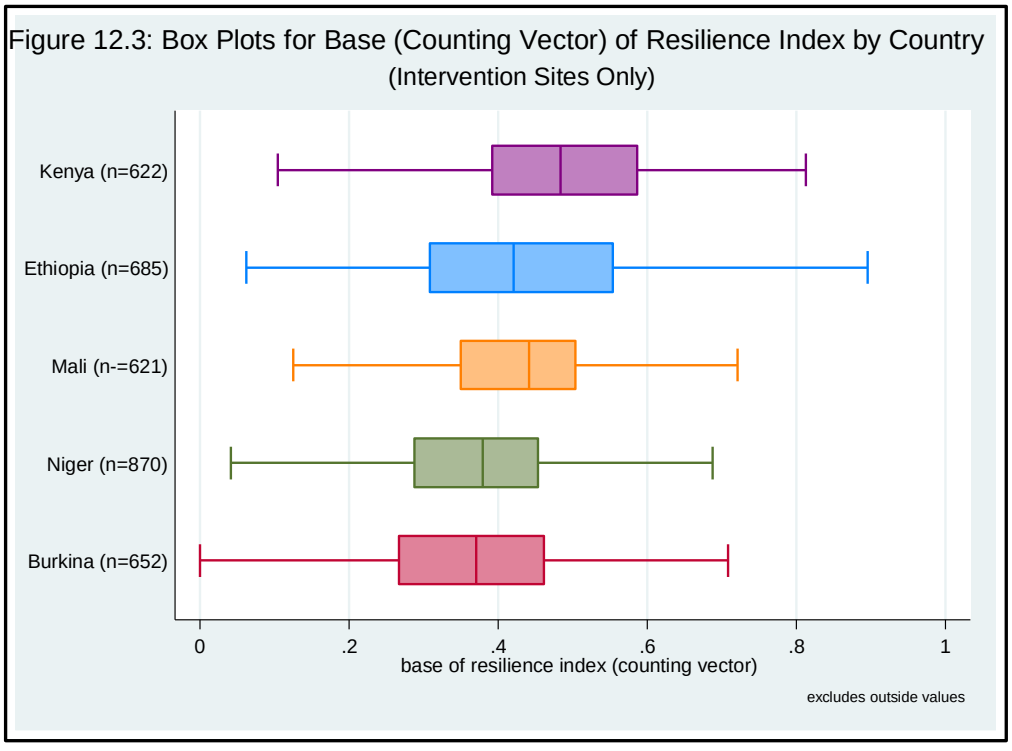
Figure 12.4 displays the resilience index again, but this time with the contribution of each of the 19 weighted indicators. Here, a number of clear differences across the five countries can be seen. The first and obvious one is the food security indicator (MDD-W); its contribution to the indices of both Ethiopia and Burkina Faso is so small that it cannot even be seen in the graph. The level of livelihood diversification in Mali and Niger is also very low, and there is reportedly poor access to reliable seasonal forecasting information with respect to the latter. Access to extension services appear to be best in the Ethiopian sites and worst in the Kenyan sites. Kenya and Ethiopia, followed by Burkina Faso, perform relatively better on the savings indicator, whereas Kenya and Burkina Faso outperform

the others on the group membership indicator. In terms of soil health, Mali is the best off, performing relatively better for both the soil erosion and soil organic carbon indicators, whereas Burkina Faso is the worst off. Ethiopia is also poorly off with respect to the soil erosion indicator, but much better off with respect to soil organic carbon. Recall that much of this is driven by the Versitol soils of Jarso District. Finally, irrigation access is relatively higher in Ethiopia and Niger, and Burkina Faso is the most deprived on the grazing land and fodder access indicator.

Table 12.1: Resilience Index (RI)—mean ($\bar{x}$) & median ($\tilde{x}$) differences: Intervention & Comparison Sub-watersheds

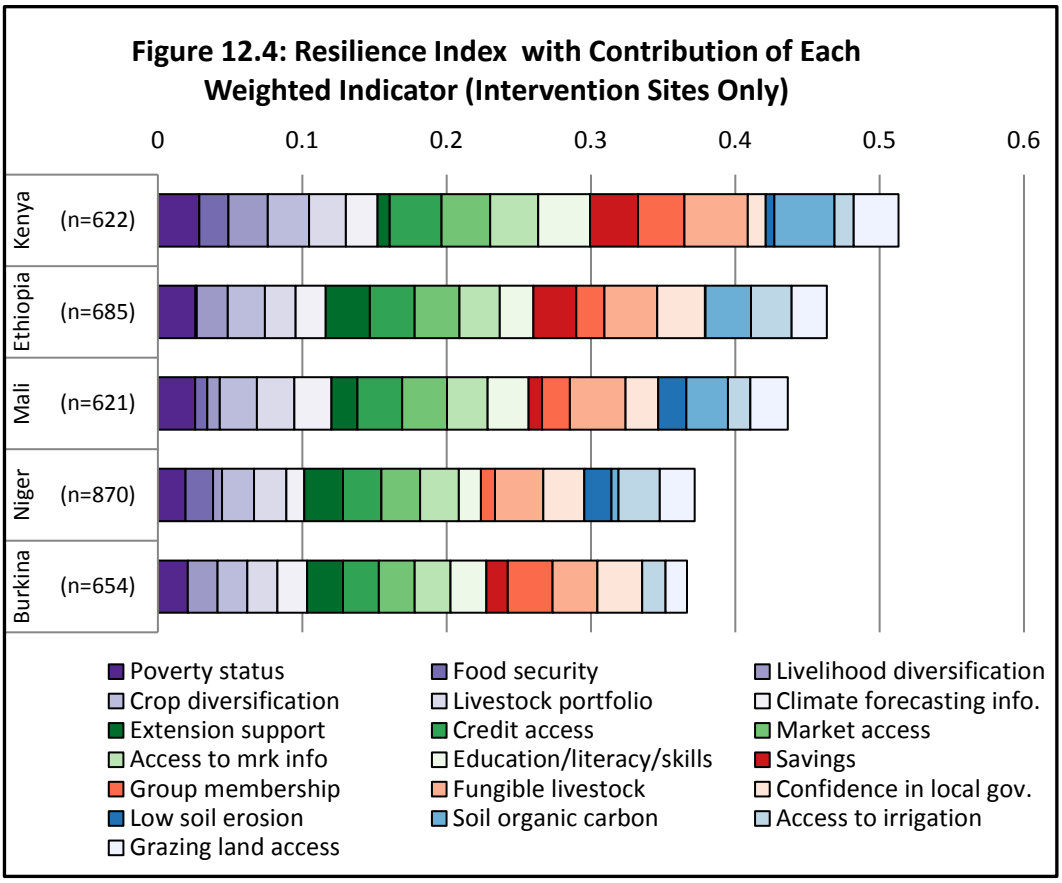
	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Base of RI (counting vector)															
$\bar{x}$	0.4861	0.4894	-0.0033	0.4350	0.4110	0.0239	0.4306	0.4295	0.001	0.3694	0.3786	-0.009	0.3657	0.3708	0.0247
$\tilde{x}$	0.4833	0.4917	-0.0083	0.4208	0.4083	0.0125	0.4417	0.4417	0.000	0.3791	0.3917	-0.013	0.3410	0.3417	0.0292
Resilience Index															
$\bar{x}$	0.5132	0.5113	0.0019	0.4634	0.4306	0.0328	0.4363	0.4324	0.004	0.372	0.380	-0.008	0.3665	0.3431	0.0234
$\tilde{x}$	0.4833	0.4917	-0.0083	0.4208	0.4083	0.0125	0.4416	0.4417	0.000	0.379	0.392	-0.013	0.3708	0.3417	0.0292
Proportion of HHs demonstrating resilience (scoring at positively on at least 2/3 of the weighted indicators)															
$\bar{x}$	0.0965	0.0780	0.0185	0.1051	0.0667	0.0384	0.0193	0.009	0.010	0.008	0.004	0.004	0.003	0.008	-0.005
n	**622**	**795**	**1417**	**685**	**869**	**1554**	**621**	**857**	**1478**	**870**	**1107**	**1977**	**652**	**775**	**1427**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level



The contribution of each characteristic to the resilience index varies considerably by country.

Figure 12.4: Resilience Index with Contribution of Each Weighted Indicator (Intervention Sites Only)



13. Field Characteristics & Management Practices

This final section presents results from both enumerator observations and farmer discussions pertaining to the fields that were randomly selected and visited.

13.1 Field Tilling Practice

Figure 13.1.1 present percentages on specific field tilling practices reportedly used on the sample fields. It is clear that in Kenya and Ethiopia, very few households rely only on hand tilling; ox plough tilling or a combination of hoe and ox plough tilling is much more prominent. Hand tilling is, however, a much more common practice in Mali, Niger, and, to a lesser extent, Burkina Faso. Note that very few if any households in any of the countries till the sampled fields using tractors. Table 13.1.1 presents the specific proportions for both the intervention and comparison sampled fields. While there are differences, none of these are statistically significant, particularly following the clustering of standard errors at the sub-watershed level.

Soil management improvement options promoted by DryDev should take into account farmers' current tilling practices.

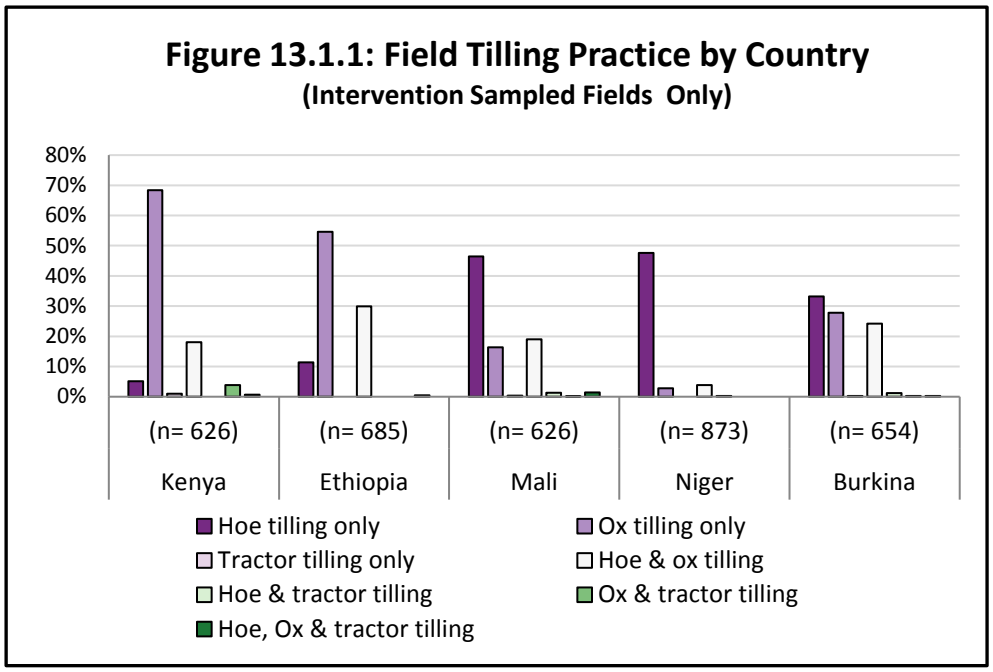


Table 13.1.1: Proportion of HHs Practicing Specific Field Tilling Methods on Sampled Fields—mean ($\bar{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Hoe only															
$\bar{x}$	0.0511	0.0424	0.0087	0.114	0.175	-0.061	0.4640	0.4166	0.0473	0.477	0.492	-0.015	0.332	0.381	-0.049
Ox ploughing only															
$\bar{x}$	0.6837	0.6970	-0.0133	0.546	0.568	-0.022	0.1632	0.1192	0.0440	0.027	0.022	0.006	0.278	0.252	0.026
Tractor ploughing only															
$\bar{x}$	0.0096	0.0062	0.0034	0.000	0.000	0.000	0.0032	0.0023	0.0009	0.000	0.003	-0.003	0.003	0	0.003
Hoe and ox ploughing															
$\bar{x}$	0.1805	0.1945	-0.0140	0.299	0.218	0.081	0.1904	0.3264	-0.1360	0.039	0.025	0.014	0.242	0.198	0.044
Hoe and tractor ploughing															
$\bar{x}$	0.000	0.0050	-0.0050	0.000	0.000	0.000	0.0128	0.0151	-0.0022	0.002	0.001	0.001	0.012	0.005	0.007
Ox and tractor ploughing															
$\bar{x}$	0.0383	0.0249	0.0134	0.000	0.000	0.000	0.0016	0.0023	-0.0007	0.000	0.000	0.000	0.003	0.000	0.003
Hoe, ox and tractor ploughing															
$\bar{x}$	0.0063	0.0037	0.0026	0.004	0.002	0.002	0.0144	0.0046	0.0098	0.000	0.001	-0.001	0.003	0.001	0.002
n	**626**	**802**	**1,428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1119**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

13.2 Soil Fertility Management Practice & Irrigation

Figure 13.2.1 displays the percentages of specific soil fertility management practices reportedly applied on the sampled fields, as well as whether the field is typically irrigated. Particularly noteworthy are the high percentages of households reportedly practicing minimum tillage in Mali and Niger, as well as crop rotation in Ethiopia, Mali and, to a lesser extent, Kenya and Burkina Faso. Significant percentages of the fields in the three Sahel countries were also found with trees that are reportedly there, at least in part, as an intentional strategy to enhance soil fertility, i.e. fertilizer trees. Table 13.2.1 presents the specific proportions for both the intervention and comparison fields, as well as the

Soil fertility management strategies vary significantly across the five countries.

differences between the two. This time, several statistically significant differences were identified, i.e. for minimum tillage in Ethiopia and fallowing in both Kenya and Ethiopia.

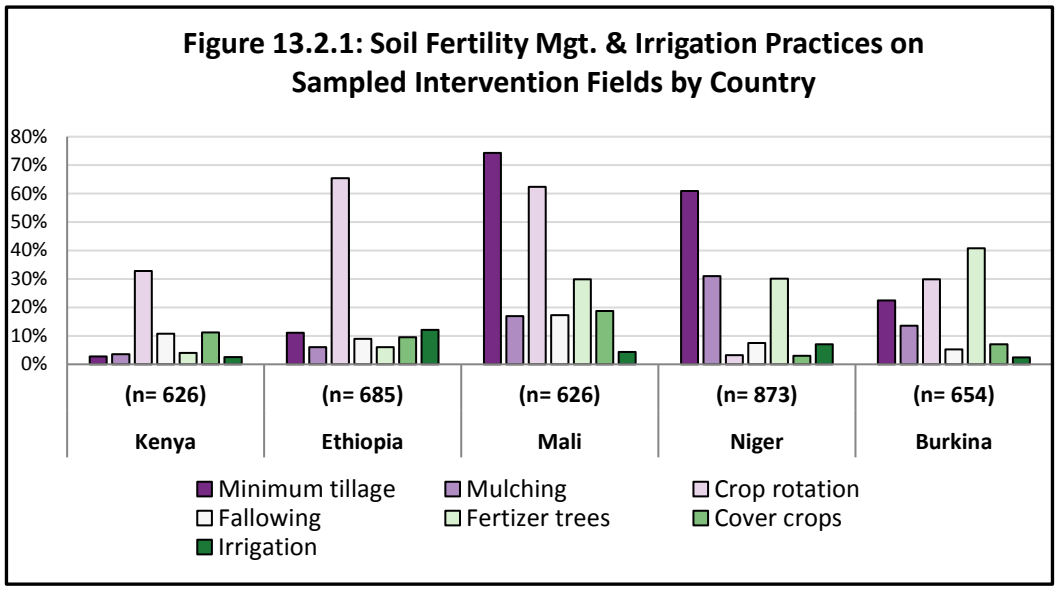


Table 13.2.1: Proportion of HHs Practicing Specific Soil Fertility Mgt. Practices & Irrigation on Sampled Fields—mean ($\bar{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Minimum tillage															
$\bar{x}$	0.0272	0.0287	-0.0015	0.111	0.057	0.054**	0.7424	0.6412	0.1011	0.609	0.582	0.027	0.225	0.253	-0.028
Mulching															
$\bar{x}$	0.0351	0.0262	0.009	0.060	0.058	0.002	0.1696	0.1170	0.0527	0.310	0.312	-0.001	0.136	0.115	0.021
Crop rotation															
$\bar{x}$	0.3275	0.29551	0.0320	0.654	0.606	0.048	0.624	0.5937	0.03025	0.032	0.017	0.015	0.298	0.286	0.012
Fallowing															
$\bar{x}$	0.1070	0.0786	0.0285*	0.089	0.026	0.063*	0.1728	0.1285	04432	0.074	0.047	0.027	0.052	0.031	0.021
Fertilizer trees															
$\bar{x}$	0.0399	0.0436	-0.0037	0.060	0.051	0.009	0.2992	0.3125	-0.0133	0.301	0.289	0.012	0.408	0.385	0.024
Cover crops															
$\bar{x}$	0.1118	0.1197	-0.0079	0.095	0.058	0.037	0.1875	0.11498	0.0725	0.030	0.019	0.011	0.070	0.085	-0.015
Irrigation															
$\bar{x}$	0.0256	0.0200	0.0056	0.121	0.186	-0.065	0.0432	.0648	-0.0216	0.070	0.061	0.009	0.024	0.013	0.012
n	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1119**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

13.3 Soil Erosion Control Practices

Figure 13.3.1 presents the percentages of soil erosion control measures practiced on the sampled fields. Given the hilling nature of the topography associated with the Kenyan and Ethiopian DryDev sites, it is not surprising that terracing and trenches were found to be practiced to a significantly greater extent, as compared with the three Sahelian countries. There are very few soil erosion control measures being practiced in Mali and Niger, while Burkina Faso is clearly an anomaly where nearly half of the sampled fields were found with *zai* pits. As is presented in Table 13.3.1, the only statistically significant differences

between intervention and comparison fields of each country are with respect to terracing in Ethiopia and Mali.

Topographic differences among the countries have influenced the adoption of specific types of soil erosion control practices.

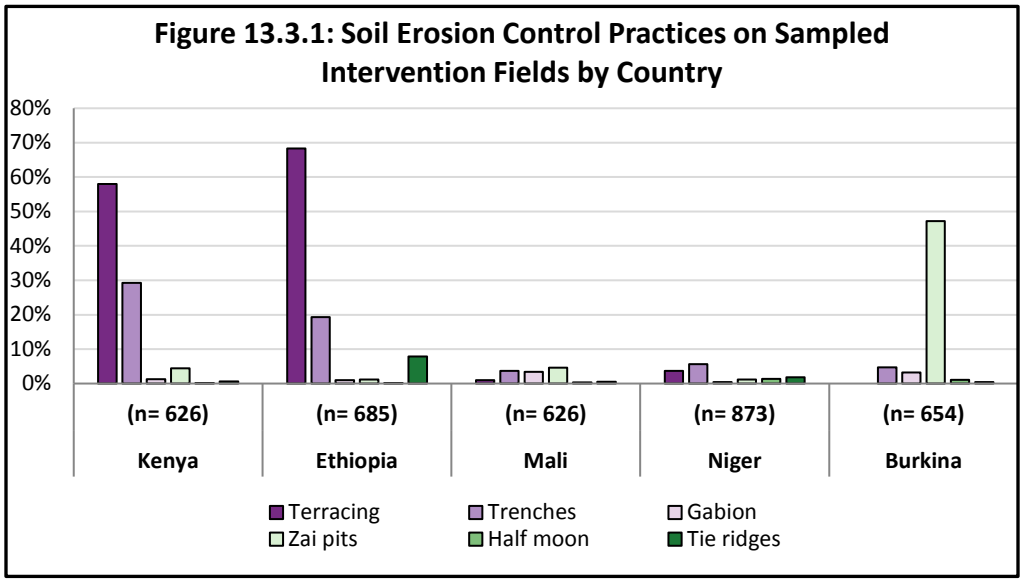


Table 13.3.1: Proportion of HHs Practicing Specific Soil Erosion Control Measures on Sampled Fields—mean ($\bar{x}$) differences: Intervention & Comparison Sub-watersheds

	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Terracing															
$\bar{x}$	0.5799	0.5486	0.0312	0.683	0.590	0.093**	0.0096	0.0961	-0.0865**	0.037	0.024	0.012	0.000	0.003	-0.003
Trenches															
$\bar{x}$	0.2923	0.3167	-0.0244	0.193	0.137	0.055	0.0368	0.0498	-0.0130	0.056	0.044	0.012	0.047	0.065	-0.017
Gabion															
$\bar{x}$	0.0128	0.0162	-0.0034	0.010	0.007	0.003	0.0336	0.0289	0.0047	0.005	0.004	0.001	0.032	0.023	0.009
Zai pits															
$\bar{x}$	0.0447	0.0299	0.0148	0.012	0.007	0.005	0.0464	0.0324	0.0140	0.011	0.010	0.002	0.472	0.492	-0.019
Half moon															
$\bar{x}$	0.0016	0.0000	0.0016	0.001	0.005	-0.003	0.0032	0.000	0.0032	0.014	0.005	0.008	0.011	0.006	0.004
Tie ridges															
$\bar{x}$	0.0064	0.0062	0.0002	0.079	0.027	0.052	0.0048	0.004	0.0013	0.018	0.019	0.000	0.005	0.014	-0.010
n	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1119**	**1989**	**654**	**775**	**1429**

* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

13.4 Trees in Crop Fields

Upon visiting the sampled fields, the enumerators were instructed to examine whether trees were present and, if so, the approximate numbers. Figure 13.4.1 presents the percentages of fields found with trees in specific arrangements. As is clear, high percentages of the fields of Kenya, Mali, Niger, and Burkina Faso were found with trees scattered within them. Far fewer fields in all countries were found to have trees in other configurations, e.g. along field boundaries, in alleys, or as wood lots. However, as indicated in Table 13.4.1, several statistically significant differences between the intervention and comparison sites in relation to these less common arrangements were

Trees were found in unstructured arrangements in most of the sampled fields in four out of the five countries.

identified, i.e. for boundary planting, alley, and woodlots in Ethiopia and for boundary trees in Mali.

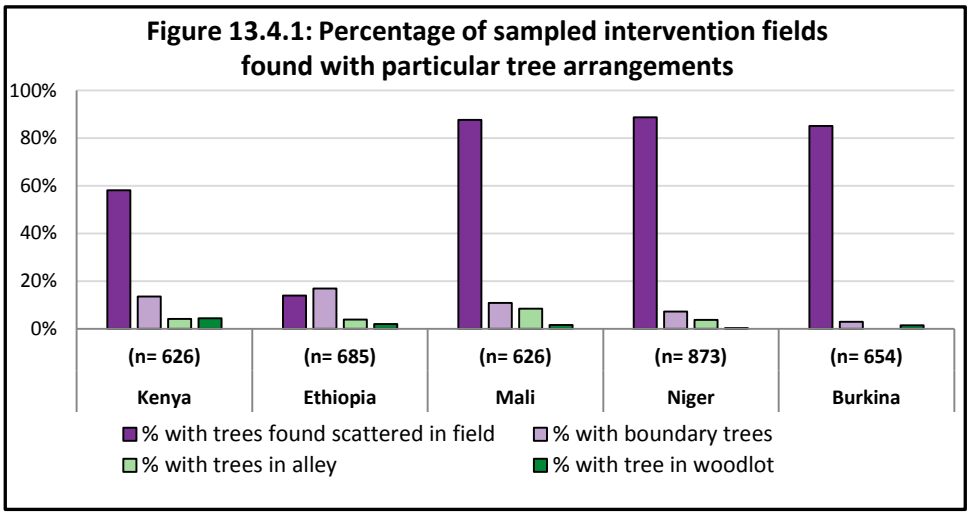


Table 13.4.1: Proportions of Sampled Fields Found with Specific Tree Arrangements—mean ($\bar{x}$) differences: Intervention & Comparison Sub-watersheds

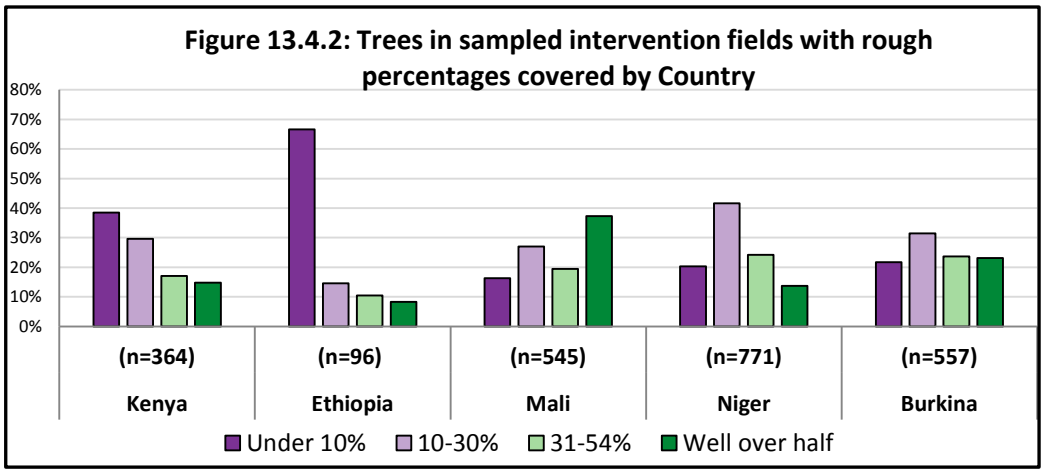
	Kenya			Ethiopia			Mali			Niger			Burkina Faso		
	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.	Inter.	Com.	Dif.
Trees found scattered in field															
$\bar{x}$	0.5815	0.5387	0.0428	0.140	0.099	0.041	0.8768	0.7998	0.077	0.888	0.858	0.029	0.852	0.810	0.041
Boundary trees															
$\bar{x}$	0.1358	0.1060	0.0298	0.169	0.089	0.081*	0.1088	0.0613	0.048**	0.072	0.057	0.015	0.029	0.023	0.006
Trees planted in alley															
$\bar{x}$	0.0415	0.0362	0.0054	0.039	0.006	0.034**	0.0848	0.0532	0.0316	0.038	0.031	0.006	0.000	0.001	-0.001
Trees planted in woodlots															
$\bar{x}$	0.0447	0.0561	-0.0114	0.020	0.003	0.017**	0.016	0.0115	0.0044	0.002	0.008	-0.006	0.015	0.010	0.005
n	**626**	**802**	**1428**	**685**	**881**	**1566**	**625**	**864**	**1489**	**873**	**1119**	**1989**	**654**	**775**	**1429**

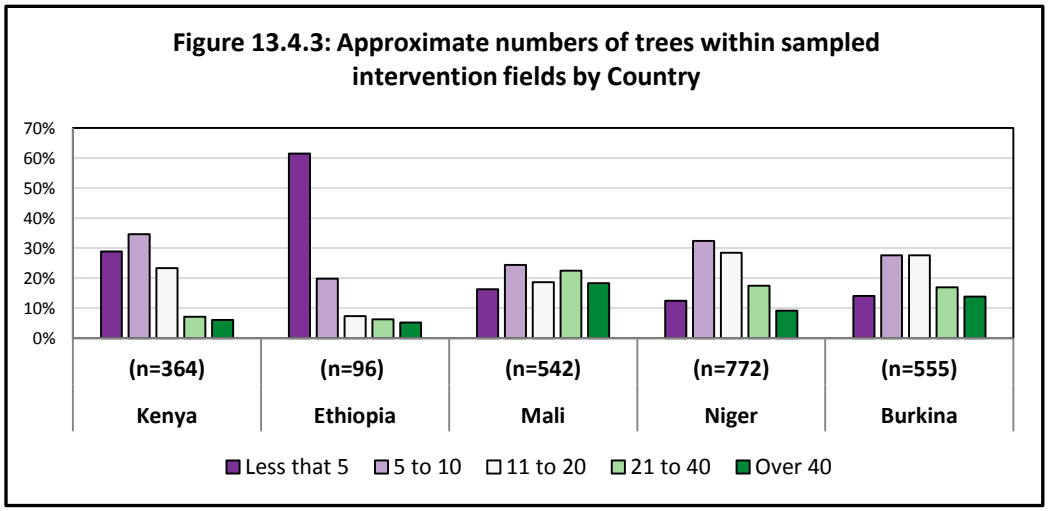
* p<0.1, ** p<0.05, *** p<0.01; standard errors clustered at sub-watershed level

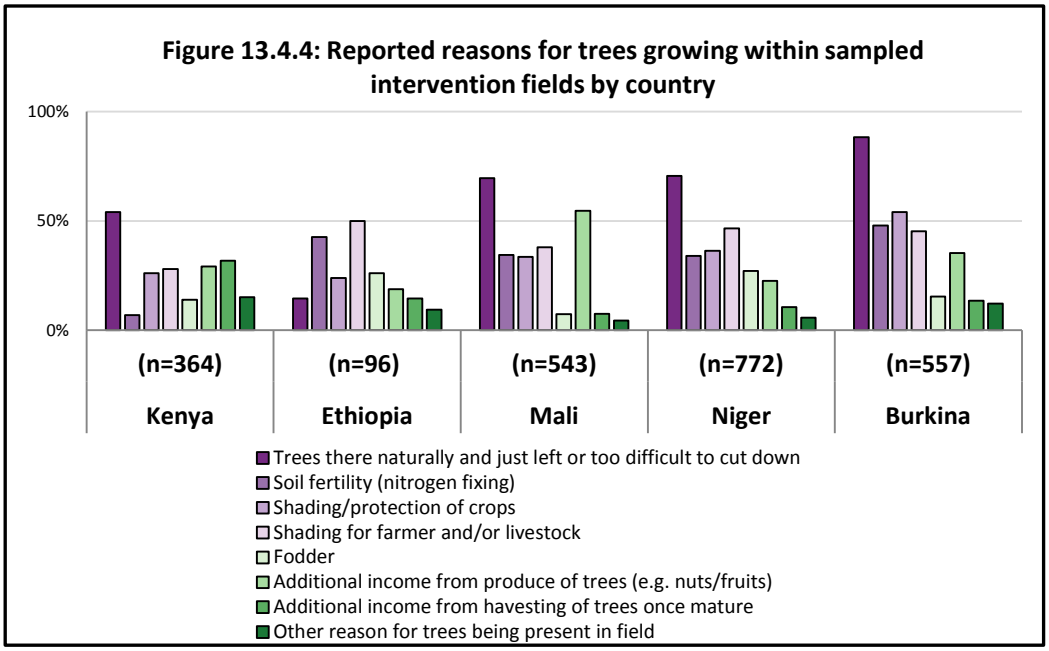
For those fields found containing trees, the enumerators were asked to estimate the rough percentages of the field that is covered and the approximate numbers of trees. The results are presented in Figure 13.4.2 and Figure 13.4.3, respectively. It is clear that not only were far fewer fields in Ethiopia and, to a lesser extent, Kenya found with trees but also the percentages of the fields covered and specific numbers of trees are significantly less in comparison with the three Sahelian countries.

The enumerators also asked the interviewed farmers the reasons for having trees in their fields. Figure 13.4.4 presents their responses. The most popular response is that trees are there naturally and have simply been left or are too difficult to cut down. Soil fertility enhancement and provision of shade are also popular reasons. For Mali and, to a lesser extent, Burkina Faso, significant percentages of the farmers cited the provision of additional income from tree products (e.g. timber, firewood, and fruits) as being a key reason.

The presence, numbers, and densities of trees in crop fields are much greater in the Sahelian countries.







14. Summary Indicator Table

While the main purpose of the baseline survey is to enable DryDev's impact to be assessed following its implementation, some of the data and findings documented in this report may prove useful for informing intervention design and programmatic prioritization. Table 14.1 summarizes the main results for both the intervention and comparison sites by country.

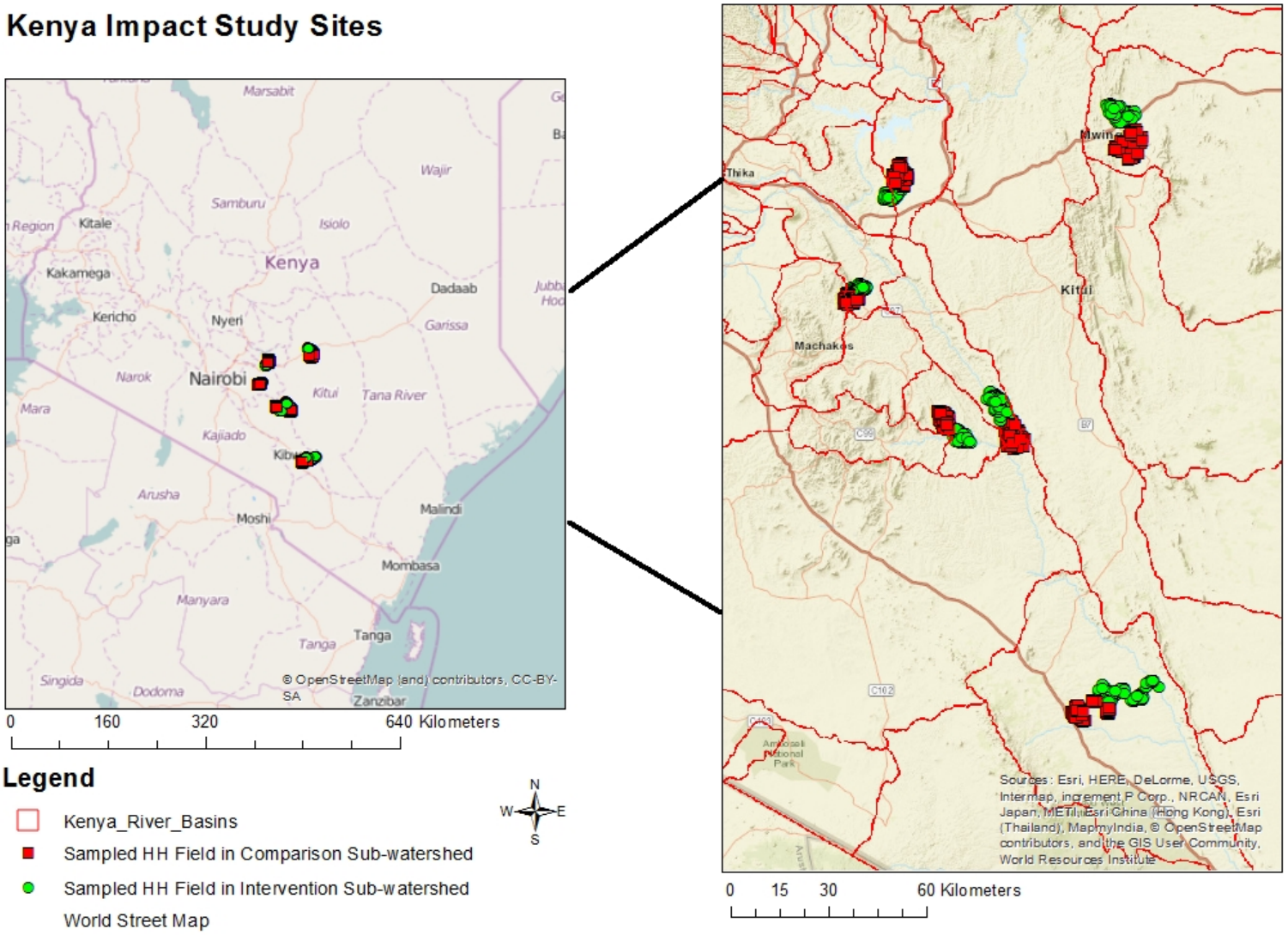
TABLE 14.1: Summary Baseline Results for Key Impact and Outcome Indicators

Outcome level	Indicator	Kenya		Ethiopia		Mali		Niger		Burkina	
		P	C	P	C	P	C	P	C	P	C
Impact Level											
Sustained improvements in food and water security, livelihoods, and resilience, and the empowerment of women and other disadvantaged groups	% of respondents consuming 5 or more of the Minimum Dietary Diversity food groups	30%	31%	2%	1%	19%	19%	35%	35%	13%	10%
	% HHs at or above international poverty line ($USD 1.90 per person per day, purchase power parity)	86%	83%	76%	75%	68%	61%	46%	50%	46%	50%
	Multi-dimensional Poverty Index (MPI)	0.691	0.706	0.986	0.989	0.945	0.958	0.980	0.970	0.945	0.962
	Women's Empowerment in Agriculture Index (WEAI) – women	0.615	0.625	0.351	0.350	0.311	0.324	0.255	0.267	0.322	0.310
	Women's Empowerment in Agriculture Index (WEAI) – men	0.691	0.651	0.580	0.535	0.557	0.511	0.590	0.585	0.720	0.720
	Resilience index	0.513	0.511	0.463	0.431	0.436	0.432	0.372	0.380	0.367	0.343
Outcome Level											
2. Increased water capture & soil conservation/ fertility at watershed & farm levels	Soil Erosion (% of estimated soil erosion per 30m pixel)	52%	55%	51%	52%	49%	54%	62%	65%	70%	72%
	Soil Organic Carbon (estimated grams/kilogram in 30m pixel)	20	22	22	21	15	13	10	9	10	10
	Fractional Vegetative Cover (relative index to compare fraction of vegetative cover in pixel)	50	51	37	34	38	38	13	16	35	33
	% of sampled farm plot(s) serviced by irrigation in last growing season	7%	6%	24%	30%	7%	17%	13%	14%	8%	6%
3. Increased production of profitable, climate-smart commodities & food crops	Estimated average cash value of main crops grown in previous year (USD)	339	289	367	309	1249	1089	410	394	457	412
5. Increased sales of targeted value chain commodities sold by male, female, and vulnerable farmers	Estimated average cash value of crops sold in previous year (USD)	107	117	68	85	603	367	104	117	83	67
6. Improved local governance & farmer organization functioning (Part of the resilience index and WEAI but reported here separately.)	% of households that received extension services more than 1 time in past 12 months	13%	8%	70%	59%	25%	26%	17%	19%	11%	15%
	# of female farmers participating in & reporting benefits from FOs	8%	9%	4%	1%	10%	11%	1%	1%	6%	7%
	# of male farmers participating in & reporting benefits from FOs	10%	5%	15%	10%	8%	9%	2%	5%	7%	7%

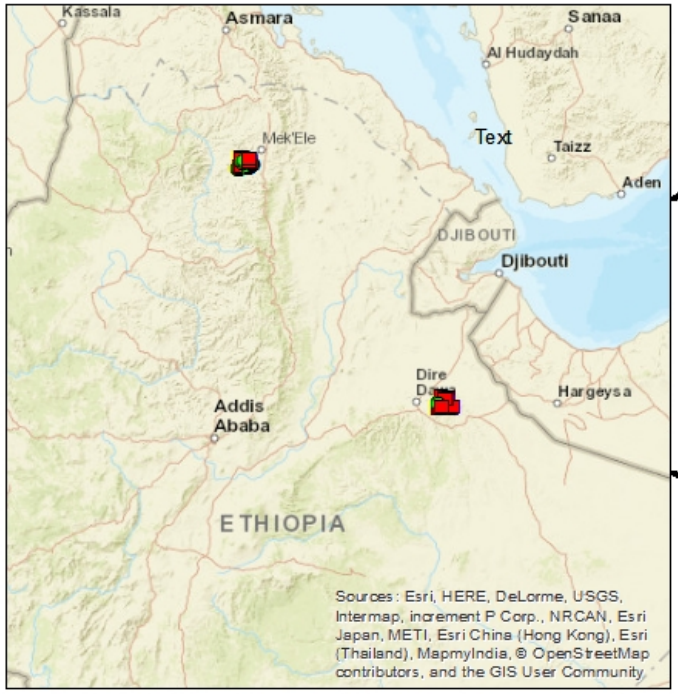
P = Programme Site; C=Comparison Site

Annexes

Annex 1: Country Maps of Impact Study Sites



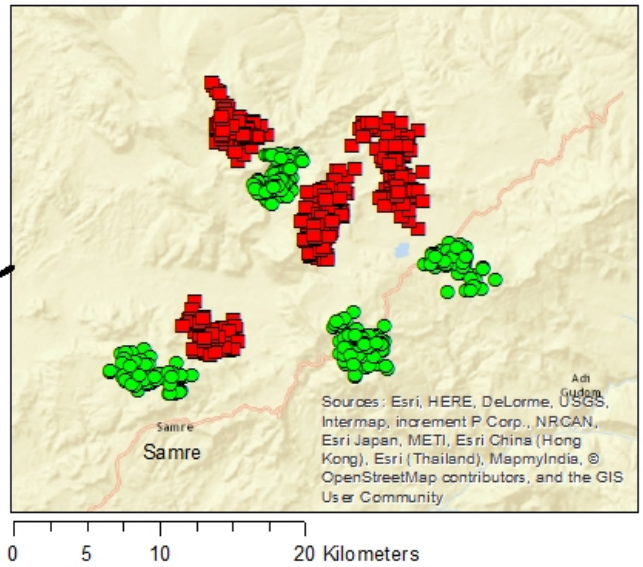
Ethiopia Impact Study Sites



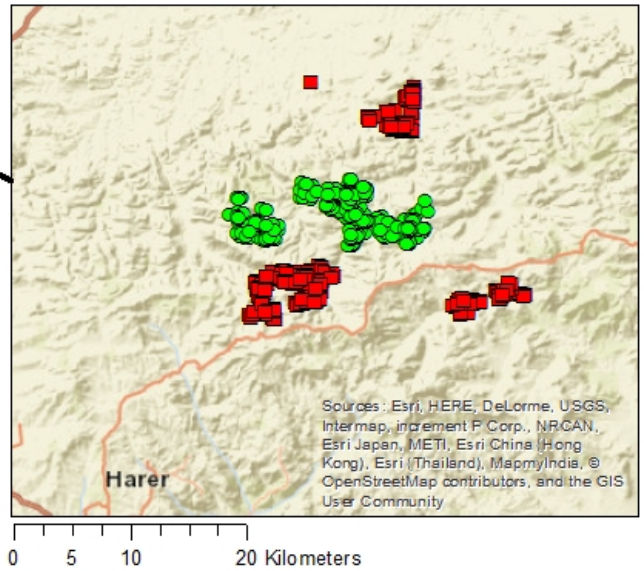
Legend

- Sampled HH Field in Comparison Sub-watershed
- Sampled HH Field in Intervention Sub-watershed

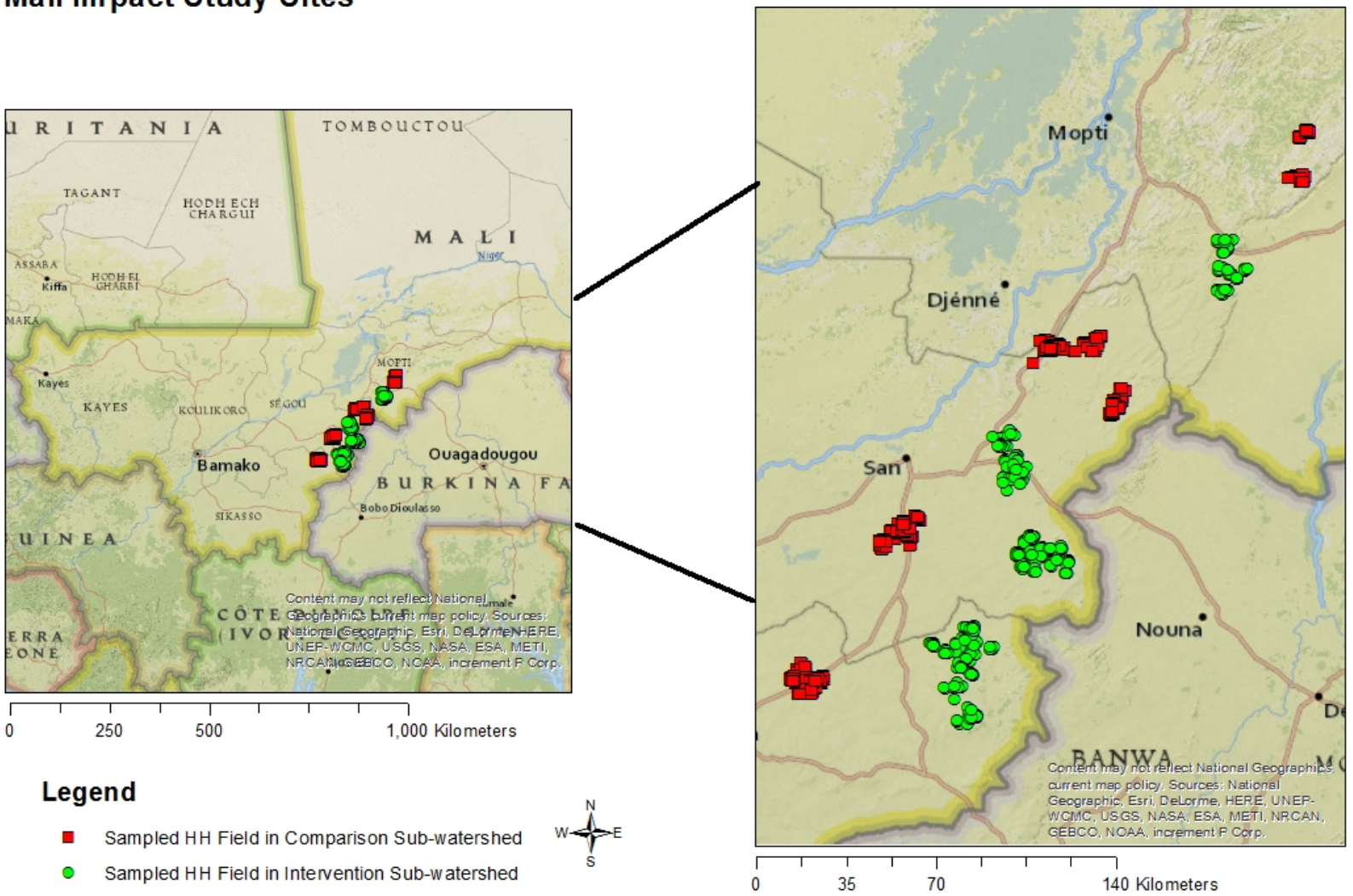
Samre District



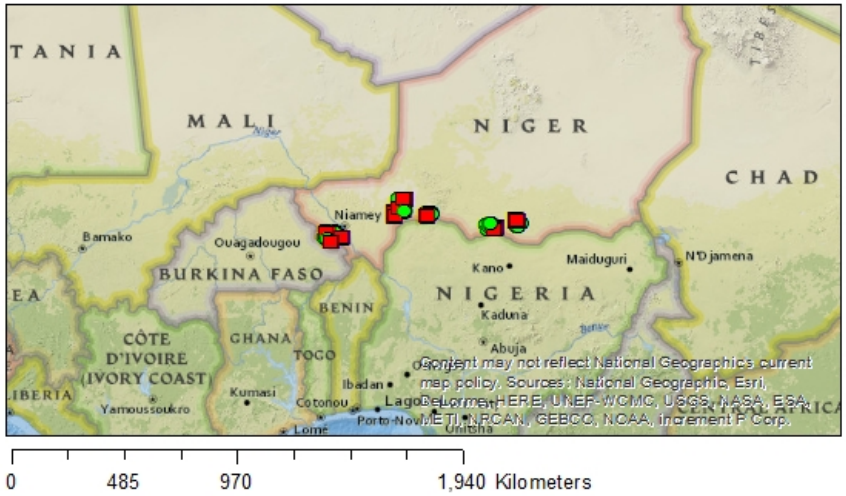
Jarso District



Mali Impact Study Sites

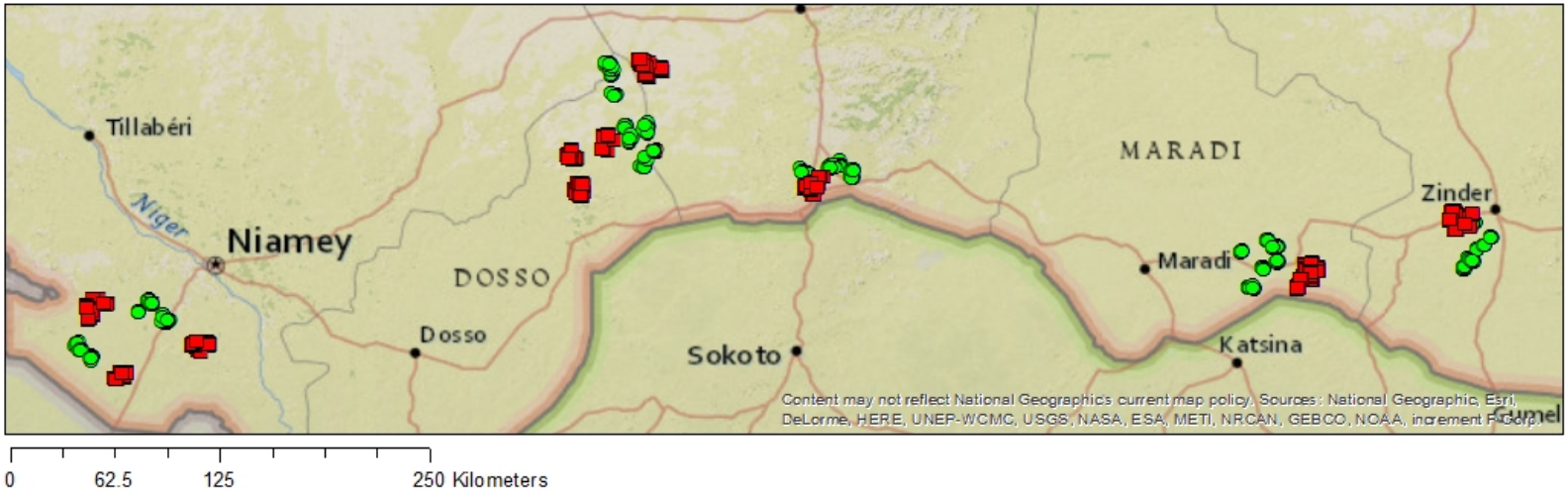


Niger Impact Study Sites

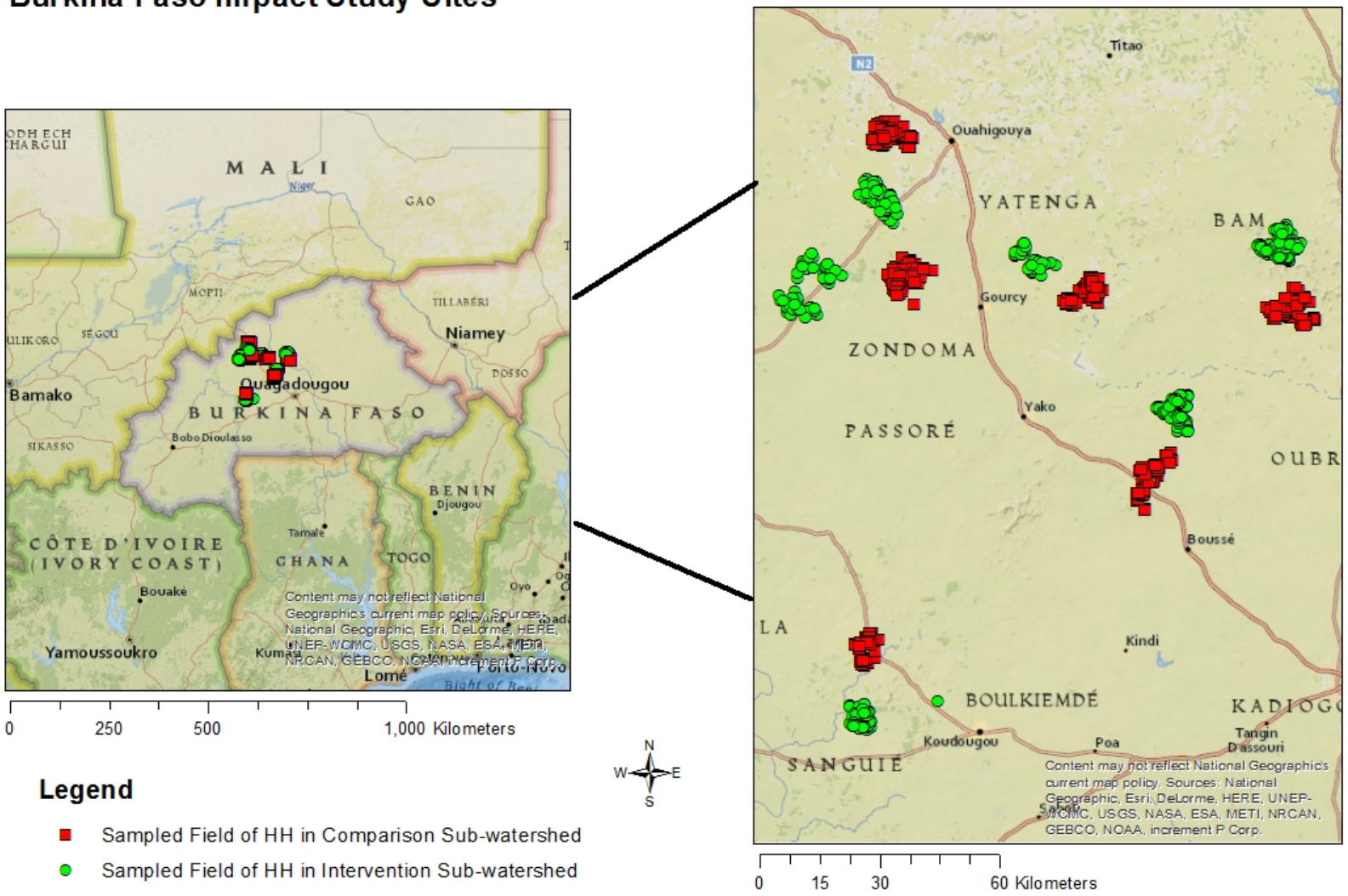


Legend

- Sampled HH Field in Comparison Sub-watershed
- Sampled HH Field in Intervention Sub-watershed



Burkina Faso Impact Study Sites



Annex 2: Specific Names and Locations of DryDev's Impact Study Area Sites

Kenya

County	Sub-county	Location	Sub-location	Sub-watershed	Intervention	Sample Size
Machakos	Mwala	Mwala	Kibau	Kibau	Yes	100
Machakos	Mwala	Mwala	Kamwala	Kamwala	No	130
Machakos	Masinga	Ikatini	Ikatini	Ikatini	Yes	130
Machakos	Masinga	Ikatini	Itunduimuni	Itunduimuni	No	170
Makueni	Kibwezi East	Ngwata	Mukange Lower	Mukange Lower	Yes	90
Makueni	Kibwezi East	Ngwata	Mukange Upper	Mukange Upper	No	116
Makueni	Mbooni	Katangini	Ititu	Ititu	Yes	92
Makueni	Mbooni	Katangini	Thwake	Thwake	No	118
Kitui	Mwingi Central	Endui	Kathoka	Kathoka	Yes	108
Kitui	Mwingi Central	Enziu	Enziu	Enziu	No	133
Kitui	Kitui Rural	Kalulini	Syomunyu	Syomunyu	Yes	106
Kitui	Kitui Rural	Kalulini	Syumakanda	Syumakanda	No	135
					Total sample size	**1,428**

Ethiopia

Region	Wareda (district)	Kabele	Sub-watershed	Intervention	Sample Size
Oromia	Jarso	Mulata	Mudi	Yes	83
Oromia	Jarso	Epa Jalela	Abrohama	No	116
Oromia	Jarso	Semen Debelo	Mite Hirab	Yes	84
Oromia	Jarso	Gidiya Beha	Handole	No	107
Oromia	Jarso	Oda Muda	Walle	Yes	74
Oromia	Jarso	Aneno Mite	Sebeta	No	104
Oromia	Jarso	Burka Mite	Kora	Yes	94
Oromia	Jarso	Melka Jebdu	Woldeya	No	104
Tigray	Samre	Amdiweyane	Endamariam	Yes	72
Tigray	Samre	Wenberet_Adikaela	Wenberet	No	141
Tigray	Samre	MayTeklit	Bara	Yes	103
Tigray	Samre	Addis Alem	Hantebat	No	146
Tigray	Samre	Waza	Endagergis	Yes	90
Tigray	Samre	Tesh	Endayesus	No	98
Tigray	Samre	Dekera	Atami	Yes	85
Tigray	Samre	Metkel Limat	Tsalda	No	65
				Total Sample Size	**1,566**

Mali

Region	District	Commune	Sub-watershed	Intervention	Sample Size
Sikasso	Yoroso	Menamba_1	Menamba_1	Yes	71
Sikasso	Yoroso	Koumbia	Koumbia	Yes	143
Sikasso	Yoroso	Sorobasso	Sorobasso	No	184
Ségou	Tominian	Tominian	Kondala	Yes	131
Ségou	Tominian	Tominia	Ouan	No	142
Ségou	Tominian	Mandiakuy	Mouina	Yes	183
Ségou	Tominian	Mandiakuy	Souroutouna	No	281
Ségou	Tominian	Mandiakuy	Lanfiala	No	129
Mpoti	Bandiagara	Soroly	Dourou	No	128
Mpoti	Bankass	Ségué	Kogo	Yes	97
				Sample Size	**1,489**

Niger

District	Commune	Sub-watershed	Intervention	Sample Size
Torodi	Torodi	Digbari centre	Yes	59
Torodi	Torodi	Digbari	No	74
Torodi	Torodi	Goroubi Ouest	Yes	60
Torodi	Torodi	Makalondi	No	72
Torodi	Torodi	Goroubi Est	Yes	57
Torodi	Torodi	Gueladio	No	76
Doutchi	Dogon Kiria	Dallol Nord	Yes	60
Doutchi	Dogon Kiria	Bagaroua	No	76
Doutchi	Dogon Kiria	Dallol Centre	Yes	58
Doutchi	Dogon Kiria	Soucoucoutane	No	76
Doutchi	Dogon Kiria	Dallol Sud	Yes	59
Doutchi	Dogon Kiria	Matankari	No	74
Malbaza	Malbaza	Maggia Ouest	Yes	107
Malbaza	Malbaza	Maggia Sud Est	Yes	61
Malbaza	Malbaza	Tsernawa	No	215
Aguié	Aguié	Goulbi Nkaba Nord	Yes	88
Aguié	Aguié	Goulbi Nkaba Sud	Yes	104
Aguié	Aguié	Gazaoua	No	247
Mirriah	Droum	Korama Damagaram NE	Yes	80
Mirriah	Droum	Korama Damagaram SE	Yes	80
Mirriah	Droum	Tirmini	No	206
			Sample Size	**1,989**

Burkina Faso

Province	Commune	Sub-watershed	Intervention	Sample Size
Sanguié	Kyon	BV27 Kyon	Yes	100
Sanguié	Didyr	BV27 Didyr	No	128
Passoré	Arbollé	BV16 Arbollé	Yes	119
Passoré	Kirsi	BV16 Kirsi	No	83
Bam	Kongoussi/Tikaré	BV13 Kongoussi/Tikaré	Yes	165
Bam	Rouko	BV13 Rouko	No	210
Sourou	Kiembara	BV7 Kiembara	Yes	88
Sourou	Lankoué	BV7 Lankoué	No	112
Zondoma	Bassi	BV8 Bassi	Yes	90
Zondoma	Tougo	BV8 Tougo	No	116
Yatenga	Zogoré	BV9 Zogoré	Yes	92
Yatenga	Tangaye	BV9 Tangaye	No	126
			Sample Size	**1,429**

Annex 3: Tests for Linear Trend

Table A3 1: Relationship between Landholding Size and Cash Value of 2014 Harvest

	Kenya	Ethiopia	Mali	Niger	Burkina
Regression (OLS) Coefficients					
Cash value of 2014 harvest regressed on Farmed land (ha)	240.33*** (72.04)	265.79*** (27.42)	160.24*** (15.66)	127.05*** (10.78)	121.88*** (10.36)
Constant	3.70 (91.46)	121.28*** (35.96)	-9.37 (103.62)	-46.30 (31.38)	46.99* (26.34)
R-squared	0.07	0.02	0.26	0.20	0.11
Tests for Linearity					
Level 1	151.97** (66.05)	127.75** (65.43)	517.87*** (91.66)	88.31** (40.58)	191.20*** (40.95)
Level 2	288.39*** (53.43)	223.17*** (48.40)	638.89*** (95.88)	199.04*** (31.78)	267.42*** (36.96)
Level 3	277.81*** (64.63)	429.90*** (49.31)	1107.79*** (86.26)	343.3987*** (34.30)	409.43*** (40.74)
Level 4	484.01*** (49.99)	537.89*** (52.84)	2360.99*** (88.96)	703.94*** (26.21)	774.43*** (34.39)
Linear contrast test (F stat.)	24.71*** (22.17)	121.19*** (14.60)	152.31*** (54.34)	260.49*** (13.79)	99.25*** (21.23)
Cuzick's rank sum non-parametric test for trend (Z stat.)	10.78***	19.55***	21.08***	25.88***	22.76***
Sample size	**1319**	**1457**	**1334**	**1864**	**1392**

* p<0.1, ** p<0.05, *** p<0.01; standard errors in parentheses

Table A3 2: Relationship between Consumption Expenditure and Asset Wealth

	Kenya	Ethiopia	Mali	Niger	Burkina
Regression (OLS) Coefficients					
Raw asset index regressed on log of HH consumption expenditure	0.03*** (0.00)	0.03*** (0.00)	0.03*** (0.00)	0.04*** (0.00)	0.05*** (0.00)
Constant	0.60*** (0.04)	0.61*** (0.03)	0.46*** (0.05)	0.15*** (0.04)	-0.21*** (0.04)
R-squared	0.21	0.09	0.05	0.10	0.22
Tests for Linearity					
Level 1	0.879*** (0.034)	0.843*** (0.028)	0.709*** (0.042)	0.408*** (0.030)	0.118*** (0.030)
Level 2	1.084*** (0.030)	0.831*** (0.026)	0.757*** (0.039)	0.467*** (0.028)	0.309*** (0.030)
Level 3	1.261*** (0.031)	0.913*** (0.025)	0.867*** (0.039)	0.621*** (0.030)	0.492*** (0.031)
Level 4	1.638*** (0.031)	1.190*** (0.023)	1.053*** (0.035)	0.861*** (0.025)	0.806*** (0.028)
Linear contrast test (F stat.)	271.73*** (0.017)	96.16*** (0.012)	45.06*** (0.019)	141.94*** (0.014)	282.91*** (0.015)
Wilcoxcon-type rank sum non-parametric test for trend (Z stat.)	15.78***	10.93***	6.90***	11.98***	15.94***
Sample size	**1416**	**1549**	**1474**	**1955**	**1417**

* p<0.1, ** p<0.05, *** p<0.01; standard errors in parentheses

Annex 3: Details of the Women Empowerment in Agricultural Index (WEAI) Adapted for DryDev

Dimension	Indicator	Measurement Approach	Binary "Empowerment" Cut-off	Indicator Weight
Production	Production Decision-making	The respondent is first asked whether they were involved in certain productive activities, such as cultivating food and cash crops, rearing livestock, or running an off-farm business during the past 12 months. If so, they were then asked the extent to which they were involved decisions about how the activity was undertaken, e.g. the types of crops planted and how they were managed.	Respondent reports at least being involved to a medium extent in two of the productive decision-making areas.	1/10
	Autonomy in Production	Six different vignettes are read out one by one to the respondent, and s/he is asked the extent to which they are like the character in the vignette. In two of the vignettes, the character does not have decision-making power. In two others, s/he mainly acts in a way their family and/or community expect. In another two, the character acts in a way s/he believes is right and could choose to act differently if they wanted to.	Respondent states s/he is (a) not like or only a little like the two characters that have no decision-making power; (b) not to a large extent like both characters that mainly act in a way that is expected; and (c) a least to a medium extent like the two characters that have productive autonomy	1/10
Resources	Asset Ownership	The respondent is asked whether they personally own or partly own various productive assets, such as land, woodlots, livestock, poultry, fish ponds, farming equipment, or bee hives or bee keeping equipment. They are then asked who owns most of the item in their household.	Respondent owns (i.e. states both that they personally own and can decide to sell, etc. the item) at least two small asset or 1 large asset, i.e. land, mechanized agricultural equipment, wood lot, large livestock, fish pond, bee keeping equipment, or vehicle.	1/15
	Control over assets	For each of the above items, the respondent is asked who in their household could decide to sell, exchange or give away the item.	Respond both says they own and can sell, exchange or give away at least two small assets or 1 large asset.	1/15
	Access to credit	Respondent is asked two questions (a) whether anyone in their household took out a loan from various sources over the past 12 months, as well as who in the household did so and decided how to use the credit; and (b) if their household hypothetically had to borrow money, whether it could and who in	Respondent either states that their household took out a loan in the previous 12 months and was solely or jointly involved in deciding how the money was spent or their could take out an loan if need and they would be either solely	1/15

Dimension	Indicator	Measurement Approach	Binary "Empowerment" Cut-off	Indicator Weight
		their household would decide about how to use the money.	or jointly involved in deciding how this money would be used.	
Income	Control over income	Respondent is asked whether s/he was involved in selling food crops, cash crops, livestock, or fish or running an off-farm business or participating in wage labour and, if so, the extent to which they decided on how the money earned was used.	Respondent reports being involved in at least 1 cash earning activity and in control of how the resulting money was used to at least a medium extent.	1/5
Leadership	Active group member	The respondent is asked whether s/he had participated in various groups over the past year and, if so, the approximate number of times they met with groups and their involvement in group decision-making.	Respondent reports being in at least 1 group and has met with this groups more than two times over the past year and is involved in group decision-making to at least a medium extent.	1/15
	Confidence in public speaking	Respondent is asked whether they are comfortable speaking in public in three specific situations, i.e. helping to decide on public infrastructure, ensuring proper payment for work they have undertaken, and protesting the behaviour of elected officials.	Respondent reports speaking with little or no in at least one of the three issues.	1/15
	Self-efficacy	Self-efficacy scale is administered to the respondent. http://userpage.fu-berlin.de/health/selfscal.htm	Respondent states that s/he is confident to at least a medium extent in relation to four of the six statements	1/15
Leisure & low stress	Leisure time	WEAI's Activity Profile is administered to profile the respondent's activities during the previous regular working day.	Respondent engaged in less than 10.5 hours of productive work during the previous day.	1/10
	Low stress	Perceived stress scale is administered to respondent. http://www.mindgarden.com/132-perceived-stress-scale	Respondents score positively on more than five of the 10 scales items.	1/10

Annex 4: Details of the Multidimensional Poverty Index (MPI) Adapted for DryDev

Dimension	Indicator	Measurement Approach	Binary MPI Cut-off	Indicator Weight
Health	Under-5 mortality	Respondent is asked whether any under-5 child from their household had passed away during the last 5 years.	HH death of under-5 child in last 5 years	1/6
	MDD-W	Respondent is asked specific types of foods eaten during the previous day. These food items fall into 10 groups.	Respondent reports consuming less than 5 of the 10 food groups.	1/6
Education	Education of adults in HH	Respondent is asked to provide information on how many years of formal education each adult in the household has	No adult in the household has had at least 5 years of formal education.	1/6
	School attendance	Respondent is asked whether each child over the age of 5 is attending school.	At least one children between the ages of 7 and 15 years is not going to school.	1/6
Living Standards	Cooking Fuel	Respondent is asked the main fuel the household uses for cooking.	Household cooks with wood, animal dung, or crop residue, rather than electricity, gas, or charcoal.	1/18
	Improved sanitation	Respondent is asked the type of toilet facilities the household regularly used.	Household does not have flush toilet or pit latrine of any type with slab.	1/18
	Safe drinking water	Respondent is asked about the household's regular source of drinking water.	Household draws its drinking water from unprotected source, such as river or unprotected well or spring.	1/18
	Electricity	Respondent is asked whether their household has electricity.	Household does not have electricity	1/18
	Flooring	Respondent is asked main type of floor their home has.	Floor of home primarily made of earth.	1/18
	Assets	Respondent is asked whether they or anyone in their household has specific small assets (i.e. radio, TV, bicycle, and/or phone) or larger assets (i.e. motorcycle, car/truck, or fridge/freezer)	Household has less than 2 small assets and less than 1 large asset	1/18

Annex 5: Details of the Resilience Index Adapted for DryDev

Dimension	Indicator	Measurement Approach	Binary Resilience Cut-off	Indicator Weight
Livelihood viability	Poverty status	See Subsection 7.1: Household Consumption Expenditure.	>= to $1.90 PPP adjusted per capita per day poverty cut-off	1/24
	Food security	Same as MDD-W	Same as MDD-W	1/24
	Livelihood diversification	Respondent is asked specific questions about livelihood activities undertaken by household during the previous 12 months	Household undertook at least two livelihood activities, with at least 1 being largely unaffected by potential drought or flooding	1/24
	Crop diversification	Respondent is asked specific questions about the types and number of crops planted in previous 12 months	Household grew at least three crop varieties during previous 12 months	1/24
	Livestock portfolio	Respondent asked about the types of livestock owned by the household	Household possesses at least 2 varieties of livestock, with at least one considered hardy to adverse climate conditions, e.g. goats, sheep, or camels.	1/24
	Climate forecasting info. access	Respondent is asked to rate their household's access to reliable seasonal forecasting info. on a four point ordinal scale	Respondent reports having no problems or only small problems access such information	1/24
Innovation potential	Extension support	Respondent is asked whether their household received extension support in previous 12 months and, if so, the number of times	Respondent reports having had received extension support more than 1 time during the previous 12 months	1/20
	Credit access	Respondent asked whether their household took out a loan during the previous 12 months or whether they could borrow at least $200 if the need arose	Respondent reports that household took out loan during the previous 12 months or could borrow at least $200 if the need arose.	1/20
	Market access	Respondent is asked to rate their household's access to markets on a four point ordinal scale	Respondent reports having no problems or only small problems accessing markets to sell crops or livestock	1/20
	Access to market info.	Respondent is asked to rate their household's access to market info. on a four point ordinal scale	Respondent reports having no problems or only small problems accessing reliable market information on crop and livestock prices	1/20

Dimension	Indicator	Measurement Approach	Binary Resilience Cut-off	Indicator Weight
	Education, literacy, and skills	Respondent is asked profile each adult member of their household, including number of years of education and whether the person can read and write.	At least 1 adult in household reported as being literate and having at least 5 years of formal education.	1/20
Access to contingency resources & support	Savings	Respondent is asked whether their household has any savings and, if so, how many days their household could survive living off these savings alone.	Respondent reports household has savings which would enable the household to survive at least 14 days.	1/16
	Group membership	Same questions as in WEIA.	Respondent reports participation in at least 3 groups with significant decision-making in at least 1 of these.	1/16
	"Fungible" livestock	Respondent is asked whether their household owns at least 3 goats/sheep and at least 5 poultry birds	Respondent reports that their household possesses at least 3 goats/sheep or at least 5 poultry birds	1/16
	Confidence in local gov.	Respondent is read 5 statements about the responsiveness of local government and leaders in times of crisis and asked the extent to which they agree with each	Respondent agrees at least to a medium extent to 4 out of the 5 statements.	1/16
Integrity of natural and built environment	Soil erosion	Remote sensing based (see Section 11)	Less than 1/3 of the pixel is estimated to be significantly eroded.	1/16
	Soil organic carbon	Remote sensing based (see Section 11)	Greater than 15 grams of carbon estimated to be in the soil	1/16
	Access to irrigation	Respondent is asked whether any of the fields the cultivated in the last 12 months were irrigated.	Household reports at least 1 of their fields was irrigated.	1/16
	Grazing land access	Respondent is asked to rate their household's access to grazing land or use of fodder on a four point ordinal scale	Respondent reports household only experiencing small problems or no problems accessing suitable grazing lands or fodder during last dry season	1/16