FARMING PRODUCTION DIVERSITY, MARKET PARTICIPATION, VILLAGE SAVINGS AND LENDING, AGRICULTURAL TECHNOLOGY ASSOCIATION WITH DIETARY DIVERSITY AND ASSET ACCUMULATION

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EXECUTIVE SUMMARY

Food and nutrition security in rural Zimbabwe are linked to the performance of agriculture, not only because food is from agriculture, but also because many malnourished people reside in rural areas where agriculture is the main livelihood activity. In this study, influences of farm production diversity, market participation, VS&L participation and agricultural technologies on nutrition, farm income and assets accumulation were investigated. Cross-sectional data collected through a household survey was used to estimate regression models and draw inferences on the nature of the relationships. The choice of key explanatory variables used in the study was informed by the interventions that are promoted under the ENSURE project’s strategic objective of increasing household income. The study sought to provide empirical evidence of the nature of association between the mentioned variables in the context of smallholder farmers and also contribute to growing literature on relationship between farm production diversity and nutrition.

The descriptive statistics from the study showed mixed results with regards the extent farm households integrated improved farming practices promoted in the project. A positive finding showed that over 80% of the farmers used improved seed varieties in at least one crop they cultivated during the 2017/18 season. On average each household cultivated five different crop species and kept three different types of livestock. Adoption of minimum tillage, a conservation agriculture component, was found to be low, with 40% of farmers partially adopting. Other associated practices such micro-dosing was also adopted by low (<30%) proportion of the farmers. Fodder production, that specifically focused on improving livestock production, was adopted by less than 20% of the farmers, despite over 70% of farmers owning livestock and being at risk of facing feed shortages during the dry season. The main source of technical information for farmers were government departments such as AGRITEX. Lead farmers who were promoted in the project were cited by few (20%) farmers as a source of information.

On average at household level, less than six food groups out of 12 used in calculating household dietary diversity score (HDDS) were consumed, with 52% of the households falling into category of low dietary diversity score. The pattern was similar for individual level dietary diversity, which in this study focused on women members of the household of reproductive age. The results showed that on average, women consumed less than 4 out of 10 food groups used in calculating Women Dietary Diversity Score (WDDS). The most frequently consumed food groups during a 24-hour recall period at both household and women level, were cereals and vegetables. All (100%) of households and women in the study consumed cereals and over 90% consumed for vegetables. Few households and women reported consuming animal-based products during the 24-hour recall period Few households consumed fruits (31%), milk and dairy products (31%), meat (22%), fish (12%), roots and tubers (12%), and eggs (10%).

Crop and livestock production diversity were found to be positively and significantly associated with household dietary diversity (HDD), while only crop diversity was significantly associated with women dietary diversity (WDD). A unit increase in number of crop species cultivated resulted in 4% and 5% increase in HDDS and WDDS, respectively. Market participation was also positively and significantly associated with both HDDS and WDDS, with a 1% increase in the proportion of total output marketed resulting in 0.3% increase in in both HDDS and WDDS. Participation in VS&L and adoption of improved technologies had positive and significant effect on HDDS only. Households that were members of VS&L groups tended to have HDDS which were 5% higher than those who were not members. Of the agricultural technologies included in the model, only fodder production had a significant and positive relationship with HDDS. On indicators related to building household resilience capacity, the study
found that households that participated in VS&L, and those that adopted improved technologies, tended to realise higher agricultural income. Asset accumulation was also positively influenced by VS&L, diverse livestock production, and market participation.

The findings of the study show that promoting agricultural diversification, VS&L and market participation have a positive effect on nutrition and contribute to building resilience capacity of households.
1. INTRODUCTION

Nutrition is closely linked to agriculture, not only because food comes from the sector, but also because the majority of the undernourished are smallholder farmers residing in rural areas of the developing countries like Zimbabwe, (Koppmair, Kassie and Qaim, 2017). Interventions in agricultural development have traditionally focused on improving household food security through enhancing access to the staple crop from the farmer’s own production. Despite these efforts, problems of chronic malnutrition remain pervasive among rural populations and thus calls for a paradigm shift in the design of programs that aim to address the challenge. Improving access to diverse foods from the farmer’s own production or from the market by farm households are some of the interventions that are likely to improve nutrition outcomes at both household and individual levels. There is growing literature showing the relationship of farm production diversity and nutrition. The conclusions in most of these works show that there exists a positive and significant association between agricultural production diversity, market participation and intake of improved diets, (Murendo et al., 2018), (Koppmair, Kassie and Qaim, 2017), (Ochieng et al., 2017), (Pellegrini and Tasciotti, 2014), (Sibhatu, Krishna and Qaim, 2015). This positive relationship is plausible because most of what smallholders consume is usually produced on farm, (Sibhatu, Krishna and Qaim, 2015). These findings further highlight the centrality of supporting interventions that enhance farm production diversity and market participation in improving dietary diversity, which is positively associated with nutrition outcomes at individual level (Traissac and Delpeuch, 2007).

Enhancing Nutrition, Stepping Up Resilience and Enterprise (ENSURE) programme, from which this report draws its data, is an integrated USAID-funded programme underpinned by three strategic pillars to contribute to the long-term food and nutrition security of communities in Zimbabwe. ENSURE provides an opportunity for empirical evidence on the association of dietary diversity and agricultural diversification, market participation, and agricultural technology. These are key interventions promoted under the strategic objective of the programme of increasing household and micro-enterprise productivity and income through market-oriented approaches, commonly referred to as Strategic Objective 2 (SO2). The purpose of the study was to establish whether the interventions promoted in the project were influencing outcomes targeted by the project, to build a case for continued pursuit, adaptation, or consideration in future programs. This report is also contributing to growing literature on the association of production diversity, market participation, access to information, participation in Village Lending and Saving (VS&L) groups, and adoption of improved technologies and nutrition in the context of smallholder farmers in the semi-arid regions. Other dependent variables considered are agricultural income and asset accumulation, these being indicators for household resilience capacity. This report presents findings of the analysis of cross-sectional data that was collected through a household survey carried out in 4 of the 6 districts covered by the ENSURE programme, where 331 randomly selected households were interviewed.

The next section describes the study area, the methodology that was used and definitions of the concepts as they were used in the study. It is followed by a section that details both the descriptive and econometric results of the study. A section discussing the key findings follows. The last section is the conclusion.
1.1. Context
ENSURE, which was initially a 5-year program, before a 2-year extension, is organised around three interrelated strategic objectives. Its goal is to contribute to the long-term food security of communities in Zimbabwe. The three Strategic Objectives (SOs) are: (1) to improve nutrition among women of reproductive age, pregnant and lactating women, and children under five years of age; (2) to increase household and micro-enterprise productivity and income through market-oriented approaches; and (3) to increase household resilience to shocks. This study focuses on Strategic Objective 2 (SO2), improving household income. SO2, aims to address underlying causes of chronic food insecurity, through enhancing the knowledge, capacity, access to markets for income generation, asset building and savings of farm households in six districts across Manicaland and Masvingo provinces, Figure 1.

Figure 1: Distribution of ENSURE wards in relation to agro-ecological regions of Zimbabwe

The household survey was carried out during the month of September, which is around 4 months after the harvest of the staple crop under a normal season. It took place against a background of political developments in the country that commenced in November 2017 and culminated in elections during the month of July. The Presidential input programme and Command Agriculture programmes were active during the 2017/2018 agricultural season. Both programmes are designed to improve access to inputs for farmers under both dryland and irrigation in the country, and project participants could also have benefited from these as well.

A number of limitations exist in this study. The study did not include qualitative data from focus group discussions and key informant interviews, for example, to gain an in-depth understanding of some of the issues that emerged from the analysis of the quantitative data. In addition, the study was based on cross-sectional data, which only captured a moment in time and, as such, could not account for the changes in dependent variables as the explanatory variables used in the study changed. With the study...
limited to four districts of the country, where ENSURE targeted a specific group of farmers, the results might not be applicable in other areas and programs.

2. METHODOLOGY

2.1. Data and Sampling

The study covered four districts from the two provinces targeted by the project. Data was collected using a structured questionnaire, which was administered by trained enumerators. A group of eight enumerators and two supervisors underwent a week-long training to gain in-depth understanding of the data collection tool. To ensure collection of high quality data, a thorough inspection of the completed questionnaires to check on correctness and completeness was undertaken in the field. Enumerator training, and household survey and data entry and cleaning using SPSS was carried out from the 4th of September 2018 to the 23rd of October 2018. Data for the following variables was collected: household characteristics, farming activities, market participation, household and individual dietary intake during a 24-hour recall period, access to information, participation in various grouping including VS&L, and productive and non-productive asset holding, (See Annex 1, Questionnaire).

The first-choice sampling frame was a list of SO2 households that were also participating in the other SOs. Unable to access such a database, the SO2 database was used as the sampling frame. The first stage of sampling involved a convenient selection of four districts, namely Buhera, Chimanimani (Manicaland) and Bikita and Zaka (Masvingo). Wards and villages, thereafter, were randomly chosen. From each village list, households were randomly selected and, in the case, that the selected household could not be interviewed due to absence or other reasons, a nearby qualifying household was interviewed as a replacement. The sample size was determined through the Cochran’s formula:

\[
n_0 = \frac{Z^2 \cdot p \cdot q}{e^2}
\]

where \(n_0\) = sample size, \(Z\) values for the confidence level, \(p\) is the level of variability in the level of attributes being measured, \(q=1-p\) and \(e\) is the level of precision (margin of error). Using a confidence level of 95%, \(p = 0.5\) (indicating maximum variability in the population), and margin of error 5%, a sample size of 385 beneficiary was found to suffice for the study. A total of 331 households were eventually sampled, representing about 86% of the target. Table 1 shows the distribution of the respondents.

<table>
<thead>
<tr>
<th>District</th>
<th>Number of Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buhera</td>
<td>77</td>
</tr>
<tr>
<td>Chimanimani</td>
<td>80</td>
</tr>
<tr>
<td>Bikita</td>
<td>96</td>
</tr>
<tr>
<td>Zaka</td>
<td>78</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>331</strong></td>
</tr>
</tbody>
</table>
3. DESCRIPTION OF CONCEPTS AND THEIR MEASUREMENT

3.1. Dietary Diversity Scores
Dietary diversity is a widely used proxy for nutrient adequacy. In this study it was measured through dietary diversity score, which is simply a sum of different food groups consumed at household or individual level during a reference period, usually a 24-hour recall period. Specific food consumed is placed in appropriate food group and it is the food groups that are used in calculating the score and not the specific food consumed. The 24-hour recall period is used in many dietary diversity studies, (Ochieng et al., 2017) and evidence exists that it is significantly associated with nutritional outcomes of individuals at household level, (Traissac and Delpeuch, 2007). Assessing food consumption through the 24-recall period is simpler, faster and cheaper than quantitative or frequency methods. The reference period of 24-hours is generally subject to less recall errors than the 7-day or longer recall period. For results to give an accurate picture of the normal diet during a particular period, focus should be on a normal diet typically consumed in the household. It therefore becomes important to verify that the 24-hour recall period did not coincide with special occasions such as weddings, funerals, religious events and others, (Bilinsky and Swindale, 2006). This study measured household and individual level (women of reproductive age) dietary diversity scores and these were used as dependent variables the regression models.

3.1.1. Household Dietary Diversity Score (HDDS)
HDDS is designed to reflect dietary diversity at household level. It incorporates food groups consumed by members of the household. Information on different food consumed in the household is collected using a 24-hour recall. For the score, a total of 12 food groups are, (Bilinsky and Swindale, 2006). Food groups used in this study for calculating HDDS are: cereals, roots and tubers, vegetables, fruits, meat, eggs, fish, nuts and pulses, milk and dairy products, oils and fats, condiments and beverages, sugar, sweets. HDDS provides a snapshot of the economic ability of a household to access a variety of foods. For each household the diversity score is calculated as follows;

\[
HDDS = A + B + C + D + E + F + G + H + I + K + L
\]

Where A to L are food groups consumed by members of the household and will either be 0 or 1. The score ranges from 0 to 12 per household.

3.1.2. Women Dietary Diversity Score (WDDS)
WDDS is an individual level dietary diversity score, specific to women of reproductive age, that is, those aged between 15 and 49 years. As with the HDDS, WDDS is calculated by summing the number of different food groups consumed by women household members during a 24-hour recall period preceding the interview. The number of food groups used in calculating individual dietary score was 10, less than the 12 used to calculate HDDS. While outside pregnancy or lactation, other than iron, the requirements for women of reproductive age (WRA) may similar to say that of men, they require a more nutrient-dense diet because they are small and eat less quantities, (FAO and FHI 360, 2016). According to (Ochieng et al., 2017), research has shown that food groups such as; fats and oils, sugar/honey and condiments do not contribute to the micro-nutrient density of the diet and as such are not part of the dietary diversity score for women. The food groups used in computing WDDS were;
cereals; pulses; dark green leafy vegetables; vitamin-A rich fruits and vegetables; roots and tubers; other fruits and vegetables; milk and milk products; egg; fish; meat.

3.2. Farm Production Diversity
Production diversity is a composite measure consisting of crop and livestock diversity. It is a simple count of both plant and animal species produced on farm. Crop diversity score considers crops cultivated in the 12 months preceding the date of the survey. The same approach applies to livestock diversity score.

3.3. Market Participation
There are a number of ways that have been used in different studies to measure the level of market participation of farmers. These include dummy variables for whether a farmer sold agricultural produce or not; where ‘1’ is for yes and ‘0’ for no. The method is simple and less cumbersome, especially on the farmer as it only requires recall on sales. In this study however, we opted for the proportion of output that was sold by the farmer. In other words, we were measuring the intensity of farmer participation in the market. We modified the formula used by (Osmani and Hossain, 2015), for market participation by only using quantities sold and total production as shown in the following formula;

\[ \text{Market Participation} = \frac{\text{Total quantity of crops sold}}{\text{Total quantity of crop production}} \]

3.4. Resilience
Resilience is defined as the capacity that ensures adverse stressors and shocks do not have long lasting adverse developmental consequences, (Smith and Frankenberger, 2018). The concept of resilience aims at measuring households’ capability to absorb the negative effects of shocks and is a legitimate component of vulnerability assessment, (Alinovi et al., no date). A household that is resilient has the capacity to maintain its well-being in the face of shocks and stressors. While resilience is the ability to recover or cope with shocks, resilience capacity is a set of conditions, attributes or skills that are thought to enable the household to achieve resilience in the face of shock. Resilience cannot be observed, but can be assessed through variables that are observable and measurable. Several indicators are used to measure different resilience capacities (Absorptive capacity; adaptive capacity and transformative capacity) that collectively give the resilience capacity of a household. Resilience capacities are measured as a set of indices, one for each dimension of resilience capacity (Capacities and Op, 2018). While we note that there is no single indicator that measures resilience according the measurement framework developed by the Resilience Measurement Technical Working Group (RMTWG), in this report we focus on two indicators, agricultural income and assets. Both agricultural income and assets are included contribution of the intervention to building resilience capacity of households. Household resilience is made of several pillars and income and assets constitute part of the pillars. While the two do not necessarily give a full picture of household resilience, it is expected that interventions that enhances the two has a positive effect to the household resilience.

3.5. Agricultural Income
Agricultural income used in this study is the sum of income from crop and livestock sales. It is common for data on agricultural income to have many zeros, either through genuine responses of no sales during the reference period or respondents withholding the information (Humphreys, 2013). Whenever a variable, such as income, has many observed data values that are zero during the survey, it does not necessarily mean that the respondent does not earn agricultural income but could be a case that during the reference period in the survey, no income was realised.
3.6. Asset Index
We use factor analysis to aggregate several binary variables for ownership of specific assets into an asset index. Included in the construction of the asset index are both productive and non-productive assets, which include; ploughs, oxen, scotch carts, radios, TVs, solar panels, mobile phones, bicycles, wheelbarrows and harrows among others. Assets may provide insights into long term living standard than a snapshot of income because they have been accumulated over time and last longer and can also enhance the capacity of the farm household to meet its food requirements, (Moser and Felton, 2007).

4. ANALYTICAL APPROACH

4.1. Poisson Regression Models
Dietary diversity, crop and livestock diversity scores are count variables. The common approach for handling models in which the dependent variable is a count variable is to estimate such models using Poisson regression, which is a log-linear function. Poisson regression models the log of the expected count as a function of the independent variables. The choice of the specific form of Poisson regression will depend on whether the assumption that the mean and variance of the dependent count variable are equal, holds, or is violated. In the case that the two statistics are equal, the data would be said to fit the Poisson distribution and standard Poisson regression model will be appropriate as it will result in consistent coefficients. However, when the assumption is violated, which is common, either Binomial negative regression (variance greater than mean) or Generalised Poisson regression model (variance less than the mean) is used. In this study, the Generalised Poisson model was used and the models were estimated using STATA.

4.1.1 Dietary Diversity
To analyse the relationship between dietary diversity and farm production diversity, market participation, VS&L participation and improved agricultural technology, the following generalised Poisson regression model was used:

$$DD = \beta_0 + \beta_1CD + \beta_2LD + \beta_3M + \beta_4S + \beta_5AT + \beta_6H + \epsilon$$

where DD is log dietary diversity score; CD is crop production diversity score; LD is livestock production diversity score; M is the proportion of farm production marketed; S is dummy variable for participation in Village Lending and Savings group; AT is a vector of dummy variables for adoption of agricultural technologies by household; (CD, LD, M, S and AT are variables of interest); H is a vector of socio-economic characteristics of household; $\epsilon$ is error term; $\beta_1$...$\beta_6$ are coefficients to be estimated, which will show the direction and magnitude of the relationship between the independent variable and dependent variable.

To check the robustness of the model, we estimated the regression model in stages, with the first equation consisting of crop and livestock diversity scores only as the explanatory variables and added other individual explanatory variables of interest. if the model is robust, the statistical significance of the coefficient will not change as a result of adding explanatory variables.
4.1.2 Drivers of Farm Production Diversity
We also estimate a generalised Poisson regression model to investigate the drivers of crop and livestock diversity. The models are specified as follows;

\[ CD = \beta_0 + \beta_1 S + \beta_2 LD + \beta_3 DM + \beta_4 H + \epsilon \]  
\[ LD = \beta_0 + \beta_1 S + \beta_2 CD + \beta_3 DM + \beta_4 H + \epsilon \]  

where, CD is log crop diversity score; LD is log livestock diversity score; S is a dummy variable for being a member of the VS&L; DM is distance to market; H vector of household socio-economic factors; \( \epsilon \) is error term; \( \beta_1,...,\beta_6 \) are coefficients to be estimated.

4.2. Drivers of Agricultural Income
The model in which agricultural income is the dependent variable is estimated in this study using Tobit regression model. The distribution of agricultural income with many zeroes is skewed and using Ordinary Least Squares (OLS) regression will result in inconsistent coefficient estimates, due to extreme values in the data set. Using log transformations does not work well for income data, because a substantial subset can indicate zero income and \( \ln(0) \) is undefined. To deal with this challenge, one could exclude the cases with zero, but in so doing ignore a significant segment of the population. The Inverse Hyperbolic Sine (IHS) transformation presents a solution to the problem. To explore the drivers of agricultural income Tobit regression model is specified, with log transformed agricultural income as the dependent;

\[ ihs(Y) = \beta_0 + \beta_1 S + \beta_2 CD + \beta_3 LD + \beta_4 AT + \beta_5 DM + \beta_6 H + \epsilon \]  

where, \( ihs(Y) \) is a latent variable for Agricultural income, observed for values greater than zero and censored for values less than or equal to zero

\[ AI = \begin{cases} 
  ihs(Y), & x > 0 \\ 
  0, & x \leq 0 
\end{cases} \]

4.3. Asset Holding
In addition to agricultural income, the study also investigated how factors such as participating in VS&L group market participation, crop and livestock production diversity and agricultural technologies were associated with household asset holding. To analyse the association, we estimated the following Ordinary Least Squares (OLS) regression model;

\[ A = \beta_0 + \beta_1 S + \beta_2 CD + \beta_3 LD + \beta_4 AT + \beta_5 M + \beta_6 H + \epsilon \]  

where A is Asset index; S is a dummy variable for being a member of the VS&L; CD is crop production diversity score; LD is livestock diversity score; AT is a vector of dummy variables for adoption of agricultural technologies by household; DM is distance to market; M is market participation vector of household socio-economic factors; \( \epsilon \) is error term; and \( \beta_1,...,\beta_6 \) are coefficients to be estimated.

4.4. Regression Estimates
4.4.1. Poisson Regression Estimates  
Recall the Poisson regression model is a log-linear model and as such the coefficients should not be interpreted as representing a change in the dependent variable as a result of a unit change in the explanatory variable of interest. Technically, the coefficients are directly interpreted as the difference between the log of expected count as a result of 1 unit change in the explanatory variable.

A more convenient way of estimating the coefficients is to explain them as the percentage change in the dependent variable as a result of a unit change in the explanatory variable. To do so will require minor mathematical manipulation. We first get the exponent of the coefficient, $\exp(\beta)$ and to get the percentage change of the dependent count variable as a result of a unit increase in the explanatory variable, we use the following expression:

$$\exp(\beta) - 1$$

4.4.2. Tobit Regression Estimates  
Since the income dependent variable is log transformed, the interpretation of the coefficients will be same as explained in section 4.4.1.

4.4.3. OLS Estimates  
For the asset index model, recall that asset index is a composite index generated from many different assets through factor analysis. Since we are dealing with a composite measure, what will make sense is to focus on the sign of the coefficient and not the magnitude.

4.4.4. Significance Testing  
In all the equations 1-5, the null hypothesis being tested is that the regression coefficients are equal to zero, implying that there is no relationship between the dependent and independent variable. The alternative hypothesis is that these coefficients are not zero and therefore a relationship exists. The decision rule is that when $p-value < \alpha$, where $\alpha$ is the significance level, we conclude that there is strong evidence against the null hypothesis and reject it, in other words, we conclude that the relationship is statistically significant and not due to chance.

5. RESULTS

5.1. DESCRIPTIVE STATISTICS

5.1.1. Socio-Economic Characteristics  
Table 2 shows descriptive statistics for selected socio-economic characteristics. Average age of household head at the time of the survey was 55 years, with the majority (60%) aged between 40 and 60 years, 24% over 60 years and 16% below 40 years. Just below 25% of the households were female headed. About 20% of the households indicated that they had at least one member who was chronically ill. Information on household composition showed that there were about 20% and 66% of the households that had at least one member who was below the age of 2 years and women of reproductive age (15-49 years), respectively. On average, households had access to about 3ha of arable land. As expected, a significant proportion of households participated as members in farmers producer groups and VS&L. These types of groups were promoted under SO2 for capacity building of farmers, market participation, and access to financial resources. Almost 50% of the respondents indicated that agricultural activities provided the bulk of the income, while 40% indicated that their main source of income was off-farm activities.
Table 2: Socio-economic characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household head age</td>
<td>Age of household head in years</td>
<td>54.6(18.5)</td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>Total number of household members</td>
<td>5.9(2.5)</td>
<td></td>
</tr>
<tr>
<td>Education level of household head</td>
<td>Numbers of years in education for household head</td>
<td>8.3(3.4)</td>
<td></td>
</tr>
<tr>
<td>Female-headed households</td>
<td>Proportion of households headed by females</td>
<td></td>
<td>22.8</td>
</tr>
<tr>
<td>Chronically ill HH member</td>
<td>Chronically ill household members (1=yes)</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>Children between 6 and 23 months</td>
<td>Child between age of 6 and 23 months (1=yes)</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Households with women of reproductive age</td>
<td>Women between age of 15 and 49 years (1=yes)</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>Arable land size</td>
<td>Total arable land under the control of the household in ha</td>
<td>2.9(1.7)</td>
<td></td>
</tr>
<tr>
<td>Farmer group</td>
<td>Member of farmer producer group (1=yes)</td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>VSL membership</td>
<td>Member of VS&amp;L group (1=yes)</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>Agric income</td>
<td>Agriculture as main source of income (1=yes)</td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>Off-farm income</td>
<td>Off-farm income as main source of income (1=yes)</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Remittances</td>
<td>Remittances as the main source of income (1=yes)</td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard deviation

5.1.2. Dietary Diversity and Food Access
Household and women dietary diversity scores and information related food production and access is shown in Table 3. The results showed that households, on average, consumed five different food groups during a 24-hour recall period and women consumed about four food groups that were considered in calculating WDDS. This difference is not unusual; first the household level measurement considers food groups consumed by household members, while the WDDS is an individual level measurement. Secondly, the total number of food groups used to derive the two scores differed. Households were categorised into three groups based on HDDS. Those with scores 5 and below were considered to have low dietary diversity, while medium group had a score of 6-7, and those in the high category had scores of 8-12, (Murenko et al., 2018). About 52% of the households in the sample could be categorised as having low diversity, 40% having medium diversity and just about 8% classified as having high dietary diversity.
Slightly over 50% of the households indicated they had managed to produce enough food from the 2017/18 season production to last them until the next harvest in 2019. This was consistent with over 60% of farmers who indicated that the quality of season ranged from average to very good. Also interesting was that 40% of farmers indicated that compared to similar seasons of the past, their yields had improved. Drought, shortage of inputs, and low soil fertility were the reasons that were put forward for inadequate food production during the 2017/2018 season. To fill the food gap caused by low production, 56% of the affected households indicated that they were going to rely on off-farm income to purchase food from the market. Other means to address the food shortage included remittances, food aid, and sale of livestock to buy food.

Table 3: Food access and nutrition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household dietary diversity score</td>
<td>Number of food groups consumed in the household in 24hr period</td>
<td>5.3(1.3)</td>
<td></td>
</tr>
<tr>
<td>Women dietary diversity score</td>
<td>Number of food groups consumed Women Dietary Diversity Score (age 15-49 years) in 24hr period</td>
<td>3.7(1.2)</td>
<td></td>
</tr>
<tr>
<td>Food production adequacy</td>
<td>Households with adequate food supply from own production</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Drought</td>
<td>Drought as a reason for food shortfall from own production (1=yes)</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Shortage of inputs</td>
<td>Shortage inputs as a reason for food shortfall from own production (1=yes)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Low soil fertility</td>
<td>Low soil fertility as a reason for food shortfall from own production (1=yes)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Food Aid</td>
<td>Food aid to fill food gap (1=yes)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Off-farm income</td>
<td>Purchases using off-farm income to fill food gap (1=yes)</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Livestock sales</td>
<td>Livestock sales to fill food gap (1=yes)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Remittances</td>
<td>remittances to fill food gap (1=yes)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Crop yields past 5 years</td>
<td>Crop yields improving in the last 5 years increasing (1=yes)</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard deviation

5.1.3. Household Dietary Diversity

The most consumed food types were cereals and vegetables during the 24-hour period preceding the survey (Table 4). All households indicated consuming a cereal based food items and this was expected, given that maize was a staple. The source of cereals consumed was own production for over 90% of the respondents. Vegetables and fats and oils were also widely consumed, with over 90% of the respondents reporting that these were part of the diet. The pattern is similar to the findings contained in the baseline report. The vegetables were also mainly sourced from own production. Over 80% of the respondent indicated that they relied on the market to access fats and oils. Pulses and nuts were consumed by slightly over 50% of the respondents, with 80% of the households indicating that they sourced these from own production. Few households consumed fruits (31%), milk and dairy products (31%) meat (22%), fish (12%), roots and tubers (12%) and eggs (10%).
Table 4: Household dietary diversity and food sources

<table>
<thead>
<tr>
<th>Food group</th>
<th>Consumption (%)</th>
<th>Main Source</th>
<th>Own production</th>
<th>Purchased</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>100</td>
<td>%</td>
<td>92</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>12</td>
<td>49</td>
<td>44</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>91</td>
<td>91</td>
<td>7</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>31</td>
<td>89</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>22</td>
<td>62</td>
<td>30</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>10</td>
<td>97</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>12</td>
<td>13</td>
<td>83</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Nuts and pulses</td>
<td>53</td>
<td>84</td>
<td>12</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Milk and dairy</td>
<td>31</td>
<td>54</td>
<td>43</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Oils and fats</td>
<td>91</td>
<td>7</td>
<td>82</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Condiments</td>
<td>76</td>
<td>26</td>
<td>71</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>72</td>
<td>24</td>
<td>71</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

5.1.4. Women Dietary Diversity

Table 5 shows the distribution of the consumption of different food groups consumed by WRA. As with the HDDS, all the women indicated consuming cereal-based foods during the reference period. The second widely consumed food group were dark leaf vegetables such as rape, chomoullier, pumpkin greens, spinach, and amaranth green food that were consumed by 60% of the target group. Other vegetables and fruit such as cabbage, cucumbers, okra, tomato, and banana, were consumed by almost 60% of the women during the recall period. Nuts and pulses were consumed by more than half of the WRA. Vitamin-A rich vegetables, that included pumpkins and carrots, were consumed by 18% of the respondents. As with HDD, the proportion of WRA who indicated consuming animal-based protein was low: meat (26%), milk and dairy products (26%), fish (12%), and eggs (9%).

Table 5: Proportion of WRA who consumed food in each food group

<table>
<thead>
<tr>
<th>Food group</th>
<th>Number (sample size)</th>
<th>Consumed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>218</td>
<td>100</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Dark leafy vegetables</td>
<td>131</td>
<td>60</td>
</tr>
<tr>
<td>Vitamin A-rich vegetable and fruit</td>
<td>40</td>
<td>18</td>
</tr>
<tr>
<td>Any vegetable and fruit</td>
<td>128</td>
<td>59</td>
</tr>
<tr>
<td>Meat</td>
<td>56</td>
<td>26</td>
</tr>
<tr>
<td>Eggs</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Fish</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>Nuts and pulses</td>
<td>111</td>
<td>51</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>57</td>
<td>26</td>
</tr>
</tbody>
</table>

5.1.5. Agricultural Production

Table 6 shows information related to farming activities carried out by farm households. Most (75%) farm households practice mixed-crop livestock farming. On average, farm households cultivated over five different crop species that fell into a maximum of three food groups and kept three different types of livestock (cattle, goats and poultry). Cereal crops were widely planted, with all respondents planting maize during the 2017/18 season. Other widely grown crops included legumes (96%) and vegetables (92%). In line with enhancing farmers’ knowledge and capacity, the project has been promoting
adoption of improved agricultural practices, such as conservation agriculture, use of improved seed varieties, fodder production, and micro-dosing. A total of 40% of the respondents reported practicing minimum soil tillage, a principle of conservation agriculture, on a portion of total cultivated area. Over 80% of the farmers indicated that they used inorganic fertilisers and improved seed varieties in crop production. While the percentage of those who used fertiliser was high, the same could not be said about micro-dosing, which was practiced by less than 30% of the respondents. The high proportion of farm households that indicated using improved inputs, particularly fertiliser, could be attributed to a government input subsidy programme that coincided with the election season.

Table 6: Farm production and practices

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production diversity score</td>
<td>Number of crop species</td>
<td>5.6(1.9)</td>
<td></td>
</tr>
<tr>
<td>Food group diversity</td>
<td>Number of different food groups cultivated</td>
<td>2.5(0.6)</td>
<td></td>
</tr>
<tr>
<td>Livestock production diversity score</td>
<td>Number of livestock species</td>
<td>3.2(1.3)</td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>Grew cereals (1=yes)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td>Grew pulses (1=yes)</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>Grew vegetable (1=yes)</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Improved tillage</td>
<td>Mechanised or manual tillage on all or some part of the cultivated area (1=yes)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Fertiliser use</td>
<td>Application of inorganic</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Micro-dosing</td>
<td>Micro-dosing (1=yes)</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Improved seed</td>
<td>Improved seed (1=yes)</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Fodder production</td>
<td>Fodder production (1=yes)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Own cattle</td>
<td>Own cattle (1=yes)</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Cattle herd size</td>
<td>Number of cattle owned</td>
<td>5.8(4.0)</td>
<td></td>
</tr>
<tr>
<td>Own goat</td>
<td>Own goats (1=yes)</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Goat flock size</td>
<td>Number of goats owned</td>
<td>5.5(3.6)</td>
<td></td>
</tr>
</tbody>
</table>

*Numbers in parentheses are standard deviation*

Over 75% of the households owned cattle and goats (Table 6). On average, cattle herd size and goat flock size was 5.8 and 5.5, respectively. The high percentage of households owning cattle and average household cattle herd size being higher than that of goats was unusual. Investment in livestock production through fodder production, which was also promoted in the project, was low, with 20% of the farmers reporting having planted fodder crops during the 2017/18 season.

5.1.6. Access to Agronomic, Post-harvest and Livestock Husbandry Information

Government departments such as AGRITEX were the main source of extension information related to agronomic, post-harvest, and livestock husbandry practices for the majority of the farmers (Table 7). These findings were expected given the presence of government extension personnel at ward level and also the synergistic relationship between the project and government departments. The proportion of households that accessed information from lead farmers and other farmers as a source of information was low, contrary to expectation given that this was a model being promoted in the project. It is possible that there could have been a conflation of sources, with respondents not distinguishing clearly between ENSURE and Lead Farmers, as the former mainly used lead farmers to cascade the extension messages. It is common in the field to hear expressions such as “ENSURE demo plot”.

Table 7: Sources of information for agricultural practices

<table>
<thead>
<tr>
<th></th>
<th>Agronomic</th>
<th>Post-harvest</th>
<th>Livestock husbandry</th>
</tr>
</thead>
</table>
5.1.7. Modes of Accessing Technical Agricultural Information

Oral presentations were the dominant methods for cascading technical information across all the technical areas. The demonstration plots were found to be one of the main methods through which over 60% of the respondents received technical information on agronomic practices (Table 8). Unlike agronomic practices, demonstrations were not a common means for delivering training on post-harvest management and livestock husbandry. This could have been due to an observation that demonstration sites did not have physical structures for the purpose of training. Lead farmers, after five years and several TOTs, were unable to invest in the appropriate structures such as improved granaries, hermetic metal silos or hermetic bags because of cost and availability in the market. Same applies for improved livestock housing. This is consistent with findings contained in the 2016/2017 end of season demo plot assessment that showed that the integration of improved post-harvest structures in the demo sites was low. It also needs to be noted that unlike the other activities that were promoted on the demo site, support for post-harvest was limited to technical support.

<table>
<thead>
<tr>
<th>Sources of Information</th>
<th>Proportion of Households (%)</th>
<th>Proportion of Households (%)</th>
<th>Proportion of Households (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRITEX/Government</td>
<td>78</td>
<td>80</td>
<td>74</td>
</tr>
<tr>
<td>ENSURE</td>
<td>62</td>
<td>64</td>
<td>43</td>
</tr>
<tr>
<td>Other NGOs</td>
<td>28</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Lead Farmers</td>
<td>22</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Other Farmers</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>1.3</td>
<td>4.6</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 8: Mode of accessing technical information

<table>
<thead>
<tr>
<th>Mode of accessing information</th>
<th>Agronomic</th>
<th>Post-harvest</th>
<th>Livestock husbandry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>82</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>Demonstrations</td>
<td>63</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Manuals/pamphlets</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Word-of-Mouth (other farmers)</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

5.1.8. Access to Information on Maternal and IYCF Practices

Unlike with agricultural extension, other community members in the form of Village Health Workers (VHW) were the main source of information on maternal and IYCF practices, with 80% of the respondents citing VHW as a source. The second most cited source was the ENSURE project followed by government departments. The interesting observation from this analysis was that VHW, who are community members just like lead farmers, were the main source of information for the majority of the households. To enhance the role of lead farmers, it could be important to draw lessons from the VHW model in terms of how VHW are selected, trained and incentivised.

### Table 9: Access to information on maternal and IYCF practices

<table>
<thead>
<tr>
<th>Sources of Information</th>
<th>Proportion of Households (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>24</td>
</tr>
</tbody>
</table>
5.1.9. Market Access
Table 10 summarises information related to market access and participation. About half of the farmers sold part of their crop produce to various buyers during the 2018 marketing season and the proportion sold was, on average, 27% of total crop output. Out of the households that indicated participating in the market, 64% sold maize and 26% sold groundnuts. Maize was sold at different markets, with over 44% sales occurring at the local markets, including to neighbours. The second most important market was the Grain Marketing Board, which accounted for over 30% of the sales. In the case of groundnuts, about two thirds of sales took place at the local market, with distant markets accounting for the balance. Most sales were categorised as spot sales, whereby individuals organised their own sales, that is, without any prior arrangements with the buyers. Group arranged sales, classified as improved marketing arrangements in the project, accounted for 14% of the sales reported by the respondents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sold crop</td>
<td>number of farmers who sold a crop</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Market intensity (crop)</td>
<td>Crop sold as a percentage of total production</td>
<td>27 (18)</td>
<td></td>
</tr>
<tr>
<td>Sold cattle</td>
<td>Number of farmers who sold cattle</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Market intensity (cattle)</td>
<td>Number of cattle sold</td>
<td>1.7 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Sold goats</td>
<td></td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Market intensity (goats)</td>
<td>Number of goats sold</td>
<td>3 (2.5)</td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>Participation in the poultry value chain (1=yes)</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Individual sales</td>
<td>Number of sales that were done individually</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Group Sales</td>
<td>Number of sales that were done through a group</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Major market</td>
<td>Distance to major output market km</td>
<td>26.3 (18.1)</td>
<td></td>
</tr>
<tr>
<td>Market participation over the years</td>
<td>Market participation increased in the past 5 years (1=yes)</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard deviation

Less than 20% of cattle owners sold cattle and about 25% of goat farmers sold goats during the 12-month period preceding the date of the interview. Most (96%) of the households indicated that they purchased food items from the market using income realised from the agricultural produce sales.
5.1.10. Expenditure Patterns
An analysis of Table 11 shows the distribution of expenses covered by income from VS&L and agricultural activities. Over 70% of expenses covered by VS&L income were not directly related to agricultural production: food (18%), school fees (12%), household goods (30%), etc. It is however positive to note that part of the resources from VS&L are invested in productive activities, such as agricultural inputs (17%) and purchase of agricultural equipment and livestock, which collectively accounts for 12% of the expenses covered by VS&L. As with VS&L, most of the expenses covered by income from agricultural activities were for food and school fees. Expenses related to agriculture, such as purchase of inputs, livestock and agricultural inputs, is low relative to other expenses.

Table 11: Savings and income expenditure patterns

<table>
<thead>
<tr>
<th>Type of expenditure</th>
<th>Savings</th>
<th></th>
<th>Farm income</th>
<th></th>
<th>Livestock</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>(sample size)</td>
<td></td>
<td>(sample size)</td>
<td></td>
<td>(sample size)</td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>90</td>
<td>18</td>
<td>138</td>
<td>27</td>
<td>65</td>
<td>24</td>
</tr>
<tr>
<td>School fees</td>
<td>59</td>
<td>12</td>
<td>130</td>
<td>25</td>
<td>88</td>
<td>33</td>
</tr>
<tr>
<td>livestock</td>
<td>42</td>
<td>9</td>
<td>27</td>
<td>5</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Agricultural inputs</td>
<td>86</td>
<td>17</td>
<td>84</td>
<td>15</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Agricultural equipment</td>
<td>27</td>
<td>5</td>
<td>26</td>
<td>5</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Household goods</td>
<td>147</td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Construction/housing</td>
<td>13</td>
<td>3</td>
<td>52</td>
<td>9</td>
<td>24</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>32</td>
<td>7</td>
<td>20</td>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

6. ECONOMETRIC RESULTS

6.1. Association between Agricultural Production Diversity and Dietary Diversity
Table 12 presents results of the regression of dietary diversity against crop and livestock diversity, a shortened version of equation 1. Crop production diversity is positively and significantly associated with both HDDS and WDDS. This was expected given that most of the food items consumed in households are from crops produced on-farm. Marginal increase in crop production diversity score, results in 4% and 5% increase in HDDS and WDDS, respectively. Livestock diversity is significantly associated with HHDS. A unit increase in the number of livestock species kept on the farm results in a 5% increase in HDDS. It is however not significantly associated with WDDS. These results show that a substantial increase in agricultural diversification will be required if this was the only intervention that was being pursued to improve household nutrition status.

Table 12: Association between agricultural production diversity and dietary diversity

<table>
<thead>
<tr>
<th></th>
<th>HDDS</th>
<th>WDDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop diversity score</td>
<td>0.036***</td>
<td>0.045***</td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.018)</td>
<td></td>
</tr>
<tr>
<td>Livestock diversity score</td>
<td>0.045***</td>
<td>0.022</td>
</tr>
<tr>
<td>(0.011)</td>
<td>(0.016)</td>
<td></td>
</tr>
</tbody>
</table>
6.2. Association of Market Participation and Dietary Diversity

This section focuses on the relationship between dietary diversity and market participation. An expanded model from the one described in section 6.2, where market participation and household socio-economic characteristics are included was estimated. The results shown in Table 13 show that market participation is positively and significantly related with both HDDS and WDDS. Increasing the volume of marketed produce by 1% will result in both HDDS and WDDS increasing by 0.3%. Promoting market participation could be an appropriate strategy to enhance nutrition outcomes at household and individual level. Market participation is likely to contribute to improved nutrition through increasing the ability of the household to purchase food not produced on-farm and enhancing the capacity of farmers to purchase inputs for agricultural diversification and intensification. In the context of smallholder farmers, pathways to improving market participation are more likely to yield results if they simultaneously address bottlenecks to market access and improved productivity.

Table 13: Association of market participation and dietary diversity

<table>
<thead>
<tr>
<th></th>
<th>HDDS</th>
<th>WDDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop diversity score</td>
<td>0.032***</td>
<td>0.038***</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Livestock diversity score</td>
<td>0.035***</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Market participation</td>
<td>0.003***</td>
<td>0.003***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Female head of household</td>
<td>-0.040</td>
<td>-0.009</td>
</tr>
<tr>
<td></td>
<td>(0.034)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>Age of household head</td>
<td>0.0001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Education level of household head</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Chronically ill proportion</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Household size</td>
<td>-0.012***</td>
<td>-0.033***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Arable land in ha</td>
<td>0.012</td>
<td>0.037**</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.386***</td>
<td>1.019***</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.097)</td>
</tr>
<tr>
<td>Observations</td>
<td>331</td>
<td>218</td>
</tr>
</tbody>
</table>

Coefficient estimates are shown with Standard Errors (SEs) in parentheses. *,**,***. Statistically significant at 10%, 5% and 1% level, respectively.

6.3. Association between VS&L and Dietary Diversity

Access to financial resources for investment into agriculture, or purchase of productive assets, is generally expected to enhance the capacity of farm households to increase their agricultural production. These financial resources, made available to households through both borrowing and own
savings can also be used to directly purchase food that is not produced on-farm and thus likely to have a direct effect on household dietary intake. Table 14 shows the results of the analysis of the association of VS&L with household and women’s dietary diversity. VS&L is shown to be positively and significantly associated with HDDS but not significantly associated with WDDS. The results show that households that are members of VS&L have HDDS which are on average 5% higher than those that are not members.

Table 14: VS&L and dietary diversity

<table>
<thead>
<tr>
<th></th>
<th>HDDS</th>
<th>WDDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop diversity score</td>
<td>0.030***</td>
<td>0.035***</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Livestock diversity</td>
<td>0.035***</td>
<td>0.0136</td>
</tr>
<tr>
<td>score</td>
<td>(0.011)</td>
<td>(0.0153)</td>
</tr>
<tr>
<td>Market participation</td>
<td>0.003***</td>
<td>0.003***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>VS&amp;L Membership</td>
<td>0.051*</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Female head of house-</td>
<td>-0.038</td>
<td>-0.009</td>
</tr>
<tr>
<td>hold</td>
<td>(0.031)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Age of household head</td>
<td>-0.000</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Education level of household head</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Chronically ill</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td>proportion</td>
<td>(0.00106)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Household size</td>
<td>-0.0141***</td>
<td>-0.031***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Arable land in ha</td>
<td>0.013</td>
<td>0.037***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.0132)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.367***</td>
<td>0.990***</td>
</tr>
<tr>
<td></td>
<td>(0.0672)</td>
<td>(0.099)</td>
</tr>
<tr>
<td>Observations</td>
<td>331</td>
<td>218</td>
</tr>
</tbody>
</table>

Coefficient estimates are shown with Standard Errors (SEs) in parentheses. *,**,***. Statistically significant at 10%, 5% and 1% level, respectively.

6.4. Association of Improved Agricultural Technology and Dietary Diversity

One of the technologies widely promoted in the project is conservation agriculture, particularly the mechanised version for its labour-saving attractiveness, compared to the manual one. Associated technologies or practices include use of improved seed varieties, inorganic fertilizers, and micro-dosing, among others. Table 15 shows the results of the model in which dummy variables for improved technologies are added to the model described in Table 14. In the model, three technologies are included: improved seed and improved tillage associated with crop production, and fodder production for livestock production. The association of technologies and dietary diversity, while positive except for fodder production, were not statistically significant.

Table 15: Association of agricultural technologies and dietary diversity

<table>
<thead>
<tr>
<th></th>
<th>HDDS</th>
<th>WDDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop diversity score</td>
<td>0.031***</td>
<td>0.035***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Livestock diversity</td>
<td>0.034***</td>
<td>0.011</td>
</tr>
<tr>
<td>score</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**6.5. Drivers of Crop and Livestock Diversification**

Agricultural production diversity has shown to have a positive effect on dietary diversity in a number of studies. This section presents findings on the drivers of agricultural production diversity. Table 16 shows the results of the estimation of the model (equation 2), where the dependent variable is a count variable. The results show that being a member of a VS&L group is positively and significantly associated with both crop and livestock diversity. On average, households that participated in VS&L groups had crop and livestock diversity scores that were 12% and 11% higher than those that did not participate, respectively. Belonging to VS&L was one of the social groupings that were promoted in the study, others included farmer producer groups, nutrition groups and women groupings. Including these variables in the model did not change the result that VS&L was significantly associated with agricultural production diversity, even though the other social groupings were not significant.

Market access, represented by distance to major output markets, was also found to be significantly associated with both crop diversity and livestock production diversity. The negative sign for crop diversity means that the closer the major output market, the higher the crop diversity on farm. Explained in another way, the greater ease with which the crop market is accessed, the higher the number of crop species that a farm household cultivates. For livestock diversity, the model showed that diversity increased with distance to the major market. The higher prices livestock usually fetch at distant markets compared to local markets could explain the direction of the relationship. These
results point to the critical role market access has on production diversity on-farm and nutrition, given that the bulk of food consumed at household level is from the farm.

**Table 16: Drivers of crop and livestock diversity**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Crop diversity</th>
<th>Livestock diversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS&amp;L member</td>
<td>0.112***</td>
<td>0.103**</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Crop diversity</td>
<td>0.0175</td>
<td>0.012</td>
</tr>
<tr>
<td>Livestock diversity</td>
<td>0.0224</td>
<td>0.003**</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Distance to major market (km)</td>
<td>-0.003**</td>
<td>0.003**</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Female household head</td>
<td>0.080*</td>
<td>-0.111**</td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>Age of household head</td>
<td>0.001</td>
<td>0.003**</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.001</td>
<td>0.0168**</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Education level of household head</td>
<td>-0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Size of arable land (ha)</td>
<td>0.0277***</td>
<td>0.0404***</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Food aid</td>
<td>-0.162***</td>
<td>-0.026</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>Chronic Illness proportion</td>
<td>-0.000</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.550***</td>
<td>0.594***</td>
</tr>
<tr>
<td></td>
<td>(0.0828)</td>
<td>(0.115)</td>
</tr>
<tr>
<td>Observations</td>
<td>324</td>
<td>324</td>
</tr>
</tbody>
</table>

Coefficient estimates are shown with Standard Errors (SEs) in parentheses. *, **, ***. Statistically significant at 10%, 5% and 1% level, respectively.

**6.6. Agricultural Income**

Table 17 shows the results of the Tobit model estimation, where agricultural income is the dependent variable and the explanatory variables include variables that capture the interventions promoted under SO2 and household socio-economic characteristics. Livestock production diversity is positively and significantly associated with agricultural income. The results from the model indicate that with a more diverse livestock holding, income from agriculture tends to be higher. Diversification in crops seems not to have the same effect as livestock on agricultural income. Among the agricultural technologies included in the model, improved seed was shown to be significantly associated with agricultural income. Improved agricultural technology is generally associated with increased agricultural productivity and this could explain its positive influence on agricultural income. VS&L was also shown to be positively and significantly associated with farm income. Promotion of livestock diversity, adoption of fodder production, use of improved seed varieties and participation in VS&L are interventions worth pursuing to enhance agricultural income.

**Table 17: Factors influencing agricultural income**

<table>
<thead>
<tr>
<th></th>
<th>Agricultural Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21
<table>
<thead>
<tr>
<th>Asset Index</th>
<th>Coefficient</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS&amp;L member</td>
<td>0.253**</td>
<td>(0.104)</td>
<td></td>
</tr>
<tr>
<td>Crop diversity</td>
<td>-0.026</td>
<td>(0.028)</td>
<td></td>
</tr>
</tbody>
</table>

6.7. Assets Holding

Access to assets is one of the indicators for household resilience capacity. Both productive and non-productive assets are critical in enhancing the resilience capacity of a household. They can be utilised to increase food production, and in the event of poor production, used to earn income for purchase of food. The size of the coefficients is not interpreted in the usual manner of OLS, as the dependent is an index, combining different variables. However, the sign is important as it shows the direction of influence. From the results in Table 18, VS&L is shown to have a positive effect on asset accumulation, as is the case with livestock and market access. The interventions promoted in the project have a positive effect on asset accumulation and contribute to enhancing household resilience to food insecurity caused by shocks such as drought.
7. DISCUSSION

Access to technical information by project participants was not a challenge given the high proportion of respondents that indicated that they received information on agronomic, post-harvest, animal husbandry and maternal and IYCF practices. The prominence of government departments, particularly in agricultural extension, is indicative of the potential that exists to transform smallholder farmers through appropriate messaging. The fact that the project also used existing extension organisations was strategic for reaching the high proportion of farm households that reported to have accessed technical information. Access to information is key in enhancing nutrition and resilience outcomes given the demonstrated role agriculture has in rural livelihoods. Adoption of CA principles collectively remains low in the programme due to challenges such as labour, biomass for mulching, access to adequate seed for leguminous crops, and perceptions. In this study we focused on minimum soil disturbance, which we perceived to be one of the practices that was most likely to be the first to be adopted, given its simplicity. The findings showed that the adoption rate of this component was low, at around 40%, five years after the intervention. Further research to understand the dynamics driving adoption of CA will be required to unpack the reasons for the developments observed in the project. This recommendation also applies to other practices promoted in the project.

Dietary diversity scores at both the household level and for WRA were found to be generally low. On average, households consumed less than six basic food groups out of the 12 that were considered in calculating HDDS. More than 50% of the households had dietary diversity that is classified as poor. A similar picture regarding women’s dietary diversity exists, with women on average consuming less...
than four out of the 10 basic food groups used in calculating the WDDS. A disappointing finding from the study was related to the low consumption of animal products, despite a high percentage of households indicating that they owned livestock such as cattle, goats, and poultry. For example, only 10% of the households indicated consuming eggs, despite 95% of farm households owning poultry. The low proportion of households consuming products from animals, which did not require the animals to be slaughtered, could be a reflection of low productivity from animal production. Interventions that increase animal productivity have the potential to increase access to affordable high-value protein sources. Some of the interventions already promoted in the project, such as fodder production, have the potential to increase milk production. Formulating poultry feed from crops already produced by farmers in the project also has the potential to improve poultry production. Strengthening crop-livestock integration could be a viable option to increase availability of animal-based food groups in household diets.

Findings from regression models that investigated how different factors were associated with dietary diversity showed mixed results. Crop production diversity and market participation showed positive association with both household and women dietary diversity, while livestock production diversity, VS&L and agricultural technology were shown to have a positive effect on household dietary diversity. The key message that can be extracted from these findings is that, while the interventions in question positively affect dietary diversity, the effect will not be necessarily be the same at household and individual level. The conclusion one draws about these findings is that for interventions that seek to improve nutrition outcomes, it is important to investigate not only their effect at household level, but also the appropriate dietary intake for vulnerable household members such as children and WRS.

Agricultural income and asset holding both contribute to building the resilience capacity of households and access to food, thus could influence the adequacy of dietary intake. Income and assets can reinforce each other. Agricultural income can be used to purchase additional household assets and assets also enhance the capacity of households to earn income. The role of agriculture in providing resources for asset acquisition is amplified by its potential to provide a marketable surplus. This observation confirms that promoting market access is critical not only for nutrition outcomes but also for building resilience capacities of households. It is also important to note that agricultural income is likely to affect decisions on investing in productivity-enhancing inputs such as fertiliser, improved seed, and adoption of technologies. Interventions promoted in the project such as VS&L, livestock diversification, improved seed varieties, and fodder production were relevant to enhancing agricultural income, which has the potential to address multiple objectives.

8. CONCLUSION
This study investigated the association of crop and livestock production diversity, market participation, VS&L, and agricultural technology on household and women’s dietary diversity. It further investigated the role of farm production diversity, VS&L, agricultural technology and market participation in agricultural income and asset holding. Findings showed that market participation, farm production diversity, agricultural technology, and VS&L positively influenced dietary diversity at household and women’s levels and contributed to enhancing the resilience capacity of households. The importance of the findings is that the interventions promoted in the project had a positive effect on dietary diversity and thus need to be promoted individually or in combination with programmes that are focused on nutrition. Market participation, for example, directly addresses household income and also has a positive effect on dietary diversity, pointing to the importance of increasing the capacity of the smallholder farmers to participate in the market. In general, smallholder farmers face the twin challenges of physically accessing the markets and producing surplus for the market. Strengthening
drivers of agricultural income and livestock diversification becomes a crucial intervention strategy for programmes seeking to improve the food and nutrition security of households.
REFERENCES

Alinovi, L. et al. (no date) ‘MEASURING HOUSEHOLD RESILIENCE TO FOOD INSECURITY: APPLICATION TO PALESTINIAN HOUSEHOLDS’.


Annex 1: Questionnaire