FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Low diet diversity and its associated factors among the mothers and their children in agroforestry land use systems of Sidama, Ethiopia: A community-based cross-sectional study

Beruk Berhanu Desalegn¹* and Biruk Jagiso²

Abstract: Despite the agroforestry has multi-purpose benefit, it has been evolving from time to time in southern Ethiopia. Therefore, the objective of this study was to assess the diversity of diet (DD) consumed by mothers and their children and their associated factors in the agroforestry land use systems of rural Ethiopia. Community-based cross-sectional study was conducted to recruit 417 mother–child pairs living in the three land use systems of rural Sidama using multi-stage stratified systematic sampling technique. The mean DD score of mothers (2.93) and children (2.38) were low. Our multivariate regression analyses revealed that mothers who did not receive any nutrition counseling, living in food-insecure households and not growing any fruits had higher odds (3.9, 4.8 and 3.6) for consuming less diversified diet compared to their references, respectively. Whereas, younger children had higher odds for consuming less diversified diet compared to older children. Being a child from the households of the lowland, food insecure, not growing fruits, and vegetables had higher odds (3.67, 7.11, 1.97 and 2.42, respectively) to consume diet from less diversified food groups than their respective references. Children from households not owning front or woodland had 2.05 times higher odds for consuming less diversified diet than their counters. Thus, the quality of diet consumed by the mothers and children was low. Interventions targeting on improving the diet quality of mothers and children should be designed with a prior focus on agro-ecology-based nutrition-sensitive agriculture and dissemination of nutrition knowledge to mothers.

ABOUT THE AUTHOR

Beruk Berhanu Desalegn (PhD) is an assistant professor of food science and nutrition at the School of Nutrition, Food Science and Technology, Hawassa University. He pursued his BSc and MSc at Hawassa University (Ethiopia) and recently completed his PhD degree at University of Hohenheim (Germany). Dr. Beruk has published more than 25 papers in peer-reviewed reputable journals, including Nature. Biruk Jagiso is lecturer of natural resource economics, at Wondo Genet College of Forestry and Natural Resources, Hawassa University (Ethiopia). He did his BSc and MSc at Hawassa University and Haromaya University of Ethiopia, respectively.

PUBLIC INTEREST STATEMENT

Despite the contribution of agroforestry is immense to the livelihood of rural households, food and nutrition insecurity is a public health problem of different agroforestry land use households in Ethiopia, and yet the determinant factors for these problems are not well understood. Therefore, this study was designed to assess the quality of diet consumed by the nutritionally need groups (women and children), at different agroforestry land use systems and also to identify the bottlenecks for not consuming adequate quality diet at the district in general. Thus, the finding of this study will contribute to designing nutrition-specific and sensitive intervention to reduce the high food and nutrition insecurity problem in rural settings.
Subjects: Nutrition; Epidemiology; Allied Health; Health Conditions

Keywords: agroforestry; diet diversity; children; mothers; Ethiopia

1. Introduction

Inadequate intake of quality diet by individuals in the rural subsistent farming households is a serious public health problem of developing countries including Ethiopia. As a result, it has been challenging to achieve the plan set for reduction of undernutrition problem of these countries at the national level and globally at large. Inadequate dietary intake is known as one of the immediate causes of maternal and childhood undernutrition (UNICEF, 1998). This undernutrition problem exists in two forms, as acute and chronic. The chronic form of undernutrition is mainly related to inadequate intake of micronutrients for longer time and its consequence passes from generation to generation. Thus, it causes deleterious impact in the short and long periods at the individual, community and national levels. However, the existing sub-optimal dietary practices in developing countries such as Ethiopia could be due to either limited access to food and/or inadequate knowledge about the importance of eating diversified diet with adequate quantity (Dafursa & Gebremedhin, 2019; Dangura & Gebremedhin, 2017; Gebremedhin et al., 2017; Hirvonen et al., 2017; Zerfu & Biadgilign, 2018).

Despite that the agriculture sector in Ethiopia and other African countries has shown continuous growth in the last few years, much of this growth is exhibited due to area expansion by deforestation than increases in land productivity. But, the expansion of new agricultural land is expected to decline gradually, as a result, the sustainability of the existing agricultural growth will face a great challenge, unless intensive and also climate change resilience sustainable agricultural practices are implemented widely. But, evidence in Ethiopia and also Nigeria show that the intensified agriculture decreased the production diversity, which may cause the subsistent farming household members to consume less diversified diet (Ayenew et al., 2018; Hirvonen & Hoddinott, 2014). For instance, the study conducted in Ethiopia shows an increasing trend in total food production between 2011 and 2015, but this increment was majorly in cereals, which was in the expense of reducing the growth of other food groups, which resulted in the significant reduction of production diversity by 3.6% and increased the source of energy from starchy foods by 2.4% between 2011 and 2015 (Baye et al., 2019). Therefore, increase in the consumption of more starch-containing foods coupled with inadequate nutrient-rich diets leads to micro-nutrient deficiencies and hidden hunger. Thus, it will be a great challenge for the agricultural sector to contribute to achieving the health-related and nutrition-related outcomes in the country. To overcome these problems, agroforestry is an ecological-based traditional, but sustainable agricultural practice in Ethiopia, which integrates tree with crop or animal husbandry simultaneously and sequentially should be promoted or revitalized (Jiru, 2019).

In Ethiopia, different agroforestry practices are identified based on their suitability to agroecology and determine the biodiversity and production diversity, as a result, the availability of the type of food items in the farming households in countries like Ethiopia, where more than two-thirds of the families’ diet of rural households’ source is their own production (Dafursa & Gebremedhin, 2019; Sibhatu & Qaim, 2017). Because of its socio-economic and environmental benefits, agroforestry has been promoted globally (Mbow et al., 2014). It is also one of the basic agricultural extension packages in Ethiopia and is highly practiced in all regions of the country with different configurations. Despite that the existing agroforestry practices in southern Ethiopia are recognized as efficient farming systems and favor the interactions and synergies among the crop, tree and livestock components, they are dramatically evolving due to changes in the socio-economic and biophysical environment. According to Teklu et al. (2018), there have been changes in the farming systems from food-oriented (Enset-based and Enset-livestock) to cash crop-oriented khat-based, and combined food and cash crop-oriented enset cereal–vegetable systems (Teklu et al., 2018). Besides these, they also found the expansion of khat from 6% to 35% area share per
farm, in addition to decrement in the combined area share for the enset and coffee by 20% and the cattle herd size by 33% per household between 1991 and 2013. Other studies in the same region revealed the expansion of khat in homogenization of the structure and composition of the traditional land use systems (Abebe et al., 2010; Dessie & Kinlund, 2008). As a result of these, the consumption pattern in the farming households could be altered, but this may also vary among different agro-ecology-based agroforestry land use. Despite these, little evidence is known in Ethiopia context, and specifically in the study area which explored the dietary pattern at individual or household levels in the areas engaged in various agroforestry practices in a comprehensive way.

Therefore, the objective of this study was to assess the diversity of diet (DD) consumed by the reproductive age (15–49 years old) women and their 2–5-year-old children at different agroforestry land use systems of Sidama, rural Ethiopia, and it was also to identify the factors associated with consumption of low diversified diet by the two groups in the district.

2. Methods

2.1. Study setting

This study included three districts, representing the highland, midland and lowland agroforestry land use systems of rural Sidama, southern Ethiopia. Sidama zone is one of the most densely populated areas, in which more than 3.6 million people are living within an area of about 7000 m². Comprising a wide range of altitude difference (501–3000 m above sea level), annual rainfall (801–1600 mm) and temperature (10°c and 27°c), the biodiversity, the livelihood system and the agricultural practices including agroforestry could be varied along different districts in the Sidama zone (Hameso, 2015). For this study, we considered different agro-ecology, as the main factor to use land for different agroforestry practices, despite that there is no single district that exclusively consists of a single agro-ecology. Therefore, the 19 districts in the Sidama were categorized into 3 based on the dominant agro-ecology they have, and Gorche, Dale and Loka Abaya were randomly selected accordingly.

2.2. Study design

A community-based cross-sectional mixed (qualitative and quantitative) study was implemented.

2.3. Sampling size calculation

A single population proportion formula (Figure 1) was used to calculate the sample size for the larger study focused on assessing the food and nutrition security in the rural Sidama district, with the following assumptions: 95% of confidence interval for true prevalence, a relative precision (d) of 5% and prevalence (p) of food insecurity (50%) or food security (1−p or q). Then, adding 8.5% of the calculated sample size to reduce the non-response rate made the final sample size 417.

2.4. Sampling technique

In this study, we implemented multi-stage stratified systematic sampling technique. Primarily, all districts in the Sidama were listed out and stratified into highland, midland and lowland categories, considering their dominant agro-ecological features. Then, Gorche for highland, Dale for midland and Loka Abaya for lowland agroforestry land use were randomly selected. Following this, 15 kebeles (lowest administrative unit in Ethiopia) were selected from the 3 selected districts', each shared 5. Then, the list of the household heads in the kebeles was found from the kebele administration offices with the support of development agents. The total sample size was distributed proportionally to the three districts' and proportionally to the selected five kebeles'.

\[ n = \frac{(Z_{a/2})^2 pq}{d^2} = \frac{(1.96)^2 \times 0.5 \times 0.5}{0.05^2} \]

Figure 1. Single population proportion formula.
Therefore, the sampling was conducted systematically after the sampling frame was created for each kebele included in the study.

2.5. Data collection and quality assurance
A questionnaire which consists of both closed and open-ended questions to assess information on socio-demographic and economic, agricultural production and income, household food security and dietary information for the mothers and their 2–5-year-old children in the last 24 h preceding the interview were used. Before we started the data collection, the whole questionnaire was translated to Amharic and pre-tested on households not included in the study area and modifications were made, followed by training of the 10 data collectors recruited, who were certified at least with diploma. Specifically, household food security was collected using the standard Household Food Insecurity Access Scale questionnaire which was developed by FANTA project (Jennifer et al., 2007). In this questionnaire, there are nine occurrence questions, followed by a follow-up question for each of the nine occurrence questions, which helps to determine the how often the condition (1 = rarely, 2 = sometimes, 3 = often) occurred. To collect the quantitative 24-h dietary information, for both the mothers and their children, the mothers were asked interactively using the 24-h recall dietary assessment method with multiple pass technique developed for developing countries (Gibson & Fergusen, 1999).

2.6. Data management and analyses
The individual diet diversity score of the mothers was calculated out of standard 10 food groups for women: grains, white roots and tubers, and plantains; pulses (beans, peas and lentils); nuts and seeds; dairy; meat, poultry and fish; eggs; dark green leafy vegetables; other vitamin A–rich fruits and vegetables; other vegetables; and other fruits. To count the food group as consumed, at least a summed 15 g of the food items in the group should be consumed. Then, the score was computed by summing the number of food groups consumed by the individual mothers in the last 24-h preceding the survey (FAO and FHI 360, 2016). Whereas, the diet diversity for the 2–5-year-old children was computed out of the standard seven food groups including grains, roots and tubers; legumes and nuts; dairy products; flesh foods; eggs; vitamin A–rich fruits and vegetables; and other fruits and vegetables without considering any minimum intake requirement for a group to be counted (WHO, 2010).

In order to assess if there were significant differences in the proportions in the individual food group consumed among the mothers, and also for children in the last 24 h preceding the survey living in different agro-ecology, agricultural production, and major agroforestry products among these agro-ecologies, chi-square test was conducted. We also implemented one-way Analysis of Variance (ANOVA) to test if there were significant differences in the diet diversity score among mothers and children living in different agro-ecology.

To identify the determinant factors for consuming less diversified food groups by the mothers, we divided them into two groups: diversified and low diversified if the score was ≥4 and <4 for an individual, respectively. We also categorized those children who had diet comprised of ≥3 food groups in to diversified; otherwise, they were grouped into less diversified if they had <3 out of the seven food groups to identify determinant factors for less diversity children diets. For these, we conducted multivariate regression analyses and the candidate explanatory variables were entered with stepwise forward Wald method for both study groups. The model fitness was checked using Hosmer and Lemeshow test and the p-values were greater than 0.05, indicating the fitness. Additionally, the multi-collinearity for the variables considered in both models was checked using variance inflation factor and standard error. A statistical significance was declared at p-value <0.05.

2.7. Ethical consideration
This research was approved by the Wondo Genet College of Forestry and Natural Resources Research and graduate coordination office and later approved by the Research and Technology Vice President Office of Hawassa University. Permission was also obtained from the respective
district’s Agriculture and Rural Development Offices. The purpose of the study was explained to the mothers and consent form was filled and signed prior to the interview if the mothers agreed to participate in the study. They were also told that the information provided in this study was confidential, and whenever they wanted to terminate in the course of the interview, withdrawal from the study was also possible.

3. Results

3.1. Socio-demographic and economic characteristics
Out of the total 417 mother–child pairs expected to be included in this study, 25 did not participate in this study, which leads to a response rate of 94.0%. Of those who participated in the study (n = 392), 128 (30.69%) were included from households residing in the highland agro-ecology, whereas 139 (33.33%) and 125 (29.97%) were living in the households from midland and lowland agro-ecology.

Slightly higher proportions (51.3%) of the children were males and aged between 48- and 60-month-old children (40%). Almost all the mothers were married (97.2%) and housewives (96.4%), but majority (93.7%) of the fathers were farmers. The literacy level of mothers (55.1%) was lower than that of fathers (82.0%) of the children in the study. About two-thirds (65.6%) of the households included in the study had a family size of five or more while three-fourths (68.1%) of the household members were living in houses with fewer rooms. Most (94.4%) of the households’ main source of income was agriculture; however, more than half (55.1%) of the household income was decided by the fathers (Table 1).

3.2. Food groups grown in the studied households
According to Table 2, the proportions of households involved in producing different food groups were significantly different (p < 0.005) among the three agro-ecologies. In general, majority of the households were growing cereals (80.6%) and enset (78.1%) and also owning livestock (80.6%) during the study period. More than half of the households were also cultivating vegetables (59.7%) and root crops (55.1%) in the same period. But, half (50.5%) of the households were growing legumes and fruits (37.8%). Most of the food production types were grown by significantly higher proportions of the households from the highland agro-ecology than the proportions of the households from the midland and lowland. Whereas, a high proportion of the households (85.6%) of the lowland agro-ecology owned livestock while the proportion of households of the midland and highland were 82.7% and 73.4%, respectively.

3.3. Dietary patterns and diet diversity score of mothers
Regardless of the agro-ecology where the households reside, all the mothers consumed at least once from the “grains, white roots and tubers, and plantains” food group in the last 24h preceding the interview. However, the proportion of mothers who had diet containing any food items from the dark green leafy vegetables group was significantly different (p = 0.017) among the different agro-ecology, and which was highest in midland (87.1%), followed by mothers from the highland (82.8%) and lowland (73.6%), respectively. Likewise, the proportions of mothers who had any food item from the “dairy products” and “other vegetables” group in their diets in the last 24h preceding the survey were 31.6% in general, and these proportions among the three agro-ecologies were also significantly different (p < 0.001 and p = 0.049, respectively). The proportions of mothers who consumed from “pulse” and “meat, poultry and fish” food groups were 20.9% and 12.5%, and these proportions were statistically different among the three groups (p = 0.025 and p < 0.001, respectively). But, the proportions of the mothers whose diet comprised of any food items from the “dairy products” and “meat, poultry and fish” food groups in the highland group were higher than those of the mothers who were from the midland and lowland groups. But, the consumption of any food items from the group of “nuts and seeds”, “eggs”, “other vitamin A–rich fruits and vegetables” and “other fruits” was very small (<1%) regardless of the agro-ecological category. In general, the average diversity of the food groups consumed by the mothers was 2.93, but those mothers from
Table 1. Socio-demographic and economic characteristic of households in three agroforestry land use systems of rural Sidama, Ethiopia

| Variables                        | Highland n = 128 | Midland n = 139 | Lowland n = 125 | Total n = 392 |
|----------------------------------|------------------|-----------------|-----------------|---------------|
| Sex of the child                 |                  |                 |                 |               |
| Female                           | 46.1             | 48.9            | 51.2            | 48.7          |
| Male                             | 53.9             | 51.1            | 48.8            | 51.3          |
| Age of the child (months)        |                  |                 |                 |               |
| 24–35                            | 25.0             | 38.1            | 46.4            | 36.5          |
| 36–47                            | 38.3             | 16.5            | 18.4            | 24.2          |
| 48–60                            | 36.7             | 45.3            | 35.2            | 39.3          |
| Family size                      |                  |                 |                 |               |
| <5                               | 39.8             | 33.8            | 29.6            | 34.4          |
| ≤5                               | 60.2             | 66.2            | 70.4            | 65.6          |
| Marital status                   |                  |                 |                 |               |
| Married                          | 96.1             | 96.4            | 99.2            | 97.2          |
| Others                           | 3.9              | 3.6             | 0.8             | 2.8           |
| Paternal education               |                  |                 |                 |               |
| Literate (n = 382)               | 56.9             | 85.8            | 72.0            | 82.0          |
| Illiterate                       | 43.1             | 14.2            | 28.0            | 28.0          |
| Maternal education               |                  |                 |                 |               |
| Literate                         | 39.8             | 70.5            | 53.6            | 55.1          |
| Illiterate                       | 60.2             | 29.5            | 46.4            | 44.9          |
| Paternal occupation              |                  |                 |                 |               |
| Farmer                           | 91.9             | 90.3            | 99.2            | 93.7          |
| Others                           | 8.1              | 9.7             | 0.8             | 6.3           |
| Maternal occupation              |                  |                 |                 |               |
| Housewives                       | 89.1             | 100.0           | 100.0           | 96.4          |
| Farmers                          | 9.4              | 0.0             | 0.0             | 3.1           |
| Others                           | 1.6              | 0.0             | 0.0             | 0.5           |
| Number of rooms in the household |                  |                 |                 |               |
| <3                               | 74.2             | 59.0            | 72.0            | 68.1          |
| ≤3                               | 25.8             | 41.0            | 28.0            | 31.9          |
| Main source of household income  |                  |                 |                 |               |
| Agriculture                      | 96.9             | 92.8            | 93.6            | 94.4          |
| Others                           | 3.1              | 7.2             | 6.4             | 5.6           |
| Income decider                   |                  |                 |                 |               |
| Jointly                          | 55.5             | 36.7            | 32.0            | 41.3          |
| Father                           | 43.8             | 59.0            | 62.4            | 55.1          |
| Mother                           | 0.8              | 4.3             | 5.6             | 3.6           |

the highland group had significantly higher diet diversity score (3.23) than the middle (2.96) and lowland (2.58) groups (p < 0.001) (Table 3).

3.4. Dietary patterns and diet diversity score of children
Like the mothers, all 2–5-year-old children participated in the study consumed any food items from “grains, roots and tubers” food group in the last 24 h prior to the survey. Otherwise, the proportions of the children from different agro-ecologies who consumed from the diet prepared from any food items of each five food groups except the “other fruits and Vegetables” were statistically different (p < 0.05). This leads also to strong statistical difference (p < 0.001) in the mean diet diversity score result exhibited among the children who participated from the highland (2.76), midland (2.28) and lowland (2.10) agro-ecology in ANOVA. To be more specific to each food group consumption, the proportion of children from highland agro-ecology was high for dairy products (76.6%) and vitamin A–rich fruits and vegetables (68.0%), whereas the low proportions of children who consumed from the respective food groups within the last 24 h prior to the survey participated from the midland- and lowland agro-ecology. But, the consumption of diet from legumes and nuts and other fruits and vegetables food groups were relatively high in children from midland agro-ecology, followed by lowland and highland. Despite that the consumption of flesh foods and egg was very low in general, they were better consumed by the children from the
highland and lowland agro-ecology, respectively. Otherwise, there was no single child who consumed any type of flesh foods from midland and also an egg from the high land agro-ecology in the last 24 h prior to the survey (Table 4).
Table 4. Dietary patterns and diet diversity score of 2–5-year-olds in the three agroforestry land use systems of rural Sidamo, Ethiopia

| Food group                                      | Highland n = 128 | Midland n = 139 | Lowland n = 125 | P-value    | Total n = 392 |
|------------------------------------------------|------------------|-----------------|-----------------|------------|---------------|
| Grains, roots and tubers                       | 100              | 100             | 100             | -          | 100           |
| Legumes and nuts                               | 15.6             | 48.2            | 20.0            | <0.001     | 28.6          |
| Other fruits and vegetables                    | 13.3             | 24.5            | 19.2            | 0.068      | 19.1          |
| Dairy products                                 | 76.6             | 26.6            | 34.4            | <0.001     | 45.4          |
| Flesh foods                                    | 7.8              | 0.0             | 0.8             | <0.001     | 2.8           |
| Eggs                                           | 0.0              | 4.3             | 5.6             | 0.032      | 3.3           |
| Vitamin A-rich fruits and vegetables           | 68.0             | 43.9            | 28.0            | <0.001     | 46.7          |
| DD score for children*                         | 2.76 (0.56)      | 2.28 (1.01)     | 2.10 (0.89)     | <0.001     | 2.38 (0.89)   |

Data analysis was carried out using chi-square test. * indicates that the difference of the values in the specific variable is statistically tested using ANOVA. Significant level declared at p < 0.05.

3.5. Factors associated with low diet diversity of mothers and their children

According to the multivariate logistic regression analyses results presented in Table 5, mothers who did not receive any nutrition counseling and living in households not food-secure and not growing any fruits in their own landhad 3.9, 4.8 and 3.6 times of higher odds for consuming less diversified diet in the last 24 h compared to those mothers who received nutrition counseling and who were living in food-secured and fruit-growing households (Odd ratio (OR) (95% Confidence Interval(CI)) = 3.920 (1.555, 9.885); 4.781(95%CI) (2.387, 9.576) and 3.554 (95%CI), 1.743, 7.248), respectively). Whereas, children who were aged between 24 and 35 months and 36–47 months had 3.03 and 12.27 times higher odds for consuming less diversified diet than those children aged between 48 and 60 months (OR (95%CI) = 3.030 (1.546, 5.942) and 12.267 (6.146, 24.484), respectively). Likewise, the odds of consuming from less diversified groups by the children from the households reside in the lowland agro-ecology were 3.67 times higher than those living in the households of highland agro-ecology (OR (95% CI) = 3.672 (1.631, 8.266)). Those children who were living in the household not growing fruits and vegetables had 1.97 and 2.42 higher odds of consuming less diversified diet than those children who were living in the households growing fruits and vegetables (OR (95%CI) = 1.975 (1.055, 3.697) and 2.415 (1.254, 4.652), respectively). Furthermore, the odds of children who were living in the food-insecure households and not owning front or woodland were 7.11 and 2.05 times for consuming less diversified diet compared with the reference: children living in the households which were food-secure and not owning front or woodland (OR (95%CI) = 7.113 (3.920, 12.907) and 2.048 (1.140, 3.679), respectively) (Table 5).

4. Discussion

The current study assessed the DD consumed by the mothers and their 2–5-year-old children in three agroforestry land use systems of Sidama, rural Ethiopia. The factors associated with consumption of less diverse diet by the mothers and their children were also investigated. Accordingly, the aggregate average diet diversity scores for the mothers and children living in the three agroforestry land use system were very low (2.93 and 2.38, respectively). A study conducted in children of Hula and Shebedino districts also found low diet diversity score (3.2–3.3) (Bosha et al.,
Consistent findings were also reported in the study conducted in 6–23-month-old children of rural Boricha (2) (Masreha Tessema et al., 2013), Aleta Wondo (2.5) (Dafursa & Gebremedhin, 2019), Gorche (2) (Dangura & Gebremedhin, 2017) and Genta Afeshum (2.04–2.5) (B. Desalegn et al., 2019). Likewise, cross-sectional and longitudinal studies done in Ethiopia revealed low average diet diversity score for lactating women (2.5–3.0) (B. B. Desalegn et al., 2018), pregnant women (3.48–3.68) (Desta et al., 2019; Hailu et al., 2019) and women at reproductive age in general (3.20–3.26) (Bosha et al., 2019). Starchy foods were consumed by all the mothers and their children. These indicate that the consumption of diet from less diversified food group is great in nutritionally vulnerable groups in the country. Thus, micronutrient deficiency could remain as a public health challenge in rural Ethiopia unless different nutrition-sensitive and specific interventions are tailor-made to the context of the specific areas of the country.

Increasing on-farm production diversification is among the important ways for improving DD in subsistent farming households (Zanello et al., 2019). An earlier study in Ethiopia also revealed the improvement of child diet diversity by increasing the diversification of household production in an
area where there is no market access (Hirvonen & Haddad, 2014). The study conducted in Afghanistan by Zanello and colleagues also found out the positive association of improving crop production diversity with household diet diversity in the regular season; however, the market access is an important aspect for improving the diet diversity in lean season when the crop production diversity is low (Zanello et al., 2019). A study based on Malawi national representative data shows the consistent and strong association of farm production diversity with improved household diet diversity (Jones et al., 2014).

Likewise, our present study confirmed that the average diet diversity scores for the mothers and their children living in the households from highland agroforestry land use system were significantly higher in relative to those mothers and children in the midland and lowland agroforestry land use system. This is mainly related to the sizeable proportion of households from highland agroforestry land use system where production of more diversified food group in addition to joint decision-making on income is higher in these households. As such, a more diversified and sustainable food production could be observed and maintained in households with better mixed agroforestry practices, which can minimize crop failure and disease outbreaks related to climate change, unlike the monoculture cropping system. Unlike this, the lowland areas included in this study are known for frequent food shortage, due to the decreased crop production by climate variability, leading to more households waiting for food aid (Lalego et al., 2019). In support of the second justification, a study in Ghana revealed that the odds of achieving higher diet diversity among women who had decision power in their household expenditure was high (Amugsi et al., 2016). Likewise, a study conducted in Ethiopia reported enhancing women autonomy over resource improved child nutritional status (Abate & Belachew, 2017). Thus, the more pronounced effect of climate change in the lowland crop production and productivity can be reduced sustainably through an intervention rehabilitating the ever degrading home garden agroforestry system. Women empowerment in decision-making should be also promoted. These may also help to improve the diet consumption pattern of the smallholder farmers.

Furthermore, the DD of mothers and their children were positively related and their scores were correlated ($r^2 = 0.362$, $p < 0.001$) (data not shown). Studies conducted in Ethiopia, Vietnam and Bangladesh also depicted the strong correlation between maternal and child DD (Bosha et al., 2019; Nguyen et al., 2013). The probable reason for the present study might be due to the children above 2 years are majorly sharing the family food with no special attention in rural households in Ethiopia.

Provision of adequate quality diet for household members will not be achieved unless the households are food-secure. In the present study, it was found that mothers and children who were living in the food-insecure households are associated with consumption of less diversified food in the 24 h preceding the survey. A baseline nutrition survey conducted in northwest Ethiopia reported household food insecurity predisposes adolescent girls to consumption of diet from less diversified food groups (Tariku et al., 2019). Similarly, studies in Aleta Wondo and South Wollo, Ethiopia, and Maharashtra, India, showed that children living in food-insecure households had lower diet diversity score than those children living in food-secure households (Chandrasekhar et al., 2017; Dafursa & Gebremedhin, 2019; Gebremedhin et al., 2017). Likewise, Nepalese lactating women’s who were living in households at different levels of food insecurity had higher odds of consuming low diet diversity (Raj et al., 2020).

In our study, being a younger child was associated with consumption of less DD of children. Previous studies in Ethiopia, Ghana and Pakistan also found consistent results (Amugsi et al., 2016; Dafursa & Gebremedhin, 2019; Dangura & Gebremedhin, 2017; Khan et al., 2017). This could be related to the fact that as the age of children’s increase, the chance of consuming diversified vegetables and fruits which are not usually given at the early stage of childhood might increase.
In the study, being from lowland agro-ecology was also significantly associated with consumption of less DD by the children. This is in fact related to less diversified own production for household consumption and the income generated from agroforestry products was relatively lower in households from lowland agro-ecology, and so it might not support the household food and non-food expenditure (Beruk et al. 2019, submitted). Furthermore, not growing fruit trees is also one of the factors associated with consumption of less diversified diet by the mothers and children. Relatively, a high proportion of households in the highland agroforestry land use system were growing fruit trees than those households from midland and lowland agro-ecology. These fruit trees are mainly grown in front yard and/or in woodland as a resource for household consumption (food and fuel source) and as an income for the household. As a result, not owning front yard or woodland was associated with low DD, both for the mothers and for the children who participated in the present study. Similarly, a study conducted elsewhere in Sidama district, where we conducted the present study, reported the positive association of growing fruits and vegetables with child diet diversity score (Dangura & Gebremedhin, 2017). Given the contribution of fruit as a source of micronutrient and to address the challenge of seasonal availability, incorporating fruits into local food systems is inevitable. Accordingly, the method developed by the World Agroforestry (ICRAF) is based on “fruit tree portfolios”, which selects socio-ecologically suitable and nutritionally important fruit tree species for farm production, to meet local consumption needs (Mcmullin et al., 2019). Thus, the newly initiated tree plantation activities by the government of Ethiopia should consider the ICRAF-recommended “tree fruit portfolio” for its implementation to maximize the benefit and reduce the highly dominant food and nutrition insecurity problem of rural people of the country.

In our study, not growing vegetables in households also associated with consumption of less DD by the children. On the other way, children living in the households growing vegetables had better diet quality. The could also happen in two ways: 1) mothers can feed the members of the household all the vegetables the household produced, and 2) selling some or all of the vegetable produced and buying other food commodity in return for household consumption.

Mothers who did not receive nutrition counseling since they conceived their indexed children’s was associated with mothers DD. Similarly, studies conducted in Northwest Ethiopia also reported the positive association between provision of nutrition information to pregnant women with better dietary practice (Aliwo et al., 2019; Sisay Alemayehu, 2015). An intervention study conducted in Malawi also revealed nutrition education to caregivers significantly increased the proportion of children who met the minimum diet diversity and minimum acceptable diet in the intervention group compared to children in the control group (Kuchenbecker et al., 2017).

Like other cross-sectional studies, the causality interpretation may not be possible, and using a single 24-h dietary recall for assessing the DD may underestimate or overestimate the usual intake, which are the limitations of the study. However, the DD data for mothers and children were extracted from quantitative 24-h recall data, and also the minimum intake requirement (≤15 g) was considered to count the food group while computing the DD for mothers, which are the strengths of the study.

5. Conclusions
The diversity of food groups consumed by the mothers and their children was low in the study areas, but it was extremely low in lowland agroforestry land use system. Household food insecurity and not growing fruit trees are commonly associated with consumption of less diversified diet by the mothers and their children. Being a young child, living in households in lowland agro-ecology, not growing vegetables, and not owning front or woodland were associated with consumption of less diverse diet by the children. Mothers not receiving any nutrition counseling/education since the conception of the children's included in this study were associated with consumption of less diversified diet. Therefore, intervention focusing on improving the diversity of mothers and children...
diet should be designed, with a prior focus on implementing agro-ecology-based nutrition-sensitive agriculture and dissemination of nutrition knowledge to mothers.

Acknowledgements
The authors would like to thank the study participants and data collectors. We are also grateful for the development agents who were facilitating the field work of the study. This study could not be possible without the support of the Wondo Genet College of Natural Resources and Forestry.

Funding
This research was financed by Hawassa University of Ethiopia; Hawassa University (HU thematic research 2011).

Competing Interests
The authors declare no competing interests.

Author details
Beruk Berhanu Desalegn
E-mail: berhanuberuk@gmail.com

1 School of Nutrition, Food Science and Technology, Hawassa University, P. O. Box 005, Hawassa, Ethiopia.
2 Department of Natural Resource Management, Hawassa University, Wondo Genet, Ethiopia.

Author contributions
BBD, study concept; BBD and BJ, data collection; BBD, data entry, data analyses and interpretations, and drafted the manuscript; BBD and BJ, critically reviewed and approved the final version of the manuscript.

Disclosure statement
The authors declare no competing financial interest.

Citation information
Cite this article as: Low diet diversity and its associated factors among the mothers and their children in agroforestry land use systems of Sidama, Ethiopia: A community-based cross-sectional study, Beruk Berhanu Desalegn & Biruk Jagiso, Cogent Food & Agriculture (2020), 6: 1818367.

References
Abate, K. H., & Belachew, T. (2017). Women’s autonomy and men’s involvement in child care and feeding as predictors of infant and young child anthropometric indices in coffee farming households of Jimma Zone, South West of Ethiopia. PLoS ONE, 12(3), 1–16. https://doi.org/10.1371/journal.pone.0172885

Abebe, T., Wiersum, K. F., & Bongers, F. (2010). Spatial and temporal variation in crop diversity in agroforestry homesteads of southern Ethiopia. Agroforestry Systems, 78(3), 309–322. https://doi.org/10.1007/s10457-009-9246-6

Aliwo, S., Fentie, M., Awoke, T., & Gizaw, Z. (2019). Dietary diversity practice and associated factors among pregnant women in North East. BMC Research Notes, 12(123), 1–6. https://doi.org/10.1186/s13104-019-1519-6

Amugusi, D. A., Lartey, A., Kimani, E., & Mberu, B. U. (2016). Women’s participation in household decision-making and higher dietary diversity: Findings from nationally representative data from Ghana. Journal of Health, Population, and Nutrition, 35(16), 1–8. https://doi.org/10.1186/s40403-016-0053-3

Ayenew, H. Y., Baidigilign, S., Schickramm, L., Abate-Kossa, G., & Sauer, J. (2018). Production diversification, dietary diversity and consumption seasonality: Panel data evidence from Nigeria. BMC Public Health, 18(1), 1–9. https://doi.org/10.1186/s12889-018-5887-6

Boyé, K., Iđ, K. H., Dereje, M., & Remans, R. (2019). Energy and nutrient production in Ethiopia, 2011-2015: Implications to supporting healthy diets and food systems. Plos One 14(3). https://doi.org/10.1371/journal.pone.0213182

Bosha, T., Lambert, C., Riedel, S., Melesse, A., & Biesalski, H. K. (2019). Dietary diversity and anthropometric status of mother – child pairs from enset (false banana) staple areas: A panel evidence from Southern Ethiopia. Int. J. Environ. Res. Public Health, 16(12), 2170. https://doi.org/10.3390/ijerph16122170

Chandrasekhar, S., Aguyov, V. M., Krishna, V., & Nair, R. (2017). Household food insecurity and children ’ s dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. Maternal & Child Nutrition, 13(S2): e12447, 1–8. https://doi.org/10.1111/mcn.12447

Dafursa, K., & Gebremedhin, S. (2019). Dietary diversity among children aged 6-23 months in Aleta Wondo District, Southern Ethiopia. Journal of Nutrition and Metabolism, 2019, 1–10. https://doi.org/10.1155/2019/2869424

Dangura, D., & Gebremedhin, S. (2017). Dietary diversity and associated factors among children 6-23 months of age in Gorchè district, Southern Ethiopia: Cross-sectional study. BMC Pediatrics, 17(1), 1–7. https://doi.org/10.1186/s12887-016-0764-x

Desalegn, B., Lambert, C., Riedel, S., Negese, T., & Biesalski, H. (2019). Feeding practices and undernutrition in 6-23-month-old children of orthodox Christian mothers in Rural Tigray, Ethiopia: Longitudinal study. Nutrients, 11(1), 138. https://doi.org/10.3390/nu11010138

Desalegn, B. B., Lambert, C., Riedel, S., Negese, T., & Biesalski, H. K. (2018). Ethiopian orthodox fasting and lactating mothers : Longitudinal study on dietary pattern and nutritional status in Rural Tigray, Ethiopia. International Journal of Environmental Research and Public Health, 15(1767), 1–20. https://doi.org/10.3390/ijerph15081767

Dessie, G., & Kirlind, P. (2008). Khat expansion and forest decline in Wondo genet, Ethiopia. Geografiska Annaler. Series B, Human Geography, 90(2), 187–203. https://doi.org/10.1111/j.1468-0467.2008.00286.x

Destá, M., Akibu, M., Tadesse, M., & Tesfaye, M. (2019). Dietary diversity and associated factors among pregnant women attending antenatal clinic in Shashemene, Oromia, Central Ethiopia: A cross-sectional study. Journal of Nutrition and Metabolism, 7. https://doi.org/10.1155/2019/3916864

FAO and FHI 360. (2016). Minimum dietary diversity for women a guide to measurement. Rome, Italy: FAO.

Gebremedhin, S., Boye, K., Bekele, T., Tharoney, M., Asrat, Y., Abebe, Y., & Retn, N. (2017). Predictors of dietary diversity in children ages 6 to 23 mo in largely food-insure area of South Wollo, Ethiopia. Nutrition, 33, 163–168. https://doi.org/10.1016/j.nut.2016.06.002

Gibson, R. S., & Fergusen, E. L. (1999). An interactive 24-hour recall of assessing the adequacy of iron and zinc intakes in developing countries. In Heat transfer engineering (Vol. 10, Issue 2, pp. 190). International Life Sciences Institute Publishers. https://doi.org/10.1080/0145763890839699
Yenebat, T., Adugna, H., Asmamaw, T. et al. (2019). Maternal dietary diversity and micronutrient adequacy during pregnancy and related factors in East Gojjam Zone, Northwest Ethiopia. BMC Pregnancy and Childbirth, 19(1), 1–9. https://doi.org/10.1186/s12884-019-2299-2

Hameso, S. (2015). Perceptions, vulnerability and adaptation to climate change in Ethiopia: The case of smallholder farmers in Sidama. University of London.

Hirveno, K., & Hoddinott, J. (2014). Agricultural production and children’s diets: Evidence from rural Ethiopia. Ethiopia Strategy Support Program, Working Paper 69, 17.

Hirveno, K., Hoddinott, J., Minten, B., & Stifel, D. (2017). Children’s diets, nutrition knowledge, and access to markets. World Development, 95, 303–315. https://doi.org/10.1016/j.worlddev.2017.02.031

Jennifer, C., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of household food access: Indicator guide (Version 3, Issue August). Washington, D.C.: Food and NutritionTechnical Assistance Project, Academy for Educational Development, P.36

Jiru, E. B. (2019). Review on agro-forestry system and its contribution in Ethiopia. International Journal of Sustainability Management and Information Technologies, 5(1), 8–14. https://doi.org/10.11648/j.ijsm.it.20190501.12

Jones, A. D., Shrinivas, A., & Bezner-Kerr, R. (2016). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy, 46, 1–12. https://doi.org/10.1016/j.foodpol.2014.02.001

Khan, G. N., Arif, S., Khan, U., Habib, A., Umer, M., Suhag, Z., Hussain, I., Bhatti, Z., Ullah, A., Turab, A., Khan, A. A., Gorzan, A. C., Khan, M. I., & Soofi, S. (2017). Determinants of infant and young child feeding practices by mothers in two rural districts of Sindh, Pakistan: A cross-sectional survey. International Breastfeeding Journal, 12(1), 1–8. https://doi.org/10.1186/s13006-017-0131-z

Kuchenbecker, J., Reibott, A., Mitmuni, B., Krowinkel, M. B., & Jordan, I. (2017). Nutrition education improves dietary diversity of children 6–23 months at community-level: Results from a cluster randomized controlled trial in Malawi. PLoS ONE, 12(4), e0175216. https://doi.org/10.1371/journal.pone.0175216

Lalego, B., Ayalew, T., & Kaske, D. (2019). Impact of climate variability and change on crop production and farmers’ adaptation strategies in Lokka. African Journal of Environmental Science and Technology, 13(March). https://doi.org/10.5897/AJEST2018.xxx

Mbow, C., Smith, P., Skole, D., Duguma, L., & Bustamante, M. (2016). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. Current Opinion in Environmental Sustainability, 6(1), 8–14. https://doi.org/10.1016/j.cosust.2013.09.002

McMullin, S., Njogu, K., Wekesa, B., Gachuir, A., Ngethe, E., & Stodlmayr, B. (2019). Developing fruit tree portfolios that link agriculture more effectively with nutrition and health: A new approach for providing year-round micronutrients to smallholder farmers. Food Security, 11, 1335–1372. https://doi.org/10.1007/s12571-019-00970-7

Nguyen, P. H., Avula, R., Ruel, M. T., Saho, K. K., Ali, D., Tran, L. M., Frongillo, E. A., Menon, P., & Rawat, R. (2013). Maternal and child dietary diversity are associated in Bangladesh, Vietnam. The Journal of Nutrition, 143(7), 1176–1183. https://doi.org/10.3945/jn.112.172247

Raj, D., Id, S., Ghimire, S., Upadhyay, S. R., & Singh, S. (2020). Food insecurity and dietary diversity among lactating mothers in the urban municipality in the mountains of Nepal. PLoS ONE, 15(1), e0227873. https://doi.org/10.1371/journal.pone.0227873

Sibhatu, K. T., & Qaim, M. (2017). Rural food security, subsistence agriculture, and seasonality. PLoS ONE, 12(10), e0186406. https://doi.org/10.1371/journal.pone.0186406

Sisay Alemayehu, M. (2015). Dietary practice and associated factors among pregnant women in Gondar Town North West, Ethiopia, 2014. International Journal of Nutrition and Food Sciences, 4(6), 707. https://doi.org/10.11648/j.ijnjfs.20150406.27

Teriku, A., Gonete, K. A., Bikes, G. A., & Alemu, K. (2019). Household food insecurity predisposes to undiversified diet in northwest Ethiopia: Finding from the baseline survey of nutrition project, 2016. BMC Research Notes, 12(54), 1–7. https://doi.org/10.1186/s13104-019-4083-9

Teklu, B., van de Ven, G., Gillier, K., & Descheemaeker, K. (2018). Home garden system dynamics in Southern Ethiopia. Agroforestry Systems, 92(6), 1579–1595. https://doi.org/10.1007/s10457-017-0106-5

Tessemra, M., Belachew, T., & Ersino, G. (2013). Feeding patterns and stunting during early childhood in rural communities of Sidama, south Ethiopia. PanAfrican Medical Journal, 14(75), 1–12. https://doi.org/10.11604/pamj.2013.14.75.1630

UNICEF. (1998). The status of the world’s children. Oxford University Press.

WHO. (2010). Indicators for assessing infant and young child feeding practices. Part 3 Country Profiles, 1–47. ISBN 978 92 4 159797 7.

Zanelli, G., Shankar, B., & Poole, N. (2019). Buy or make? Agricultural production diversity, markets and dietary diversity in Afghanistan. Food Policy, 87(12Jul2018), 101731. https://doi.org/10.1016/j.foodpol.2019.101731

Zerfu, T. A., & Biadgiglia, S. (2018). Pregnant mothers have limited knowledge and poor dietary diversity practices, but favorable attitude towards nutritional recommendations in rural Ethiopia: Evidence from community-based study. BMC Nutrition, 4(1), 1–9. https://doi.org/10.1186/s40795-018-0251-x
