World Journal of Agricultural Sciences 16 (1): 01-10, 2020
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2020.01.10

Spatial and Temporal Variability of Household Food Nutritional Condition in Mixed Crop-Livestock Systems in Southwestern Ethiopia

Asrat Guja

Department of Animal Science, College of Agricultural Science,
Arba Minch University, Arba Minch, Ethiopia

Abstract: Hunger and malnutrition, yet present a paradox in a smallholder farm family in many developing countries. Information is insufficient in these population particularly in seasonal hunger and food nutritional conditions. The current study employed a field survey in system approach that integrates both biophysical and socioeconomic understanding of farming systems, the environment and natural resources at the farm level with mixed effects modeling. The interaction effect ($F = 1307.17$, $p=0.000$) of elevation was significant across agroecology. The marketing distance, location and agroecology were showed significant ($F = 12.76$, $p=0.000$) interaction effect. Farm size in wet highland and the dry lowland each was significantly lower compared to the other agroecology. The herd head ($x = 4.49$, $SD= 2.76$) in wet highland was significantly lower. The interaction effect ($F = 31.22$, $p= 0.000$) of household food security score index was significant such that overall means score index ($x = 3.28$, $SD= 1.23$) in the dry lowland agroecology, as well as overall means score index ($x = 2.99$, $SD= 0.92$) from March to May of the year, was lower significantly. Overall, two characteristic features are observed in households' food nutritional situation. The three basic operational options (a system manipulation, land use sparing and establishing a regular infrastructure) will be remarkable concerning resources, assets and constraints in supply side to food security and poverty reduction.

Key words: Agroecology System · Food Nutritional Status · Score Index · Socioeconomic Characteristics

INTRODUCTION

The fundamental properties of complex dynamic systems and their relation with the mechanisms that govern resilience and transformability in African smallholder agriculture emerge from the aggregation of diverse livelihood strategies in response to changes in the agro-ecosystem context are characterised by non-linearity, irreversibility, convergence/ divergence and hysteresis [1]. A useful step towards promoting multi-sectoral approaches for improving food security could be essentially based on understanding factors influence both socio-economic and biophysical potential in developing countries.

In developing countries, around 40% of the human population lives in the mountain region where most of them engage in small-scale family farms. About 300 million people of these population are food insecure, with half of them suffering from chronic hunger [2]. Limited availability of land that often has low productivity, lack of recognized land tenure rights and population pressure are all suggested elements that contribute to the unsustainable use of mountain natural resources [3]. National and regional diversity contexts also influenced family farm structures and functions, as well as livelihood strategies in agroecological conditions, territorial characteristics, infrastructure availability (access to markets, roads, etc.), policy environment and demographic, economic, social and cultural conditions [4].

Some inputs into nutrition are public goods, for instance, better health requires economic access, whereas the latter is determined by disposable income, food prices and the provision of and access to social support. Incomes earned in small agriculture commodities play a primary role in determining food security outcomes, however, often determined by the availability and quality of infrastructure, communication, food storage facilities and other installations that facilitate the functioning of markets [4]. Food security indicators at the local level should reflect local realities, measure relevant outcome

Corresponding Author: Asrat Guja, Department of Animal Science, College of Agricultural Science, Arba Minch University, Arba Minch, Ethiopia. Mob: +251 911071200.

objectives and be based on context analysis and needs for different socioeconomic groups [5]. It has particular potential as a cross-disciplinary indicator capable of promoting the link between different sectorial perspectives, for example, the link between nutrition and agriculture [6].

A framework for how to address seasonal hunger that combines agricultural livelihood development with social protection and emergency assistance [7] has been suggested. However, information is clearly insufficient regarding seasonal hunger at the national level on the distribution and severity of hunger and food insecurity in the population, the characteristics, circumstances and location of those most affected group [6]. The links between increased production and improved food consumption of poor and food-insecure persons are mediated through complex institutional and socio-economic relations, thus one should not just think of production increases in the abstract [4, 8]. This paper aimed to analyse interaction effect of environmental factor in socioeconomic characteristics and pattern of food nutritional distribution in seasons of the year across agroecology in the smallholder system in south western Ethiopia.

MATERIALS AND METHODS

Description of Study Area: The study area consisted virtually a complex raged landscape within the altitudinal range 1214 to 2723 meter above sea level (m.a.s.l.) in Southern Nations, Nationalities and Peoples' (SNNP) regional state, Ethiopia. The mean annual rainfall of the area was 1240 mm at 2800 m.a.s.l. and 850 mm at 1300 m.a.s.l. The rainfall occurs bi-modally, mainly in late dry (Mar-May) season and in summer (July-Aug and Sept-Nov) as the main rainy season. Commonly, the year divide into four local seasons [9, 10]. The major crops grown, the resource potential and the environmental factors limit peoples' accesses vary from locations to locations and across agroecology [9-14]. *Enset* (*Ensete ventricosum*), a perennial drought-resistance crop produced from highland to lowland, is provide a staple food in a form of *kochoo* (carbohydrate-based diet) and the mainstay of food security.

Sampling and Study Design: The data collection procedure and sampling design employed in the study has been indicated in an earlier study [10, 12, 14]. The study was conducted between February 2014 and December 2016. On the same occasion, major food items consumed in the households were interviewed for three dietary regimes (during breakfast, lunch and dinner) and the four local seasons of the year. Six scale scores were used in the interview to evaluate household food condition. The food availability, access to and the ability for across the season in the year was adapted in the household interview, based on the Food Insecurity Experience Scale (FIES), which is a qualitative measure of how people perceive their food security situation [6, 15, 16]. Score one the least and six was the most available, accessible and ability for food items in the season of the year in the household. The information was gathered in replicate for four seasons in three daily dietary regimes and the three qualitative variables of food security situation as how the interviewed households perceive their food security situation in the season category of the year, which summed during the data analysis.

Statistical Analysis: Among subject factor, the two-way analysis of variance (ANOVA) was conducted to study the interaction effect in a full model. The subject factors included were of environmental factors (elevation and landscape slope), marketing distance from household location, socioeconomic variables (farm size, herd head and family size) and score index of food security in a 4 agroecologies and 13 peasant administration (PAs [14]). While later in agroecology, a data split method was applied [17]. Means and standard Deviation (SD), as well as one-way analysis of variance was further carried out in split data with Bonferroni test comparisons ($p<0.05$).

Note that vectors of different groups are mapped into the same decision space but different correcting spaces the inner products in the corresponding spaces be defined by the kernels [18]. Moreover, the usefulness of data model as a framework to comparatively estimate the performance of some two mode methods is demonstrated in a Monte Carlo study [19-21]. Thus, the linear mixed-effects modeling analysis within the full data matrix was taken on the response variable of annual food security of score indices, the qualitative information on the diet items and the farm level production constraints that interviewed in the households [see 18, 22-24]. When comparing predictors in a reduced model a maximum likelihood estimate [25] was used. The χ^2 multiple comparisons tests were conducted and the p-value of individual model effect was inspected ($p< 0.05$). The analysis was carried out in the in the SPSS (2011) software version 20.

A familiar general mixed model notation is shown in E.q (1) as:

$$Y_i = X_i\beta + L_i m_i + \varepsilon_i \quad (1)$$

where Y_i is the target response variable (*i*); X_i is the data matrix of the response variable (*i*); β is a fixed effect covariate; L_i is the random effect of observed value covariates (*i*); m_i is random effect for the i^{th} subject; and ε_i is random effect error.

The overall effect fitted in a linear predictor model shown in E.q (2) as:

$$Y_i = X_i \quad (2)$$

RESULTS

Environmental Factor and Socioeconomic Characteristics: There was significant interaction effect of elevation (F = 1307.17, p= 0.000), as well as the interaction effect was significant (F= 33.36, p=0.000) for the landscape slope (%) among agroecology.

A 4 agroecological x 13 PAs x 4 market distances among subject ANOVA was conducted to analyse the interaction effect in the household marketing situation. The interaction effect, (F= 2066.88, p= 0.000) was significant such that the overall market distance among agroecology was significantly different (Error! Reference source not found).

Household interviewed, farm level agricultural production constraints were presented in Error! Reference source not found.. The overall effect of agricultural production constraint was exhibited a significant difference (χ^2 = 64.50, p = 0.00) among agroecology. Declining soil fertility condition was pronounced in all household exception to the dry lowland (DLL) and the difference was significant compared to the other factor. A crop diseases problem 23% was the highest in the wet highland (WHL) households.

Land shortage and weather variability problems were increased in gradient down to the DLL. Shortage for improved variety and increasing production cost was indicated the highest percentage count in the WHL agroecology. Labour scarcity, marketing condition limitation, the lack of credit services and lack/death of oxen were most important factors in wet lowland (WLL) households.

There was a significant interaction effect, (F = 6.38, p = 0.000) such that family size in WHL and in DLL of each was significantly higher compared to the wet upper lowland to sub-humid (WULL-SH) and the WLL (Error! Reference source not found).

The interaction effect of farm size, (F = 8.08, p = 0.000) was significant. A farm size in WHL and the DLL was each significantly lower compared to that of the WULL to SH and the WLL agroecology (Error! Reference source not found.). The herd head in WHL was significantly lower compared to the other agroecology households (Error! Reference source not found.), which the interaction effect, (F = 6.75, p = 0.000) was also significant for herd head owned in the households among agroecology.

Household Food Nnutritional Status: Various 10 diet items in the dietary regimes across the season of the year were identified in the interviewed households (Error! Reference source not found.). A bread of *kochoo* with cabbage was showed higher overall count (30%) in the households' dietary regime (during breakfast, lunch and dinner) across the season in the year. Followed by the bread of grains with cabbage 25%, coffee with either *kollo* or bread or both 12% and food of root crops 11% were higher in the households' food items. The *injera* with dairy products and sometimes with meat was accounted for 7% in the farm households' food.

The food items with coffee were fairly a uniform distribution in season in the household diet. However, the *injera* with dairy products and sometimes with meat was mainly aggregated, probably to holiday periods (Error! Reference source not found). The bread of *kochoo* with cabbage (30%) was showed a resemblance to the late summer where *kochoo* with milk products (26%) were to the early summer with a major quintessence as food to the far away PAs in the highland agroecology. Grain diets mainly observed in the late summer, early and the late dry periods were particular importance in the gradient to the lowlands. Diets from the root crops were often consumed in early (23%) and the late (35%) dry seasons in the household (Error! Reference source not found).

Distribution of diet item diversity across the seasons of the year among the PAs of the households is presented in Table 5. The overall means of the diet in distribution across the seasons was significant (χ^2=34.31, p = 0.00). The diet items diversity across the season was observed better in the PAs in WULL to SH and the WLL households.

The overall means of the diet items distribution among the season were significant (χ^2=203.28, p=0.00). The bread of grains and the bread of *kochoo* were most frequent in the households diet and the means difference was not significant (χ^2=0.28, p=0.99) between the two. Similarly, no significant difference in a means comparison between (χ^2=3.08, p=0.91) the *injera* and the root crops, as well as between (χ^2=33.74, p=0.23) the coffee and the root crops diets in the households.

Table 1: Overall (Mean and Standard Deviation (SD)) distance (minute) in agroecology

Agroecology	n*	Mean(±SD)
Wet highland	121	154.60(242.31)[a]
Wet upper lowland to sub-humid	249	188.0(283.94)[b]
Wet lowland	156	168.74(171.63)[c]
Dry lowland	209	57.17(58.54)[d]

[ab]Column means of the same superscript in category are not significant ($p<0.05$)

*The number of respondent in participatory group and interviewed household

Table 2: Respondent household count (%) to farm level production constraints in agroecology

	Count per household in agroecology				
Constraint	Wet highland (n=183)	Wet upper lowland to sub-humid (n=387)	Wet lowland (n=198)	Dry lowland (n=267)	Overall, count (%) (n=1035)
Decaling soil fertility	18	26	24	13	215 (21)
Crop disease	23	7	5	3	86 (8)
Weather variability	11	22	17	27	210 (20)
Land shortage	9	10	6	27	140 (14)
Improved variety shortage	16	9	2	3	76 (7)
Rising production cost	13	5	7	10	83 (8)
Labour scarcity	2	9	13	0	78 (8)
Marketing limitation	5	5	8	0	84 (8)
Lack of credit services	2	3	10	12	16 (2)
Lack of irrigation	0	0	0	5	14 (1)
Lack/death of ox/en	0	4	10	0	33 (3)

Table 3: Household socioeconomic characteristics in agroecology (Mean and Standard Deviation (SD))

	Family size		Farm size		Herd head	
Agroecology	n	Mean(±SD)	n	Mean(±SD)	n	Mean(±SD)
Wet highland	61	6.82(3.04)a	61	1.35(1.38)a	60	4.49(2.76)a
Wet upper lowland to sub-humid	129	6.56(2.62)b	129	2.06(1.41)b	129	6.36(3.08)b
Wet lowland	66	6.39(2.46)b	66	2.02(1.38)b	68	7.46(4.65)b
Dry lowland	89	7.06(2.14)a	89	1.32(1.05)a	95	5.77(2.64)b
Total	345	6.70(2.56)	345	1.74(1.35)	352	6.09(3.40)

[ab]Column means in category of the same superscript are not significantly among agroecology ($p<0.05$)

Table 4: Respondent household count (%) to diet item in daily dietary regime and seasons of the year

Diet item	Sept-Nov Count(%)	Dec-Feb Count(%)	Mar-May Count(%)	Jun-Aug Count(%)	Total Count (%)
Coffee with *kollo* and/or bread loaf	123(25)	132(27)	120(23)	123(25)	498(12)
Bread loaf of *kochoo* with cabbages	373(30)	241(20)	299(24)	316(26)	1229(30)
Bread loaf of *kochoo* with milk & milk products	25(11)	39(18)	78(35)	79(36)	221(5)
Bread loaf of grain with cabbages	293(28)	287(28)	213(21)	241(23)	1034(25)
Bread loaf of grain with milk & milk products	77(23)	108(32)	97(29)	51(15)	333(8)
Injera with dairy products & sometimes with meat	72(26)	107(39)	57(21)	38(14)	274(7)
Root crops	56(12)	106(23)	164(35)	145(31)	471(11)
Porridge from root crops & *kochoo*	12(38)	12(38)	3(9)	5(16)	32(1)
Maize with bean in different form	2(5)	0(0)	0(0)	36(95)	38(1)
Others	1(10)	4(40)	3(30)	2(20)	10(0)
Total count (%)	1034(25)	1036(25)	1034(25)	1036(25)	4140

Table 5: Respondent household count to the diet item in daily dietary regime in season of the year

		GQ#	LO	MY	GUZ	FH	GRS	QK	TZ	YW	ALG	ANC	FUR	PG
Season	Food item*	87	95	96	96	96	99	75	27	96	96	96	18	57
Sept- Nov	1	-	-	-	12	27	10	10	7	33	-	21	-	3
	2	87	27	92	72	18	17	7	7	25	18	6	5	5
	3	-	11	4	3	2	-	26	-	-	4	1	-	-
	4	-	25	-	-	25	53	8	1	26	61	57	7	26
	5	-	11	-	5	-	-	-	-	-	3	1	4	18
	6	-	16	-	2	-	5	2	-	-	10	9	2	4
	7	-	5	-	2	23	14	9	-	-	-	1	-	1
	8	-	-	-	-	-	-	1	12	12	-	-	-	-
	9	-	-	-	-	-	-	12	-	-	-	-	-	-
	10	-	-	-	-	1	-	-	-	-	-	-	-	-
Dec- Feb	1	15	-	-	8	25	9	7	1	31	10	21	3	2
	2	67	11	65	55	5	12	7	9	-	11	2	-	7
	3	1	9	13	3	4	-	5	-	-	-	3	-	1
	4	-	30	11	-	30	39	18	3	37	71	53	7	30
	5	-	21	3	2	5	3	3	-	-	3	-	4	10
	6	4	18	4	15	5	13	-	-	-	1	14	1	7
	7	-	7	-	13	20	23	23	10	7	-	-	3	-
	8	-	-	-	-	-	-	-	4	21	-	-	-	-
	9	-	-	-	-	-	-	12	-	-	-	-	-	-
	10	-	-	-	-	2	-	-	-	-	-	3	-	-
Mar- May	1	16	-	3	5	17	7	2	1	33	-	26	-	10
	2	63	32	45	40	25	16	13	3	-	44	4	5	17
	3	2	9	22	21	2	1	8	-	-	13	-	1	4
	4	-	18	4	2	17	37	10	10	57	39	55	7	18
	5	-	9	-	3	-	-	4	-	-	-	5	2	1
	6	1	5	22	4	7	6	-	-	-	-	5	-	3
	7	5	21	-	21	28	32	35	9	6	-	-	3	4
	8	-	-	-	-	-	-	-	4	-	-	-	-	-
	9	-	-	-	-	-	-	3	-	-	-	-	-	-
	10	-	2	-	-	-	-	-	-	-	-	1	-	-
Jun- Aug	1	-	-	4	12	18	9	4	5	32	-	25	4	10
	2	87	5	57	64	14	17	9	7	52	37	10	3	15
	3	-	9	24	7	3	5	7	-	-	12	1	-	8
	4	-	5	10	7	22	22	5	1	6	36	48	8	15
	5	-	11	-	-	4	4	9	-	-	11	1	3	5
	6	-	-	1	2	9	5	27	9	-	-	9	-	1
	7	-	66	-	4	26	35	8	1	-	-	2	-	3
	8	-	-	-	-	-	2	1	4	6	-	-	-	-
	9	-	-	-	-	-	-	5	-	-	-	-	-	-

*1=Coffee with *kollo* and/or bread loaf, 2 = Bread loaf of *kocho* with cabbages, 3 = Bread loaf of *kocho* with milk & milk products, 4 = Bread loaf of grain with cabbages, 5= Bread loaf of grain with milk & milk products, 6= *Injera* with dairy products & sometimes with meat, 7= Root crops, 8= Porridge from root crops & *kocho*, 9= Maize with bean in different form, 10= Other.

#GQ= Gmra Qema, LO= Losha, MY= Myla, GUZ= Guzza, FSH= Fishto, GRS= Grsse Zala, QK= Qchem Kessi, TZ= Tarch Zura, YW= Yallo Worbati, ALG= Alga, ANC= Ancover, FUR= Furra, PG= Para Gossa

Table 6: Overall (Mean and Standard Deviation (SD)) score index of food security situation according to respondent household in agroecology and local season of the year

Agroecology	n	Mean(±SD)	Season	n	Mean(±SD)
Wet highland	732	$3.60(0.81)^{b}$	Sept-Nov	1035	$3.90(0.98)^{a}$
Wet upper lowland to sub-humid	1548	$3.49(1.03)^{c}$	Dec-Feb	1035	$3.97(0.95)^{a}$
Wet lowland	792	$3.75(1.25)^{a}$	Mar-May	1035	$2.99(0.92)^{c}$
Dry lowland	1068	$3.28(1.23)^{d}$	Jun-Aug	1035	$3.13(1.19)^{b}$

^{ab}Column means in the category of the same superscript are not significant ($p<0.05$)

Table 7: Season effect on score index (Mean and Standard Deviation (SD)) in and across peasant administration (PA) of similar agroecology (AE)

AE	PA	n	Sept-Nov Mean(±SD)	Dec-Feb Mean(±SD)	Mar-May Mean(±SD)	Jun-Aug Mean(±SD)	Total Mean(±SD)
WHL*	GQ#	87	3.31(0.85)^{aA}	4.03(0.75)^{bA}	3.72(0.79)^{cA}	3.01(0.97)^{dA}	3.52(0.93)^{A}
	LO	96	3.48(0.87)^{aB}	3.67(0.57)^{bB}	3.67(0.57)^{bA}	3.85(0.60)^{cB}	3.67(0.68)^{B}
	Total	183	3.40(0.86)^{aAB}	3.84(0.69)^{bC}	3.69(0.69)^{bA}	3.45(0.90)^{aC}	3.60(0.81)^{AB}
WULL-SH	MY	96	3.83(0.63)^{aA}	4.86(0.92)^{bA}	3.02(0.65)^{cA}	3.79(0.97)^{aA}	3.88(1.04)^{A}
	GUZ	96	3.72(1.05)^{aAB}	4.26(1.04)^{bB}	2.83(1.07)^{cB}	2.52(0.89)^{dD}	3.33(1.23)^{BD}
	FSH	96	3.60(0.61)^{aBC}	3.93(0.44)^{bC}	3.13(0.67)^{cA}	3.22(0.78)^{cB}	3.47(0.71)^{BC}
	GRS	99	3.56(0.73)^{aC}	3.93(0.85)^{bC}	3.12(0.79)^{cA}	2.52(0.95)^{dD}	3.28(0.98)^{D}
	Total	387	3.68(0.78)^{aBC}	4.24(0.92)^{bB}	3.03(0.82)^{cA}	3.01(1.05)^{cC}	3.49(1.03)^{C}
WLL	QK	75	4.53(0.99)^{aA}	4.21(0.68)^{bA}	2.63(1.04)^{cA}	3.28(0.73)^{dA}	3.66(1.15)^{A}
	TZ	27	4.11(0.93)^{aB}	4.37(0.88)^{bB}	3.04(0.81)^{cB}	3.81(1.04)^{dB}	3.83(1.04)^{A}
	YW	96	4.38(1.18)^{aA}	3.20(1.01)^{bC}	2.73(0.89)^{cA}	4.71(0.1.23)^{dC}	3.75(1.37)^{A}
	Total	198	4.40(1.08)^{aA}	3.74(1.07)^{bD}	2.73(0.94)^{cA}	4.05(1.23)^{dD}	3.73(1.25)^{A}
DLL	ALG	96	3.99(1.15)^{aA}	3.81(0.97)^{bA}	3.07(0.76)^{cA}	2.77(0.51)^{dA}	3.41(1.01)^{A}
	ANC	96	4.32(0.80)^{aBC}	3.70(1.04)^{bA}	2.5(0.83)^{cB}	2.03(1.20)^{dB}	3.14(1.34)^{B}
	FUR	18	3.94(1.0)^{aA}	4.0(1.19)^{aB}	2.5(0.86)^{bB}	2.67(0.77)^{cA}	3.28(1.18)^{AB}
	PG	57	4.44(0.91)^{aB}	4.07(0.73)^{bB}	2.30(1.02)^{cC}	2.39(1.08)^{cC}	3.30(1.35)^{AB}
	Total	267	4.20(0.99)^{aC}	3.84(0.97)^{bA}	2.66(0.90)^{cD}	2.42(1.00)^{dC}	3.28(1.23)^{AB}

^{ab}Row means in lower case of the same superscript of the same agroecology households are not significant ($p<0.05$)

^{AB}Column means in the upper case of the same superscript of the same agroecology households are not significant ($p<0.05$)

*WHL=Wet highland, WULL-SH= Wet upper lowland-sub-humid, WLL= Wet lowland, Dry lowland

#GQ= Gmra Qema, LO= Losha, MY= Myla, GUZ= Guzza, FSH= Fishto, GRS= Grsse Zala, QK= Qchem Kessi, TZ= Tarch Zura, YW= Yallo Worbati, ALG= Alga, ANC= Ancover, FUR= Furra, PG= Para Gossa

A 4 agroecology x 13 PAs x 4 local seasons among subject ANOVA was conducted to analyse the interaction effect of food security score index in the households. The interaction effect, ($F = 31.22$, $p= 0.000$) was significant such that overall score index among agroecology, as well as among season was significantly different (Error! Reference source not found).

The overall means score index of food security in the DLL households was significantly lower compared to the other households in the agroecology. Similarly, among season the overall means of the score index of March to May was significantly lower (Error! Reference source not found).

A lower overall means of score index in the households of the WULL to SH and the WHL were observed from Jun to Aug (Error! Reference source not found). The food security, overall means score indices of the two consecutive rainy seasons, from Sept to Nov and from Jun to Aug were significant compared to the corresponding dry seasons in the Gmra Qema households ($p< 0.05$). Overall means score index comparison of food security was significant in the similar AEZ households of Gmra Qema and the Losha (Error! Reference source not found). The distribution pattern in the season was, however, almost similar in the rest households in the WULL to SH, DLL and the WLL, which low from Mar to May and high from Dec to Feb.

DISCUSSION

Environmental Effect and Socioeconomic Characteristics: Lack of good roads increases transaction costs, the steeper slopes on the farmland add to the cost of maintaining agricultural systems and there are higher production and reproductive costs are disadvantaged owing to low current investment in and less innovation adapted to, mountain farming conditions in developing and transition countries [3]. However, agroecology can play an important role in developing resilience, adaptation to climate change, preserving the ecosystem and biodiversity, which at large can support food production and food nutritional security. Gliessman [26] urged that agroecology must integrate science, technology and practice and movements for social change help to re-connect the people who grow the food and the people who eat the food in a relationship that it benefits both.

The interaction effect was significant for environmental factors such as overall means elevation (m) and landscape slope (%) in the current study among agroecology [14]. This indicates that there is a spatial variability among the study households, which could influence the farming system, social organization, as well as access of smallholder producers. The boundaries of agroecological systems include not only farming but also distribution, processing, trading and consumption [27,28].

Agricultural systems play an interactive role among its components in developing countries [29, 30] including the present study area [10, 14], however, its performances challenged by several supply side factors [8, 10, 12, 14].

As the study result indicated, the interaction effects of household socioeconomic characteristics were significant. Moreover, means of farm size, livestock and the family number was significantly different in various locations and agroecology of the study households [14]. The choice of management practices and technologies to achieve full potentials of these resources, assets and family labour, however, is always location specific, shaped by a given social-ecological context [27]. The economic agent, landscape and the market [31] simulation have been verified von Thunen theory that the net profit derived from any particular agricultural land use is a function of the linear distance from a central market.

The constraints on production factors like a land shortage, disease, market limitation, rising production cost, lack of labour and shortage to the improved crop verities were important factors pronounced by the respondent households and the statistics result was also significant among the agroecology. The monthly scale drought extremity was rife in Gamo Gofa Zone whereas both drought (12 months scale) and wet incidences were frequent in Dawuro Zone [12]. The results of the respondent farmers' further evidenced the households in the wet stress prevalent PAs were by-passed the *belg* season cropping activities which common in the others, as well as common throughout the bimodal rainfall receiving regions in the country [10].

The present study area has a huge potential for agriculture in both food and non-food production biomass, as well as an abundance of natural resources, such as soil, rivers, lakes, parks and biodiversity [9]. In fact, in tropical condition, several different factors (ecological, infrastructural, external economic, internal operational and personal acceptance) limit the possible occurrence and importance of crop and livestock types found in any actual farm system [32- 34].

Household Food Nutritional Status: Comprehensive food security and vulnerability analyse by World Food Program indicated that the rural households were likely to fill themselves up with cheap, energy giving staples but forego key nutrients and micronutrients in Ethiopia. That report demonstrated that 29% of the rural household's consumed 'less than acceptable' diets, the prevalence rose to a striking 68% in rural SNNP region, where some 34% had 'poor' food consumption, a diet consisting overwhelmingly of staples [35]. Dairy and meat supply is limited, with consumption of these products especially low in rural areas, except in pastoralist districts (Somali and Afar) where milk is a major component of the diet, consumed 4-5 days a week compared with 1.5 days on average nationally [35]. Usually, staples are accompanied by vegetables (5 days a week) and fruit consumption is low across all the districts in Ethiopia.

According to the study result, the two characteristic features are observed in households' food nutritional situation concerning resources, assets and constraints. Farm households that are lives in the faraway distance, owned comparably higher farm size, the number of herd head and less number family were evidenced larger overall means score index of food security. In contrast, those households who live in near distance to marketing situation, small farm size and herd head but large members of family size were better in seasonal diversity of food items while lower overall means score index.

The higher score indices of households' food situation from Dec to Feb could probably related to the concurrence with annual crops harvest season and suitability of dry season to process, distribute and marketing farm household products and their demand would also common all over the country. Low overall means score indices of food nutritional condition in Mar to May all around the study households could supposedly correspond with the influences of heavy dry periods of early (Dec to Feb) season and could also reflect the seasonality of farm production in the study area. The spatial variability in the score indices from Sept to Nov and from Jun to Aug seasons could probably relate with the influences of weather variability, agroecology, infrastructural and institutional challenges in the specific farming system. An earlier study was also determined a significant difference in vegetation greenness (in terms of normalized difference vegetation index) and patterns of rainfall distribution across the given four local seasons in the study area [9].

Those households that had better landholdings to grow crops such as maize, *tef*, wheat and banana together with livestock source were increased income obtained in the households [10], however, such an increase in income did not compensate food security in the households. IFAD, FAO and several other suggestions have also shown that the income growth alone did not affect food security and poverty in rural smallholder system.

The greatest potential for rural poverty reduction would be the large share of food (and particularly staple food) in the total consumption of the poor; the large share of calories the poor derive from staple food consumption;

and the large share of income the poor derive from staple food production [4, 36]. While disconnected local food markets are often resulting in hungry in most of SSA, live in rural areas and are involved in agricultural activities for subsistence or income generation [37].

CONCLUSION

A consistent supply of home-grown food items could supposedly be contributed overall higher means score index in the staple food growing households. The food items diversity could also be enhanced in such a household from the counterpart production system in the dry season. In contrast, the score index, as well as the diversity in a food item, could low in such the same households in the rainy season. Overall availability of food could more challenge in the production system mainly based on temporal cropping activities and drought prone lowland households. In the course of access difficulty to food in the households, natural capital (food products from the forest, lake, etc), marketing point, road, off- and non-farm activities, labour and safety net provision could supposedly be positive impacts. Households that have less reliance on income from milk and milk products and/or that could have better milk yield in a specific system together with possible further products produced from processing, milk and milk product consumption have observed considerable in the household food.

The concluding remarks of this study based on existing resources, assets as well as constraints of the study households, therefore, primarily laid in three basic options to determine household food nutrition security, for poverty reduction and enabling household adaptability. First positively manipulating farm level operational problems such as soil, weather variability challenges (drought and wet stress), animal and crop diseases, access and availability of farm inputs, etc. Second, sparing land use land cover in an area where staple food crop occupied the largest share in purpose to diversify food crop production in a way to diversify and promote household food availability. Third, establishing roads, infrastructure and regular social organization in a way to establish and maintain sustainable food flow from producers to the consumer to benefit both groups.

REFERENCES

1. Tittonell, P., 2014. Livelihood strategies, resilience and transformability in African agroecosystems. Agricultural Systems, 126: 3-14.
2. Veith, C. and J. Shaw, 2011. Why invest in sustainable mountain development? http://www.fao.org/docrep/015/i2370e/i2370e.pdf.
3. Wymann Von Dach, S., R. Romeo, A. Vita, M. Wurzinger and T. Kohler, 2013. Mountain farming is family farming: a contribution from mountain areas to the International Year of Family Farming 2014. FAO. https://boris.unibe.ch/46504/1/i3480e.pdf.
4. Food and Agriculture Organization of the United States, 2014. The State of Food Insecurity in the World, 2013: The Multiple Dimensions of Food Security. Food and Agricultural Organization of the United Nations.
5. Haug, R., 2018. Food security indicators: how to measure and communicate results. https://nmbu.brage.unit.no.
6. Ballard, T.J., A.W. Kepple and C. Cafiero, 2013. The food insecurity experience scale: development of a global standard for monitoring hunger worldwide. Rome: FAO.
7. Vaitla, B., S. Devereux and S.H. Swan, 2009. Seasonal hunger: a neglected problem with proven solutions. PLoS Medicine, 6(6): e1000101. https://journals.plos.org.
8. Amejo, A.G., Y.M. Gebere and H. Kassa, 2018. Integrating crop and livestock in smallholder production systems for food security and poverty reduction in sub-Saharan Africa. African Journal of Agricultural Research, 13(25): 1272-1282. https://doi.org/10.5897/AJAR2018.13020.
9. Amejo, A.G., 2018. Mapping soil terrain resources and descriptions of agro-ecological zone in Dawuro and Gamo Gofa zones in south-western Ethiopia. Journal of Soil Science and Environmental Management, 9(10): 164-179. doi:10.5897/JSSEM2018.0695
10. Amejo, A.G., Y.M. Gebere, H. Kassa and T. Tana, 2018. Agricultural productivity, land use and draught animal power formula derived from mixed crop-livestock systems in Southwestern Ethiopia. African Journal of Agricultural Research, 13(42): 2362-2381. https://doi.org/10.5897/AJAR2018.13258.
11. Amejo, A.G., Y.M. Gebere , U. Dickoefer, H. Kassa, T. Tana and P. Lawrence, 2017. Evaluation of livestock contribution to household income through descriptive analysis and modeling livestock performance in crop-livestock systems in Southwestern Ethiopia. Omo International Journal of Science, 1: 1-26.

12. Amejo, A.G., Y.M. Gebere, H. Kassa and T. Tana, 2018. Comparative analysis of climate change impact on livestock in relation to biomass base feed availability using standardized precipitation index in south-western Ethiopia. International Journal of Livestock Production, 9(7): 184-191.
13. Amejo, A.G., Y.M. Gebere, U. Dickoefer, H. Kassa, T. Tana and P. Lawrence, 2018. Herd dynamics and productivity performance modeling of livestock in smallholder crop-livestock systems in Southwestern Ethiopia. International Journal of Veterinary medicine and Animal Husbandry, 3(1), 17-24.
14. Amejo, A.G., Y.M. Gebere, H. Kassa and T. Tana, 2019. Characterization of smallholder mixed crop-livestock systems in integration with spatial information: In case Ethiopia. Cogent Food & Agriculture, 5(1): 1565299.
15. Cafiero, C., H.R. Melgar-Quinonez, T.J. Ballard and A.W. Kepple, 2014. Validity and reliability of food security measures. Annals of the New York Academy of Sciences, 1331(1): 230-248. https://academia.edu.documents.
16. Perez-Escamilla, R., M.B. Gubert, B. Rogers and A. Hromi-Fiedler, 2017. Food security measurement and governance: Assessment of the usefulness of diverse food insecurity indicators for policy makers. Global Food Security, 14: 96-104. https://www.sciencedirect.com
17. Marshall, E. and E. Boggis, 2016. The statistics tutor's quick guide to commonly used statistical tests. Statstutor Community Project. http://www.statstutor.ac.uk.
18. Vapnik, V., 2006. Estimation of dependences based on empirical data. Springer Science & Business Media. https://scholar.google.com.
19. Maitra, R. and V. Melnykov, 2010. Simulating data to study performance of finite mixture modeling and clustering algorithms. Journal of Computational and Graphical Statistics, 19(2): 354-376. https://amstat.tandfonline.com.
20. Bock, H.H., A.D. Baier, C.W. Gaul, C.K.F. Ritchley and M. Keynes, 2013. Studies in Classification, Data Analysis and Knowledge Organization. https://www.semanticscholar.org.
21. Rodriguez, M.Z., C.H. Comin, D. Casanova, O.M. Bruno, D.R. Amancio, L.D.F. Costa and F.A. Rodrigues, 2019. Clustering algorithms: A comparative approach. PloS One, 14(1): e0210236.
22. Mullen, R.S. and K.W. Birkeland, 2008. Mixed effect and spatial correlation models for analyzing a regional spatial dataset. In Proceedings of the 2008 International Snow Science Workshop, Whistler, British Columbia, pp: 421-425. https://citeseerx.ist.psu.edu
23. Yao, R., J. Yang, D. Wu, W. Xie, P. Gao and W. Jin, 2016. Digital mapping of soil salinity and crop yield across a coastal agricultural landscape using repeated electromagnetic induction (EMI) surveys. PloS One, 11(5): e0153377. https://journals.plos.org.
24. Lee, S.C., 2017. The restricted maximum likelihood estimation of a censored regression model. Communications for Statistical Applications & Methods, 24(3): 291-301. https://www.e-sciencecentral.org.
25. West, B.T., K.B. Welch and A.T. Galecki, 2014. Linear mixed models: a practical guide using statistical software. Chapman and Hall/CRC.
26. Gliessman, S.R., 2015. Agroecology: a global movement for food security and sovereignty. In FAO. Agroecology for Food Security and Nutrition: Proceedings of the FAO International Symposium. Rome, FAO.
27. Gliessman, S. and P. Tittonell, 2015. Agroecology for food security and nutrition. https://www.tandfonline.com.
28. Noushahi, A.H. and M. Hussain, 2019. A Review of Farming System, Irrigation, Intercropping and Nitrogen Management in Maize. American-Eurasian J. Agric. & Environ. Sci., 19(1): 43-47.
29. Abu-Zahra, R.T., 2019. Education, Training and Employment of Agriculture Sector in Jordan. World Journal of Agricultural Sciences, 15(3): 150-157.
30. Sanyang, E.S., L. Jobe and M. Drammeh, 2017. Commercializationof Livestock through Value Chain Approach by Smallholder Farmers in the Gambia. World Journal of Agricultural Sciences, 13(4): 172-178.
31. Sasaki, Y. and P. Box, 2003. Agent-based verification of von Thünen's location theory. Journal of Artificial Societies and Social Simulation, 6(2). http://jasss.soc.surrey.ac.uk
32. Abdulquadri, A.F., B.T. Mohammed and R.B. Daramola, 2017. Profitability Assessment of Value Addition of Cocoaby Farmers in Osun State. World Journal of Agricultural Sciences, 13(5): 179-184.

33. Ruthenberg, H., 1971. Farming systems in the tropics. Oxford Uni.: Clarendon Press.
34. Faris, A., Z. Shumeta and M. Muche, 2018. Determinants of Marketed Surplus of Potato Producers in Dedo District of Jimma Zone, Ethiopia. World Journal of Agricultural Sciences, 14(2): 74-80.
35. Ethiopia and Headquarters of World Food Program, 2014. Comprehensive food security and vulnerability analysis (CFSVA). Retrieved from http://www.wfp.org/food-security.pdf.
36. International Fund for Agricultural Development (Ed.), 2001. Rural poverty report 2001: the challenge of ending rural poverty. Oxford University Press.
37. Ströh de Martínez, C., M. Feddersen and A. Speicher, 2016. Food security in sub-Saharan Africa: a fresh look on agricultural mechanisation. How adapted financial solutions can make a difference (No. 91). Studies. https://www.econstor.eu.