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Spatial variations of household food insecurity in East Gojjam Zone, Amhara Region, Ethiopia: implications for agroecosystem-based interventions

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Abstract

Background: In Ethiopia, food insecurity remains a major public health challenge. Agroecosystem has a potential to determine food insecurity. Therefore, this study aimed to determine the spatial pattern of household food insecurity across different agroecosystems in East Gojjam Zone. An agroecosystem-linked cross-sectional survey was done among 3108 households after selecting using multistage cluster sampling. The study area is divided into hilly and mountainous highlands, midland plains with black soil, midland plains with brown soil, midland plains with red soil and lowlands of Abay valley. Data were collected on sociodemographic variables, household food access and geographical location after five days training and pretesting of the tool to maintain data quality. Data were entered using Epi Info version 3.5 and exported to SaTScan and SPSS 20 for further analysis. To identify the most likely clusters using SaTScan software, the log likelihood ratio (LLR) and *P* less than 0.05 were considered as the level of significance.

Results: The overall prevalence of household food insecurity was found to be 65.3% (95% CI 63.5, 67.00). The lowlands of the Abay valley (70.6%, 95% CI 66.9, 74.2) and hilly and mountainous highlands (69.8%, 95% CI 65.9, 73.3) showed a significantly higher prevalence compared to midland plains with black soil (61.7%, 95% CI 58.1, 65.6), midland plains with red soil (63.5%, 95% CI 59.9, 65.0) and midland plains with brown soil (61.5%, 95% CI 57.4, 65.3). SaTScan spatial analysis identified hilly and mountainous highlands (LLR: 11.64; *P* 0.0088) and lowlands of the Abay valley (LLR: 8.23; *P* 0.025) as the most likely primary and secondary clusters, respectively.

Conclusions: The lowlands of Abay valley and hilly and mountainous highlands were the most vulnerable areas of food insecurity. Concerned bodies that are working to mitigate food insecurity shall consider microlevel food insecurity variations during planning interventions. Further research is needed to determine the temporal variation of household food insecurity. Also, it is very important to validate the spatial analysis results applicability to design geographically targeted interventions.

Keywords: Food insecurity, Agroecosystem, Ethiopia

Background

Food security is one of the necessary conditions for nutrition security, and the concept has been defined variously over the years [1]. According to Food and Agriculture Organization (FAO), food security exists when all

people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [2]. Household food insecurity is recognized as a major public health problem in both developing and developed nations since it leads to poor health outcomes through a complex networking of factors [3, 4]. Food security remains a serious challenge for many households in East Africa [5], and Ethiopia is one of the most food

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insecure countries in East Africa [6, 7]. More than half of the African's food insecure population lives in Ethiopia and six other countries [6, 7]. In the country, food insecurity remains as a major development challenge due to the synergetic effects of land degradation, rapid population growth and climate change [8].

Inadequate quality and quantity of food supply to the household members affect the nutritional status of the community [9]. Also, it limits growth and development of young children and infants [10–12], increases adolescent school absenteeism, lowers educational attainment [13], lowers cognitive and academic performance among children and adolescents and affects psychosocial interaction [14, 15]. Food insecure individuals have elevated experience of anxiety, depression and other symptoms of common mental disorders compared with food secure individuals [14, 15]. This can be true in three major pathways: Initially, food insecure households may have diets that lack critical micronutrients and micronutrient deficiency may lead to anxiety and depression [16]. Secondly, food insecurity may lead to uncertainties to food supply which leads to stress. Finally, food insecurity may affect individual well-being through creating differences in the community [16].

In Ethiopia, there are efforts to improve overall livelihood of the community with an emphasis to reduce or eliminate food insecurity [17]. The Ethiopian Government has designed strategies to address food insecurity of vulnerable households, including Productive Safety Net Program (PSNP), Household Asset Building Program (HABP), Complementary Community Investment (CCI) project and Voluntary Resettlement Program (VRP) in addition to the existing agricultural extension packages [18].

Type and amount of crop produced differ from area to area due to various factors [19]. Agroecosystem characteristic is one of the factors that may create a spatial variation of household food insecurity [20]. A study from Kenya indicated that households from lower midland zones with high crop diversity were more food secure compared with those from the upper midland zones with low crop diversity [21].

In the rural part of Ethiopia, the level of agricultural productivity determines the household food insecurity, since household food energy availability is derived from household's own agricultural production [19]. Vulnerability to food insecurity is a common problem in semi-arid lowlands and mountainous high land areas including Ethiopia where rural households depend on rainfed agriculture for crop production [22]. A study from East and West Gojjam Zones indicated that households in the highland agroecological zones were more food insecure than lowland areas [23]. However, there were no statistical significant differences of household food insecurity between lowland and middle highland agroecological

zones [23]. This might be explained as most highland areas are mountainous and hilly which are prone to soil erosion and degradation, and these could reduce agricultural productivity [23]. On the other side, food insecurity contributes to degradation and depletion of natural resources, migration of the community and political and economic instability [24], which are categorized as basic causes of food insecurity.

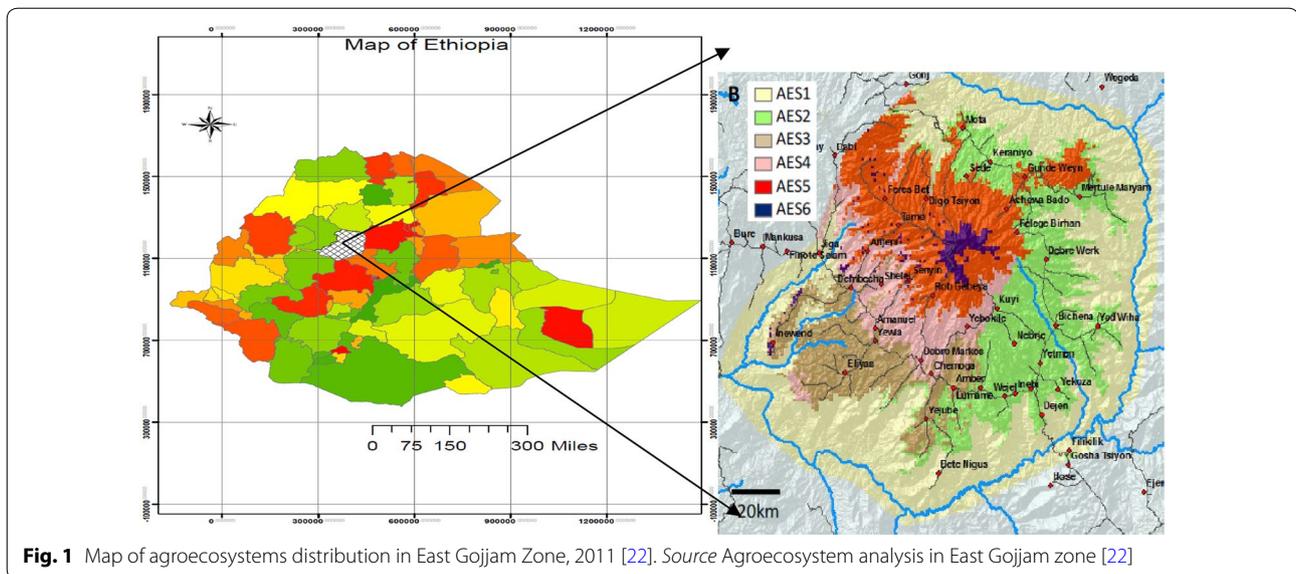
In such type of situations, World Food Programme recommends to conduct spatial analysis of food insecurity to identify the most food insecure places using geographic information system (GIS) [25]. To be effective and bring sustainable solutions and meeting the needs of the most vulnerable community [6], recognition of the spatial distribution of food insecurity in specific contexts is very crucial [4, 26]. Different studies elsewhere abroad have tried to identify certain geographical regions as highly vulnerable to household food security [27–29]. For example, a study from Nigeria indicated that food insecurity showed a clear spatial pattern across different geographical locations [28].

Understanding of household food insecurity spatial patterns at microlevel using geographic information system (GIS) [30] is very important to identify the most affected geographical locations, to design local interventions, to allocate scarce resources to the most affected areas, to convince policy and decision makers and program managers using visualizing maps and to ensure equity in the community [4, 30]. However, there are limited studies on spatial variability analysis of household food insecurity based on agroecosystem characteristics in Ethiopia. Therefore, this study aimed to identify spatial patterns of household food insecurity across different agroecosystem in East Gojjam Zone, Amhara Regional State, Ethiopia. This agroecosystem-based geographical analysis of hot-spot areas to household food insecurity is very important to identify the most vulnerable geographical locations and to give priority and develop microlevel interventions and allocate the scarce resources to the most affected areas.

Methods

Study area and period

This study was conducted in East Gojjam Zone, Amhara Regional State, Ethiopia, from January 2015 to April 2015. The 2015 population projection using 2007 Census, East Gojjam Zone has a total of 2,496,325 (1,221,255 males and 1,275,070 females) population [31]. East Gojjam Zone has a total of four town administrations and 16 rural districts. As indicated in Fig. 1, the area includes the Choke Mountain watersheds found in the Blue Nile Highlands of Ethiopia, which extends from tropical highland of over 4000 meters elevation to the hot and dry Blue Nile Gorge, including areas below 1000 m below sea level. Based on different parameters and characteristics like farming



system, temperature, rainfall, soil type, adaptation potential and constraints, the area is divided into six agroecosystems with its respective characteristics [20].

Lowlands of Abay valley (AES1) is characterized by lowland areas with unfavorable agroecological condition with extensive land degradation compared with other agroecosystems [20]. Midland plains with black soil (AES2) are characterized with a considerable high agricultural productivity potential [20]. The midland plain with red soil (AES3) is suitable for its agricultural productivity, since it has a good potential to use mechanized agriculture and irrigation [20]. The midland plain with brown soil (AES4) is characterized by low natural fertility with high level of soil acidity, sloppy terrain and higher rate of water runoff with soil erosion making the crop production potential very low [20]. The hilly and mountainous highland (AES5) was characterized with low crop productivity due to erosion and deforestation [20].

Study design

Agroecosystem-linked five-arm comparative cross-sectional study design was used to determine the spatial patterns of household food insecurity among households with a child 6–59 months of age in rural parts of East Gojjam Zone.

Sample size determination

By taking into consideration the crop productivity potential of the agroecosystem characteristics that hypothesized as it affects the spatial patterns of household food insecurity the proportion of household food insecurity prevalence difference between the highland ($p_1 = 52.3\%$) and lowland agroecological zones ($p_2 = 63.8\%$) from the study area was considered [23]

and a double population proportion formula was used. The computation was made using the Stat Cal application of Epi Info version 3.5.1 with an inputs of 95% confidence level ($Z_{\alpha/2} = 1.96$), 80% power of the study and one-to-one ratio between lowland and midland area samples. Finally, assuming 1.5 as design effects for its multistage cluster sampling and adding 5% none response rate, the sample size is 481 study participants from each agroecosystem. This study was aimed to compare food insecurity in five groups, it was multiplied by five and the total sample size from the five groups for the study was 2405 households. However, sample sizes of 3225 households were considered which was calculated to satisfy another objective.

Sampling procedures

Based on the agroecosystem characteristics, multistage cluster sampling technique was used to select study participants. In the initial phase, from 16 rural districts, 5 districts were purposively selected taking the five agroecosystem types into consideration. In each district, all kebeles with similar agroecosystem were listed. In the second phase, from each agroecosystem, 6–8 kebeles were selected using a simple random sampling technique with lottery method. In the third step from each selected kebele, one “got” was selected as a cluster using simple random sampling method and all eligible households in the cluster “got” were considered, which made the total number of clusters included 38.

Data collection

An interviewer-administered questionnaire was used to collect data on sociodemographic characteristics of

study participants. Household food insecurity status was measured using Household Food Insecurity Access Scale (HFIAS) of Food and Nutrition Technical Assistance (FANTA) questionnaire developed in 2006 with a recall period of 30 days [32]. The study participants were asked about the amount and variety of meals eaten, and the occurrence of food shortage, of the household members, causing them not to eat the whole day or eat at night only, in the past four weeks preceding the survey [32]. All “Yes” responses were coded as one and “No” responses were coded as zero, and the responses were summed to produce an index of household food insecurity [32]. Geo-reference coordinates data were collected at household level using a handheld global positioning system (GPS).

Quality control

To assure the quality of the study, content validation of the questionnaire with local experts was done before adapting the FANTA food insecurity access scale. The local language questionnaire terminologies were corrected based on the discussion with local experts. Five days training with pretesting was given to data collectors and supervisors to ensure that all research team members are kebele to administer the questionnaires properly, read and record measurements accurately. All necessary corrections were made based on the pretest finding before the actual data collection process. At the end of every data collection date, each questionnaire was checked for its completeness and consistency by the supervisors and the principal investigator and pertinent feedbacks were given to the data collectors and supervisors to correct it in the next data collection day. Wrongly filed questionnaires were excluded from the analysis to assure the quality of data.

Data management and analysis

Data were entered coded, entered and cleaned into Epi Info version 3.5 and exported to excel, SaTScan, Arc map 10.1 and SPSS 20 for further analysis. Descriptive frequency statistics were used to clean the data. The overall and respective agroecosystem prevalence with 95% CI was determined. To identify the spatial patterns of household food insecurity, SaTScan™ software version 9.1 (<http://satscan.org/>) using the Kulldorf method was used after identifying food insecure households as cases and food secure households as controls. The discrete Bernoulli model was used for such type of data (cases and controls) to analyze the spatial scan statistics. The number of food secure and insecure households in each location has Bernoulli distribution, and the model requires data with a disease (cases) or without a disease (controls) [33]. Therefore, food insecure households were considered as cases and food secure households were considered as controls for the SaTScan spatial analysis purpose.

Spatial scan statistics were used to explore the spatial patterns of household food insecurity, which can be used to identify significant spatial clusters of household food insecurity. SaTScan software uses a circular window moved systematically throughout the study area to identify significant clusters of food insecure households. Cluster analysis was performed with default maximum spatial cluster size of <50% of the population. This fifty percent was specified as the upper limit, which allowed both small and large clusters to be detected and ignored clusters that contain more than 50% of the population.

The likelihood ratio test (LLR) was used to test the hypothesis that there is elevated food insecurity risk inside the circular window compared with the risk outside the circular window. The window sizes and locations with the maximum likelihood were defined as the most likely cluster(s) for household food insecurity. Monte Carlo replications of the dataset determined the distribution and *P* value of the most likely and secondary clusters. A standard of “no geographical overlaps” was used to report secondary clusters in the SaTScan spatial statistical analysis. The *P* value was created using a combination of standard Monte Carlo, sequential Monte Carlo and Gumbel approximation and used 999 replications of Monte Carlo [33].

The result is presented with proportions at 95% CI and the location of the identified clusters using geographical locations (Northing and Easting location) with the circular window radius. Also, the result presents the ratio of expected and observed values ratio, the relative risk and the log likelihood ratio with study participants. Finally using the shape file created from the SaTScan output, the circular windows location was created using the ArcMap 10.1 and the shape file map.

Ethical consideration

Ethical clearance was sought from Addis Ababa University Institutional Review Board of College of Health Sciences, ethics and research committee of school of public health. Also, permissions were secured from Amhara Regional Health Bureau, East Gojjam Zone Health Office and from the selected districts. Participants of the study were on a voluntary basis, and informed consent was sought from study participants to confirm their willingness after detailed explanations were provided on the possible benefits and risks in participating in the survey. Privacy and confidentiality were maintained.

Results

From the total 3225 household study participants, 3108 responded to the questionnaire which made the response rate of 96.4%. Of the total study participants, 616 (19.8%)

were from lowlands of Abay valley, 629 (20.2%) from midland plains with black soil, 631 (20.3%) from midland plains with red soil, 623 (20%) from midland plain with brown soil and 609 (19.6%) from hilly and mountainous highlands.

Sociodemographic characteristics

As indicated in Table 1, the majority (91.7%) of household heads' were males, married (90%), followers of Orthodox Christianity (99.9%) and Amhara ethnicity (99.8%). The study indicated that 2492 (80.2%) of the women and 1490

Table 1 Sociodemographic characteristics of study participants in East Gojjam Zone, Amhara Regional State, Ethiopia, 2015

Variables	Category	Frequency	Percentage
Household head sex	Male	2851	91.7
	Female	257	8.3
Mother marital status	Married	2823	90.0
	Divorced	187	6.0
	Separated	67	2.2
	Widowed	31	1.0
Religion	Orthodox	3096	99.6
	Other ^a	12	0.4
Ethnicity	Amhara	3102	99.8
	Other ^b	6	0.1
Father education	No formal education	1490	47.9
	Primary (1–6 grade)	1202	38.7
	Secondary and above	416	13.4
Mother education	No formal education	2492	80.2
	Primary (1–6 grade)	304	9.8
	Secondary and above	312	10.0
Mother occupation	Farmer	2856	91.9
	Housewife	99	3.2
	Merchant	77	2.48
	Daily Laborer	36	1.2
	Employed	16	0.5
	Other	24	0.8
Father occupation	Farmer	2895	93
	Merchant	86	2.8
	Daily Laborer	58	1.9
	Employed	45	1.4
	Other ^c	24	0.8
Average family size	<5 members	1589	51.1
	≥5 members	1519	48.9
Number of under five children	One	2593	83.4
	Two and above	515	16.6
Women participation in decision making	Yes	2683	86.3
	No	425	13.7

^a Protestant and Muslim

^b Oromo and Tigrie

^c Have no job totally

(47.9%) of the men had no formal education. 2856 (91.9%) of the women and 2895 (93.1%) of men were farmers. In the study, 1589 (51.1%) of the households have less than five family size and 2683 (86.3%) women participated in household decisions.

Household food insecurity access domains

As indicated in Table 2, 76.1% of households had feelings of uncertainty and anxiety about the household food supply and 53.7% perceived that the household food supply was insufficient quality and not a preferred type. Also, 26.8% of the households were taking insufficient quantity of food in the last 30 days. Spatial inequality in the domains of household food insecurity access was observed based on agroecosystem. A higher proportion of anxiety/uncertainty in household food supply was reported from the lowlands of the Abay valley (81.8%, 95% CI 78.75, 84.85) and hilly and mountainous highlands (88.7%, 95% CI 86.2, 91.2) agroecosystems. Similarly, higher proportion (41.8, 95% CI 37.88, 45.71) of insufficient quantity household food supply was observed hilly and mountainous highlands, and higher proportion of insufficient food quality supply was observed in the lowlands of the Abay valley (57.6% (57.6, 95% CI 53.7, 61.5)).

Prevalence of household food insecurity

In this study, using Household Food Insecurity Access Scale, 65.3% (95% CI 63.5, 67.00) of the households were found to be food insecure. From the total sample households, 38.1% (95% CI 36.4, 39.7), 23.1% (95% CI 21.6–24.6) and 4.1% (95% CI 3.3, 4.8) households were mildly, moderately and severely food insecure, respectively.

Agroecosystem-based prevalence of household food insecurity showed geographical variation. The highest prevalence of food insecurity was observed in the lowlands of Abay valley and hilly and mountainous highlands compared with midland areas. A maximum proportion of household food insecurity was observed in the lowlands of the Abay valley (70.6%, 95% CI 66.9, 74.2). The second highest prevalence of household food insecurity was observed from hilly and mountainous highlands (69.8%, 95% CI 65.9, 73.3). There were no variations among the midlands plains with brown soil (61.7%, 95% CI 58.1, 65.6), midland plains with red soil (63.5%, 95% CI 59.9, 65.0) and midland plains with black soil (61.5%, 95% CI 57.4, 65.3) agroecosystems.

Spatial SaTScan analysis of household food insecurity

As indicated in Table 3 and Fig. 2, SaTScan cluster analysis indicated a cluster with geographical location of 10.573N, 37.817E, and a radius of 3.53 km from hilly and mountainous highlands was detected as the most likely

Table 2 Household food insecurity access domains at different agroecosystems in East Gojjam Zone, Amhara Regional state, Ethiopia, 2015

Agroecosystem type	Anxiety and uncertainty	Insufficient quality	Insufficient quantity
Lowlands of Abay valley	81.8 (78.75, 84.85)	57.6 (53.7, 61.5)	20.8 (17.6, 24.01)
Midland plains with black soil	67.2 (63.53, 70.87)	47 (43.1, 50.9)	24.2 (20.85, 27.55)
Midland plains with red soil	71.9 (68.40, 75.40)	47 (43.1, 50.89)	20.7 (17.54, 23.86)
Midland plains with brown soil	71.0 (67.44, 74.56)	53 (49.0, 56.9)	26.9 (23.4, 30.4)
Hilly and mountainous highlands	88.7 (86.20, 91.20)	54 (50.0, 57.96)	41.8 (37.88, 45.71)

primary cluster with the maximum LLR of 11.64 and a *P* value of 0.0088. The cluster location includes samples taken from Sinan Mariam, Abazazi Webeyegn and Zelen Amisitegna kebeles.

In the SaTScan spatial analysis, there were significant secondary most likely clusters detected in the lowlands of the Abay valley with LLR of 8.218 and a *P* value of 0.025. The cluster location includes samples taken from Mushirit Dengaye kebele. Table 3 summarizes the most likely clusters with their LLR and probability value (study participants), its geographical location with radius and identified kebeles in the clusters.

As indicated in Fig. 2, clusters with the maximum LLR (11.64) were the most likely primary cluster, which is colored with red. The most likely primary cluster is located from the hilly and mountainous highlands. The most likely secondary cluster with the second maximum LLR (8.22) is shaded with orange color, which is located in the lowlands of Abay valley.

Discussion

The current study has tried to assess the spatial patterns of household food insecurity based on agroecosystem characteristics. Overall, high proportions of households were food insecure in the study community. This study finding was lower than a study from Farta district (70.7%) [34], but higher than from studies conducted in East Gojjam Zone (56%) [19] and West and East Gojjam Zones

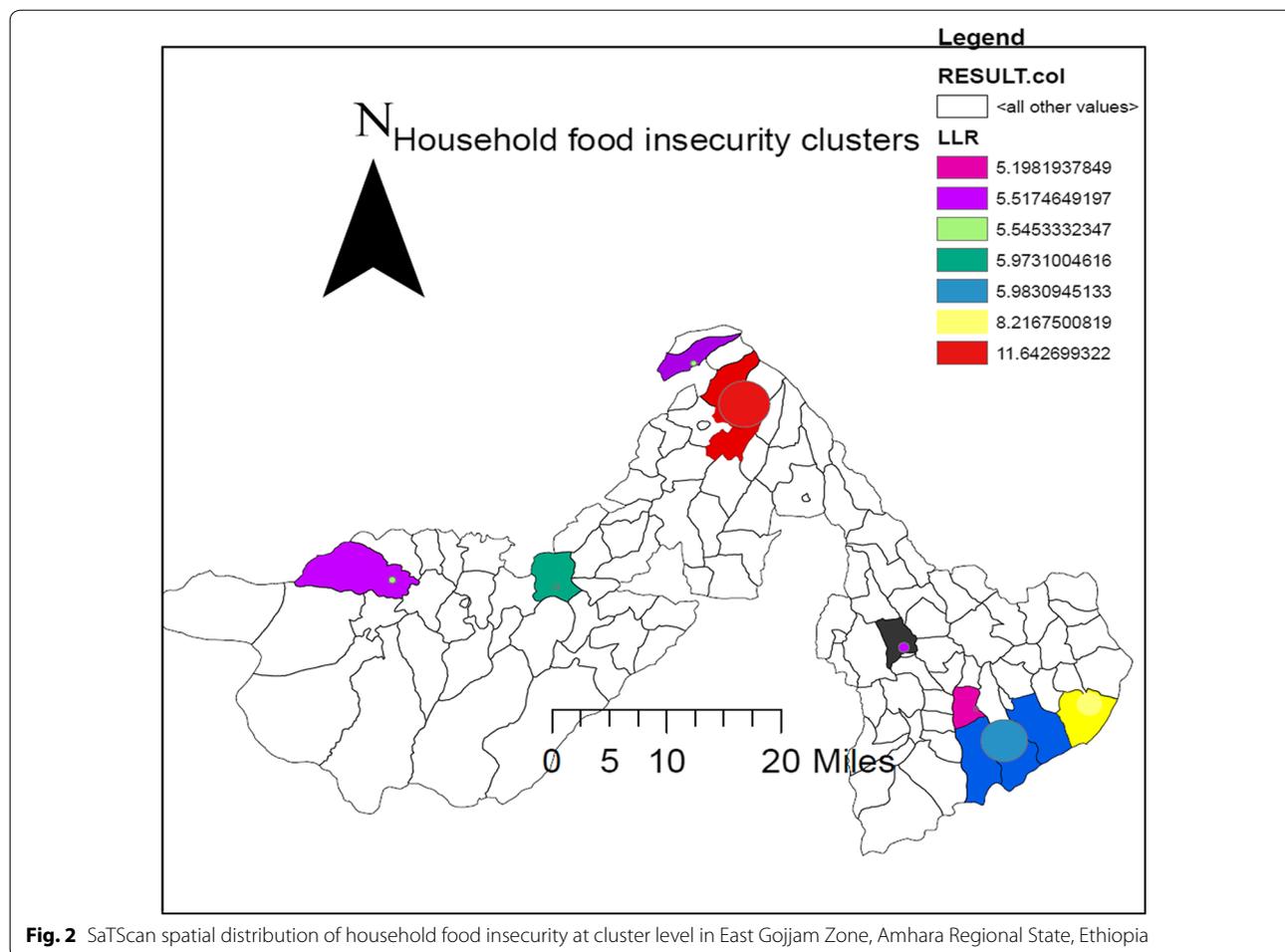
(55.3%) [23] and Sidama Zone (54.1%) [35]. This variation might be explained as household food insecurity status varies from area to area since it is the product of many predictor variables including agroecosystem characteristics [35]. Also, the magnitude of the problem depends on the local crop productivity, which might fluctuate seasonally based on the suitability of the harvest period [36]. Those findings indicated that food and nutrition insecurity is a common problem, including areas with surplus crop production [23]. This implies that food insecurity interventions are essential including surplus crop producing areas.

Another important finding of the study is that more than three-fourth of the households had feelings of uncertainty and anxiety about the household food supply. This condition affects not only household members nutritional status [23], but also their mental health status [37]. The problem is more severe among women who are responsible to feed the family which leads to maternal anxiety, depression and other related mental illness [5, 37]. This might exert negative influence on parent to child interaction and care practices [37].

In the moderate stage of household food insecurity, households manage shortage of food with reduction in diet quality [37], and in this study more than half of the households made adjustments to household food insecurity by reducing in diet quality, which may lead to micronutrient deficiencies [37]. As the severity of household

Table 3 Household food insecurity SaTScan spatial analysis identified clusters in East Gojjam Zone, Amhara Regional state, Ethiopia, 2015

Cluster	Identified kebeles	Agroecosystem	Coordinate/radius	LLR	<i>P</i> value
1	S/Mariam, Abazazi and Zelen	Hilly and mountainous highlands	(10.57N, 37.82E)/3.53 km	11.64	0.008
2	Mushrit Dengaye	Lowlands of Abay valley	(10.16N, 38.25E)/1.73 km	8.218	0.025
3	Kurar, Gelgele and Minejena	Lowlands of Abay valley	(10.11N, 38.15E)/3.21 km	5.983	0.898
4	Desse Asame Abo	Midland plains with brown soil	(10.32N, 37.58E)/0.42 km	5.973	0.958
5	Tegoderi	Hilly and mountainous highlands	(10.63N, 37.75E)/0.41 km	5.545	0.993
5	Goffichima	Midland plains with red soil	(10.33N, 37.37E)/0.49 km	5.545	0.993
6	Yegodena	Midland plains with black soil	(10.24N, 38.02E)/0.75 km	5.517	0.993
7	Teden	Lowlands of Abay valley	(10.15N, 38.11E)/0.33 km	5.198	0.995



food insecurity increases, households start to reduce the quantity of food that served to the family members [32]. In the current study, about one-fourth of the households compromised the quantity of food served to the family due to shortage of food. This situation leads to protein energy malnutrition to the household members [32]. The effect of food shortage at household level is more severe to women [5] and children due to biased food distribution within household members [23].

Agroecosystems type has an important role in determining food insecurity status, especially for farmers with subsistence farming [38]. The current study showed nonrandom distribution of household food insecurity across different agroecosystems. The highest prevalence of household food insecurity was observed from the lowlands of Abay valley. This area was characterized with relatively unfavorable agroecologic conditions, high climate change vulnerability and low climate change adaptive capacity [19]. The second highest prevalence of household food insecurity was observed from the hilly and mountainous highlands, which is located in the Blue Nile

highlands of Choke mountain [20]. This agroecosystem has lower crop production potential due to its lower temperature, lower soil fertility due to erosion, high climate vulnerability, low climate change adaptive capacity of farmers and high human-induced land degradation [20]. However, there was no statistically significant difference in prevalence of household food insecurity taken from in the midland plains.

The SaTScan spatial cluster analysis using SaTScan across different agroecosystems identified the most likely primary and secondary clusters from the hilly and mountainous highlands and lowlands of Abay valley with a statistical significant number of study participants, respectively. This study suggested that there was significant spatial clustering of household food insecurity based on agroecosystem. There were clusters within an agroecosystem at microlevel, and planning using aggregated data at macrolevel may reduce the efficiency the programs. This is because targeting food insecurity interventions based on vulnerability of the community would help to maximize the benefits from interventional

programs through optimal utilization of scarce resources [39]. Spatial SaTScan cluster analysis of food insecurity can improve food insecurity intervention coverage effectiveness [40]. This SaTScan analysis of household food insecurity identified specific geographical locations that needs assistant which can improve coverage of the program through identifying the beneficiaries [40].

The cluster analysis can provide valuable information about spatial disparity of household food insecurity that may be relevant for further epidemiological research on the topic. However, this study has limitations due to its cross-sectional nature of the survey, which makes it difficult to see the temporal variation under different seasons. Also, it is limited that clusters in this method of spatial analysis are assumed to be circular and dissimilar in size to areas within given kebele boundaries. This could result in the exclusion or inclusion of districts/kebeles that register excess or less risks to household food insecurity.

Conclusion

In this study area, the overall prevalence of household food insecurity was very high. The community was exposed to anxiety and uncertainty due to food insecurity. Also, large proportions of households had tried to manage the stress of food insecurity through reduction in diet quality and then quantity based on level of severity. The magnitude of the problem showed spatial patterns by the agroecosystem characteristics. Hilly and mountainous highlands and lowlands of Abay valley agroecosystems were significantly identified as the most hotspot areas for household food insecurity compared with other midland areas. The study suggests microlevel spatial variations of food insecurity in the study community. Designing food insecurity intervention programs and plans using regional level evidence and government administration units might mask the true picture of spatial distribution of the problem at local context. So, program-level planning shall take into account agroecosystem-based microlevel variation in allocating resources for intervention. Further research is recommended to address the spatiotemporal patterns of food insecurity. Also, further study on spatial analysis of food insecurity using panel data at microlevel is recommended to validate the current study results.

Abbreviations

LLR: log likelihood ratio; SPSS: Statistical Package for Social Sciences; CI: confidence interval; HABP: Household Asset Building Program; PSNP: Productive Safety Net Program; CCI: Complementary Community Investment Program; VRP: Voluntary Investment Program; GIS: Geographical Information Program; AES: agroecosystem; HFIS: Household Food Insecurity Access Scale.

Authors' contributions

Conception and design of the work proposal, collection of data, analysis and interpretation of data were performed by ZA, AA, AW and BS. Drafting

the manuscript article, revising it critically for intellectual content and final approval of the version to be published were performed by ZA, AA, AW and BS. Finally before submission for publication. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The data sets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Consent for publication

Information on the research objective was read to the participants, and verbal informed consent was received to collect data and for publication during data collection. The privacy and confidentiality of the study participants were also maintained.

Ethical approval

Ethical clearance was sought from Addis Ababa University Institutional Review Board of College of Health Sciences, Ethics and Research Committee of School of Public Health. Also, permissions were secured from the Amhara Regional Health Bureau, East Gojjam Zone Health Office and from the selected districts. Participants of the study were recruited on a voluntary basis, and informed consent was sought from study participants to confirm their willingness after detail explanations were given on the possible benefits and risks of participating in the survey. Privacy and confidentiality were maintained. Data collectors and supervisors gave advice about child feeding and care practice to the mothers or caregivers after completing the interview. Also, they advised to seek treatment for severely undernourished children.

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