Spatial exploration of non-resilience to food insecurity, its association with COVID-19 and household coping strategies in East Gojjam districts, Northwest Ethiopia, 2020

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The coronavirus disease-2019 (COVID-19) pandemic has posed a significant multifaceted threat to the global community. Ethiopia, as a Sub-Saharan African country, is suffering from chronic food insecurity, and the emergence of such a pandemic will exacerbate the situation. As a result, this study investigated the spatial variation of non-resilience to food insecurity, its relationship with COVID-19, and household coping strategies to become resilient in the long run among households in the East Gojjam Zone of Northwest Ethiopia. From September 22 to December 24, 2020, an agro-ecological-based cross-sectional study of 3532 households was conducted to assess the spatial distribution and associated factors of non-resilience to household food insecurity. The enumeration areas (EAs) and households were chosen using a multistage sampling technique. Data were gathered using a semi-structured questionnaire and checklist using an Android device loaded with an Open Data Kit (ODK) template. Binary logistic regression was used to identify the specific factors associated with household non-resilience to food insecurity. A thematic analysis was conducted to investigate the opportunities and challenges of resilience for household food insecurity. Nearly two-thirds (62.5%) of the households were farmers, 67.9% lived in rural areas, and nearly three-quarters (73.8%) earned less than or equal to ETB 2100 per month. Males headed more than four-fifths (81.7%) of the households. We found...
that nearly two-thirds of the households (60.02%), 95% CI 58.40, 61.64) were food insecure. After
bivariate logistic regression, we found that households who were divorced (AOR = 2.54 (1.65, 3.87)),
daily laborers (AOR = 2.37 (1.15, 4.87)), government employees (AOR = 2.06 (1.05, 4.05)), residents
of highland and hot areas (AOR = 11.5 (5.37, 16.77)) and lowland areas (AOR = 1.35 (1.02, 3.15)) were
frustrated by COVID-19 (AOR = 1.23 (1.02, 1.50)) and price inflation (1.89 (AOR = 1.42, 2.56)) were at
higher odds of being non-resilient to household food insecurity at a 95% confidence level. Geospatial
hot spot analysis revealed that Kurar kebele (the lowest government administrative unit) in Dejen
District and Debre Markos town were the red-hot spots areas of household non-resilience to food
insecurity. Less than a quarter of the households attempted to cope with food insecurity by adjusting
their food consumption, while more than 60% of the households chose none of the coping strategies
tested. According to the thematic analysis, the degree of poverty (lack of asset ownership), the
COVID-19 pandemic, farm decreased variety, and low crop productivity were identified as challenges
to coping with the hardship of resilience to food insecurity. During the COVID-19 pandemic and public
emergency, the proportion of households that were unprepared for food insecurity reached its peak.
It was recognized that a segment of the population with low economic capacity was more vulnerable
to food insecurity and less resilient. Tough developmental gains will be undermined in this case. As a
result, each responsible body and stakeholder should develop and implement solid corrective plans for
the local context.

The coronavirus disease 2019 (COVID-19) caused by SARS-CoV-2 is now a global public health emergency1.
Remarkably, this pandemic rapidly affects all segments of the global population, including Ethiopia5. However,
the case fatality rate varies regardless of age, gender, ethnicity, socioeconomic status, or health status5. COVID-
19 has now become a critical issue, exposing numerous associated problems such as panic and public anxiety
throughout the population4, livelihood insecurity4, particularly food insecurity, and food crisis6. Food insecurity,
in particular, is explained by the quantity and quality of available food, uncertainty about food accessibility,
and personal experiences with going hungry during a public emergency7. This issue may be experienced at the
individual or household level with a lack of food for consumption, allocation, and the physiological sensation
of hunger6. It can be measured using the Food and Agriculture Organization’s (FAO) method for estimating calories
available per capita at the national, regional, and district levels through the use of food balance sheets (the net
value of total food produced + food imported + food aids-food exported -foods expended for extra consumption),
household income and expenditure surveys, individual dietary intake, anthropometry, and experience-based
food insecurity measurement scales9. However, the commonly used measurement tools of food insecurity in
Ethiopia are the Household Food Insecurity Access Scale (HFIAS)10 and the Household Hunger Scale (HHS)11.
The Household Food Insecurity Access Scale (HFIAS) is the most commonly used food insecurity measure-
ment tool in Ethiopia. It can also be measured using the United Nations FAO Resilience Index Measurement
and Assessment II (RIMA-II)12. According to a 2017 UN World Food Program report, more than one hundred
million people experienced severe food insecurity3. There were also nearly one billion people who went hungry,
despite the fact that enough food was produced to feed the world’s population4. Household food insecurity is
more prevalent in Sub-Saharan African (SSA) countries. As per the FAO report, food insecurity affected more
than one out of every ten households in SSA countries in 201615. In 2017, however, more than half a billion people
required emergency food assistance16.

Food insecurity has been a major issue in different parts of Ethiopia for over a decade, resulting in a high
morbidity and mortality rate17–19. From a survey conducted among rural households in Ethiopia between 2018
and 2019, more than half of the households were food insecure19. In most of the studies performed earlier,
household non-resilience to food insecurity was used to measure the capacity for resilience to food insecurity.
Multiple household food insecurity resilience studies from different parts of Ethiopia have shown a very large
proportion of the households (more than half up to three-fourth of the households) were non-resilient16–21.

Prior to the emergence of COVID-19, more than two-thirds of households in the East Gojjam districts
experienced food insecurity, which was more pronounced in the low lands of the Abay valleys and in hilly and
mountainous areas21. According to recent studies from the neighboring zone of East Gojjam, only one-fifth of
the households are resilient to the issue of food insecurity22. This is an early warning sign of how difficult house-
hold resilience is even in a normal environment, and how it may be even more complicated in an era of public
emergency and pandemic disease, such as COVID-1919–23. A multi-country cross-sectional survey conducted across
nine African countries (Chad, Djibouti, Ethiopia, Kenya, Malawi, Mali, Nigeria, South Africa, and Uganda)
revealed a dramatic increase in non-resilience to food insecurity as a result of this COVID-19 pandemic and
public emergency24. Another similar study in Ethiopia, Malawi, Nigeria, and Uganda also found that 77% of the
population lives in households were lost income as a result of this pandemic and public emergency27. Despite the
lack of reporting on spatial distribution, one pocket study in Ethiopia also found that nearly 90% of households
experienced non-resilience to food insecurity immediately after the occurrence of this pandemic disease and
public emergency4, which was significantly higher prior to the occurrence of this pandemic and public emergency
disease28–29. After COVID-19 was declared by WHO as a global health emergency and a pandemic disease, the
efforts of humanitarian and food security organizations seeking to reverse food insecurity, resilience, and coping
strategies were undermined25.

While the government ordered people to stay at home due to the COVID-19 pandemic, the issue of Ethiopia’s
non-resilience to food insecurity became an immediate concern. As a result, household non-resilience to food
insecurity in the COVID-19 era may differ significantly from previous studies22,23. Despite, the spatial distribution
of COVID-19 incidence rates was high in the urban compared to rural at the beginning of the epidemic, the intensity of the epidemic had also shifted to a rapid surge in rural areas too. As a result of the COVID-19 lockdown, many people around the world, including Ethiopia, have lost their jobs, raising concerns about food availability, distribution, access, utilization, and supply chains. In the Ethiopian context, including our study sites, the pandemic has eroded hard-earned development gains and threatens household resilience to food insecurity, while also affecting international organizations working to improve household non-resilience to food insecurity. As a result, using gaps from international evidences and lessons from previous pandemic diseases, the authors were keen to investigate the spatial distribution of non-resilience to food insecurity, associated factors, challenges and opportunities as well as the coping strategies of it by taking into account agro-ecological data, soil types, and population residence (urban versus rural data). As a result, this study will be critical for both the regional government of Ethiopia and humanitarian organizations that are interested in providing project-based livelihood support and developing mechanisms for long-term mitigating strategies for household food insecurity that occurred during the COVID-19 pandemic and public emergency.

Methods and materials

Study area and period. This study was conducted in the East Gojjam Zone of Amhara National Regional State (ANRS), Ethiopia, from September 22 to December 24, 2020. The East Gojjam Zone, one of ANRS’s twelve zones and three city administrations, is located in the northwest of Ethiopia and the southwest of ANRS. Debre Markos serves as the administrative center and is located approximately 299 km and 264 km from the capitals of Addis Ababa and Bahir Dar, respectively. East Gojjam is divided into 19 districts and three town administrations. The zone has a population of more than 2,496,325 people, with 1,221,255 males and 1,275,070 females. The population is spread across six agro-ecological zones, ranging from hilly and mountainous terrain to the lowlands of the Abay gorge. Residents of these two extremes are highly likely to face food insecurity, particularly emergent food insecurity and food crisis during the COVID-19 pandemic.

Study design and population. A cross-sectional community-based study with a concurrent mixed methods design was used. This study’s source population consisted of all households in the East Gojjam zone. All households in the East Gojjam zone’s selected districts and town administrations were included in the study population. Community leaders, religious fathers, well-known community elders, and responsible bodies from the food and nutrition security department, disaster prevention and preparedness department, trade and marketing management department, social security and welfare department, and child and women department participated to assess government preparedness, response, and risk mitigation options, as well as anticipated challenges and opportunities.

Eligibility criteria. This study included all households with a permanent address in the enumeration areas that were chosen (EAs). Households that had been shut and whose residents were not available after three attempts of visit, as well as household heads who were unable to participate in this study, were planned to be excluded.

Sample size determination. This study considered a sample size calculation for survey study by using the following formula:

\[ N = \frac{4(r)(1 - r)(d)(1.1)}{(0.12r)^2(p)(h)} \]

where; \( N \) is the required total sample size, \( 4 \) is a factor to achieve the 95% level of confidence, \( r \) is the predicted or anticipated prevalence (coverage rate) of un-resilience among households(0.79), 1.1 is the factor necessary to raise the sample size by 10% for non-response rate, \( d \) is design effect = 2, 0.12 is the margin of error to be tolerated at the 95% level of confidence, defined as 12% of \( r \) (12% thus represents the relative sampling error of \( r \)), \( p \) is the proportion of the total households in the East Gojjam zone compared with the national estimates (\( P = 0.01 \)), \( h \) is the average household size = of 4.6 individuals per household (EDHS, 2016).

Taking into account the aforementioned parameters as well as the %age of households that were not resilient to food insecurity (79%)
the final sample size is 3532 households, which accounts for 505 households in each selected district and town administration.

Sampling procedures. For quantitative. Using a random sampling technique, one of the three town administrations was chosen for this study. Six districts were chosen using a purposive sampling technique from the 19 districts of the East Gojjam zone based on agro-ecological and weather conditions. To select clusters/gotts (subdivisions in a Kebele), multistage sampling technique was used. Two kebeles (the lowest government administrative unit) from each of the selected town administrations and two kebeles from each of the selected districts were chosen using a simple random sampling technique. Then, at random, one cluster was chosen from each kebele. Finally, the study included all eligible households in the chosen cluster (Fig. 1).
A criterion-based purposive sampling technique was used to recruit key informants and in-depth interviewees. Individuals with good awareness and experience about the issue of household non-resilience to food insecurity, individuals with experience and working on disaster preparedness and management, individuals with good awareness of the community environment and representative of the localities, and individuals on the COVID-19 steering committee were considered for the interview. Based on this, each responsible body at the zonal level was interviewed for the qualitative study, including the Food and Nutrition Security department of East Gojjam Zone, Disaster Prevention and Preparedness department, Trade and Market Management department, Social Security and Welfare department, Agricultural and Natural Resource Management department, Child and Women department, and COVID-19 steering committee. Whereas seven key informant interviews with agricultural extension workers and 36 in-depth interviews (8 community leaders, 6 religious leaders, 10 elders, and 12 selected individuals from households who had good awareness about non-resilience) were interviewed.

Variables of the study.  

Dependent variable.  

Households Resilience from emergent food insecurity at the time of shock exposure (COVID-19).

Independent variables.

- Socio-demographic and economic characteristics: age, educational status (maternal, paternal), marital status of the head, number of children, family size, occupation of the head, household assets, monthly expenditure, sex of household head;
- Agricultural extension service-related factors: Agro-ecological zone
- Environments that influence food insecurity beyond their household capacity: Shock exposure (the COVID-19 pandemic), price inflation (of basic food commodities for consumption), and unwanted weather changes.

Measurement of the dependent variable.  

Household resilience for food insecurity during the COVID-19 pandemic. The Resilience Index Measurement and Analysis II (RIMA-II) validated by the United Nations Food and Agricultural Organization (FAO) was used to calculate the resilience index score\textsuperscript{12}. To calculate the unidimensional and weighted resilience indicators, as well as the resilience index score, Principal Component Analysis was used. Then, using the following formula, households were classified as resilient or non-resilient based on the mean value of the resilience score:

\[
\text{Resilience Score} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}
\]
ATLASTi7 for qualitative data coding was used to prepare the data for thematic analysis in the qualitative aspect. Was fitted. At a P-value of 0.05, the adjusted odds ratio (AOR) was used to assess the strength of the association. Employed. To identify the factors associated with resilience to food insecurity, a binary logistic regression model was performed using the Global Moran's I statistic. Moran's I near 1, 0, −1 indicates that the spatial distribution of resilience to food insecurity is clustered, randomly distributed, and dispersed, respectively—resilience. The Getis-Ord Gi* statistic was used in GSA analysis to detect local clusters in the presence of clustering. The pattern of non-resilient food security across the entire study area, a global spatial autocorrelation (GSA) analysis was performed using the Global Moran's I statistic. Moran's I near 1, 0, −1 indicates that the spatial distribution of resilience to food insecurity is clustered, randomly distributed, and dispersed, respectively—resilience. The Getis-Ord Gi* statistic was used in GSA analysis to detect local clusters in the presence of clustering. The findings were presented in the form of text, tables, and graphs. For descriptive data, proportion and mean were obtained from the East Gojjam zone administration and each district. At the time of data collection, each study participant provided oral informed consent. Information confidentiality was maintained by encoding study participants' identities. All methods were performed in accordance with the relevant guidelines and regulations.

Results
Socio-demographic and economic characteristics. This study had a 100% response rate. More than half of the study participants (52.7%) were females, 62.2% were married, and 67.9% lived in rural areas. Farmers made up nearly one-third (62.5%) of the study participants. Almost three-fourths (73.8%) of the households earned less than or equal to 2100 Ethiopian Birr per month (Table 1).

Topographic, climatic and housing characteristics. Simane Belay et al. conducted scientific research on the overall topographic and climatic conditions of our study area. Based on his agro-ecological classification of our study area, our study found that 77.7% of the studied households lived in the Woyna-Dega climatic zone and 81.7% of the households were led by males. With regard to household ownership, 87.5% of the households are living within their own houses. Nearly three-fourths (73.8%) of the households were spending less than 2100 birr per month (Table 2).

Principal component analysis and dimension reduction. According to the Analytical Hierarchy Process (AHP), the main variable that explains 54.9% of the resilience is the status of household assets, which has a Principal Eigenvalue of 5.179 (Table 3). From the scree plot, 12 variables whose eigenvalues greater than or equal to 1 were retained (Fig. 2).
Resilience to household food insecurity. Of the total number of households, 2120 (60.02%) were food insecure (95% CI: 58.40, 61.64). More than half of married people (60.6%) were not resilient to food insecurity. During the COVID-19 pandemic and public emergency, the prevalence of household non-resilience to food insecurity was nearly identical in urban (49%) and rural (51%) areas. About 46% of mothers who could not read or write were vulnerable to food insecurity. Of the total households, 87.9% of those with a family size of less than

| Variables | Characteristics | No  | %     |
|-----------|-----------------|-----|-------|
| Sex       | Female          | 1860| 52.7  |
|           | Male            | 1672| 47.3  |
| Marital status | Divorced      | 275 | 7.8   |
|           | Married         | 2196| 62.2  |
|           | Single          | 795 | 22.5  |
|           | Widowed         | 266 | 7.5   |
| Residence | Rural           | 2398| 67.9  |
|           | Urban           | 1134| 32.1  |
| Paternal education | Cannot read and write | 1561| 44.2  |
|           | Can read and write | 756 | 21.4  |
|           | College and above | 471 | 13.3  |
|           | Primary (grades 1–8) | 477 | 13.5  |
|           | Secondary (grades 9–12) | 267 | 7.6   |
| Maternal education | Cannot read and write | 2169| 61.4  |
|           | Can read and write | 559 | 15.8  |
|           | College and above | 246 | 7.0   |
|           | Primary (grades 1–8) | 340 | 9.6   |
|           | Secondary (grades 9–12) | 218 | 6.2   |
| Occupation of the household head | Daily laborer | 145 | 4.1   |
|         | Farmer          | 2208| 62.5  |
|         | Government employee | 402 | 11.4  |
|         | Housewife       | 167 | 4.7   |
|         | Merchant        | 610 | 17.3  |
| Family size | < Five          | 2839| 80.4  |
|           | ≥ Five          | 693 | 19.6  |
| Under-five children | ≤ Two          | 3505| 99.2  |
|           | > Two           | 27  | 0.8   |
| Monthly income | ≤ 2100         | 2605| 73.8  |
|         | ≥ 2100          | 927 | 26.2  |

Table 1. Socio-demographic and economic characteristics of the study participants.

| Variables | Characteristics | No  | %     |
|-----------|-----------------|-----|-------|
| Agroecology | Highland and cold area | 234 | 6.6   |
|           | Low land area   | 126 | 3.6   |
|           | High land and hot area | 978| 27.7  |
|           | Mid land area   | 2194| 62.1  |
| Climate  | Dega            | 234 | 6.6   |
|           | Kolilla         | 552 | 15.6  |
|           | Woina-daga      | 2746| 77.7  |
| House ownership | Kebele's rent | 59  | 1.6   |
|           | Own house       | 3091| 87.5  |
|           | Private rent    | 343 | 9.7   |
|           | A relative house without rent | 39 | 1.1   |
| Household head | Female        | 646| 18.3  |
|           | Male            | 2886| 81.7  |
| Food expense /month | ≤ 2100      | 2605| 73.8  |
|           | ≥ 2100          | 927 | 26.2  |

Table 2. Topographic, climatic, and housing characteristics.
five were also vulnerable to food insecurity. According to the agro-ecological conditions, 38.1% of the non-resilient households for household food insecurity were from the midland with red soils. The Woyna-Dega climatic zones were home to 76.7% households. Respondents reported that COVID-19 was responsible for 52.7% of the non-resilience of household food insecurity and price inflation was responsible for 74.1% (Table 4).

**Associated factors of household non-resilience to food insecurity.** From the findings of this study, marital status, occupation of the household head, monthly income, residence district, agro-ecological condition, climate, effects of COVID-19, and price inflation were the most important factors contributing to food insecurity (Table 5).

**Spatial distribution of household non-resilience to food insecurity.** In the GSA analysis, the Moran’s I = 0.65 and p-value0.001 indicated a positive autocorrelation, i.e. a clustered pattern of non-resilience to food insecurity across the entire study areas (Fig. 3). This result suggests that additional hotspot analysis be performed to identify local clusters (Fig. 4).

**Hotspot analysis.** The hotspot analysis with Getis-Ord Gi* statistic directed the clusters of household non-resilience to food security at Debre Markos town and Kurar kebele from Dejen district, as shown in Fig. 4. (Both at 95% and 99% confidence interval).
| Variables      | Characteristics          | Resilience status |        |        |
|---------------|--------------------------|-------------------|-------|-------|
|               |                          | Resilient | No | %     | Un-resilient | No | %     |
| Marital status| Divorced                 | 70        | 25.45 | 205 | 74.55 |
|               | Married                  | 912       | 41.53 | 1284 | 58.47 |
|               | Single                   | 316       | 39.75 | 479  | 60.25 |
|               | Widowed                  | 114       | 42.86 | 152  | 57.14 |
| Residence     | Rural                    | 1316      | 34.88 | 1082 | 45.12 |
|               | Urban                    | 96        | 8.47  | 1038 | 91.53 |
| Paternal education | Cannot read and write                       | 893       | 57.21 | 668  | 42.79 |
|               | Can read and write       | 378       | 50.00 | 378  | 50.00 |
|               | College and above        | 42        | 8.92  | 429  | 91.08 |
|               | Primary (grades 1–8)     | 69        | 14.47 | 408  | 85.53 |
|               | Secondary (grades 9–12)  | 30        | 11.24 | 237  | 88.76 |
| Maternal education | Cannot read and write                       | 1193      | 55.0  | 976  | 45.0  |
|               | Can read and write       | 131       | 33.4  | 428  | 66.6  |
|               | College and above        | 12        | 4.9   | 234  | 95.1  |
|               | Primary (grades 1–8)     | 55        | 16.2  | 285  | 83.8  |
|               | Secondary (grades 9–12)  | 21        | 9.6   | 197  | 90.4  |
| Occupation    | Daily labourer           | 12        | 8.3   | 133  | 91.7  |
|               | Farmer                   | 1288      | 58.3  | 920  | 41.7  |
|               | Government employee      | 27        | 6.7   | 375  | 93.3  |
|               | Housewife                | 17        | 10.2  | 150  | 89.8  |
|               | Merchant                 | 68        | 11.1  | 542  | 88.9  |
| Family size   | ≤ Five                   | 976       | 34.4  | 1863 | 65.6  |
|               | > Five                   | 436       | 62.9  | 257  | 37.1  |
| Monthly income| ≤ 2100                   | 944       | 36.2  | 1661 | 63.8  |
|               | > 2100                   | 468       | 50.5  | 459  | 49.5  |
| Districts     | Awabel                   | 343       | 76.56 | 105  | 23.44 |
|               | Debay Tilat-gin          | 396       | 67.35 | 192  | 32.65 |
|               | Debre Ealias             | 291       | 49.24 | 300  | 50.76 |
|               | Debre Markos Town        | 57        | 11.38 | 444  | 88.62 |
|               | Dejen                    | 168       | 27.18 | 450  | 72.82 |
|               | Enebusie Sar Midir       | 33        | 5.98  | 519  | 94.02 |
|               | Sinan                    | 124       | 52.99 | 110  | 47.01 |
| Agroecology   | Highland and hot area    | 510       | 93.92 | 33   | 6.08  |
|               | Highland and cold area   | 110       | 47.01 | 124  | 52.99 |
|               | Low land area            | 393       | 70.05 | 168  | 29.95 |
|               | Mid land area            | 1107      | 50.46 | 1087 | 49.54 |
| Climate       | Dega                     | 124       | 52.99 | 110  | 47.01 |
|               | Kolla                    | 168       | 30.43 | 384  | 69.57 |
|               | Woina-daga               | 1120      | 40.79 | 1626 | 59.21 |
| Household head| Female                   | 228       | 35.29 | 418  | 64.71 |
|               | Male                     | 1184      | 41.03 | 1702 | 58.97 |
| Food expense  | < 2100                   | 944       | 36.24 | 1661 | 63.76 |
|               | ≥ 2100                   | 468       | 50.49 | 459  | 49.51 |
| COVID-19      | No                       | 121       | 8.6   | 242  | 91.4  |
|               | Yes                      | 570       | 26.2  | 1118 | 73.8  |
| Price inflation| No                      | 116       | 8.2   | 127  | 91.8  |
|               | Yes                      | 677       | 47.9  | 1570 | 52.1  |
| Conflict      | No                       | 32        | 2.3   | 149  | 97.7  |
|               | Yes                      | 120       | 8.5   | 137  | 91.5  |
| Weather change| No                       | 141       | 10.0  | 108  | 89.1  |
|               | Yes                      | 142       | 10.1  | 87   | 89.9  |

Table 4. Prevalence of non-resilience to food insecurity during at this time of COVID-19 pandemic and Public Emergency.
### Table 5. Associated factors of Household non-resilience to food insecurity at the time of COVID-19 pandemic and public emergency, Northwest Ethiopia, 2020. Significant values are in bold.

| Variables               | Characteristics               | Resilience | CoR at 95% CI | AoR at 95% CI |
|-------------------------|-------------------------------|------------|---------------|---------------|
|                         |                              | No         | Yes           |               |
| **Marital status**      | Divorced                      | 205        | 70            | 2.08 (1.57, 2.76) | 2.54 (1.65, 3.87) |
|                         | Married                       | 1284       | 912           | 1             |               |
|                         | Single                        | 479        | 316           | 1.08 (0.91, 1.27) | 0.61 (0.47, 0.78) |
|                         | Widowed                       | 152        | 114           | 0.95 (0.73, 1.23) | 1.24 (0.81, 1.89) |
| **Residence**           | Rural                         | 1082       | 1316          | 1             |               |
|                         | Urban                         | 1038       | 96            | 13.2 (10.51, 16.45) | 1.04 (0.34, 3.16) |
| **Paternal education**  | Cannot read and write         | 668        | 893           | 1             |               |
|                         | Can read and write            | 378        | 378           | 1.34 (1.23, 1.59) | 2.15 (0.59, 2.19) |
|                         | College and above             | 429        | 42            | 13.66 (9.79, 19.04) | 0.87 (0.46, 1.65) |
|                         | Primary (grades 1–8)          | 408        | 69            | 7.91 (6.01, 10.40) | 2.73 (0.87, 3.98) |
|                         | Secondary (grades 9–12)       | 237        | 30            | 10.56 (7.13, 15.64) | 2.3 (0.39, 3.80) |
| **Maternal education**  | Cannot read and write         | 976        | 1193          | 1             |               |
|                         | Can read and write            | 428        | 131           | 3.99 (3.23, 4.94) | 2.15 (0.59, 2.19) |
|                         | College and above             | 234        | 12            | 23.8 (13.26, 42.84) | 2.91 (0.33, 6.37) |
|                         | Primary (grades 1–8)          | 285        | 55            | 6.33 (4.69, 8.56) | 0.88 (0.57, 1.34) |
|                         | Secondary (grades 9–12)       | 197        | 21            | 11.46 (7.26, 18.12) | 0.9 (0.50, 1.63) |
| **Occupation**          | Daily labourer                | 133        | 12            | 1.39 (0.73, 2.64) | 2.37 (1.15, 4.87) |
|                         | Farmer                        | 920        | 1288          | 0.09 (0.07, 0.12) | 0.13 (0.08, 0.21) |
|                         | Government employee           | 375        | 27            | 1.74 (1.10, 2.77) | 2.06 (1.05, 4.05) |
|                         | Housewife                     | 150        | 17            | 1.11 (0.63, 1.94) | 1.55 (0.08, 3.00) |
|                         | Merchant                      | 542        | 68            | 1             |               |
| **Family size**         | < Five                        | 1863       | 976           | 1.17 (1.00, 1.35) | 2.67 (0.11, 3.39) |
|                         | ≥ Five                        | 257        | 436           | 1             |               |
| **Monthly income**      | ≤ 2100                       | 1661       | 944           | 1.79 (1.54, 2.09) | 1.34 (1.05, 1.70) |
|                         | > 2100                       | 459        | 468           | 1             |               |
| **Districts**           | Awabel                        | 105        | 343           | 1             |               |
|                         | Debay Tilat-gin               | 192        | 396           | 1.58 (1.02, 2.09) | 1.44 (0.99, 2.07) |
|                         | Debre Erias                   | 300        | 291           | 3.37 (2.57, 4.42) | 3.6 (2.31, 5.61) |
|                         | Debre Markos Town             | 444        | 57            | 25.4 (18.90, 21.8) | 3.50 (0.96, 12.52) |
|                         | Dejen                         | 168        | 450           | 8.75 (6.60, 11.59) | 4.21 (3.56, 6.78) |
|                         | Enebsie Sar Midir             | 519        | 33            | 51.6 (33.96, 77.74) | 31.3 (15.65, 48.15) |
|                         | Sinan                         | 110        | 124           | 2.89 (2.07, 4.06) | 1.86 (1.20, 2.89) |
| **Agro-ecology**        | Highland and hot area         | 510        | 33            | 15.2 (10.57, 21.79) | 11.5 (5.37, 16.77) |
|                         | Highland and cold area        | 110        | 124           | 0.87 (0.67, 1.14) | 0.42 (0.12, 1.05) |
|                         | Low land area                 | 393        | 168           | 2.3 (1.88, 2.80) | 1.35 (1.02, 2.56) |
|                         | Mid land area                 | 1107       | 1087          | 1             |               |
| **Climate**             | Dega                          | 384        | 168           | 2.56 (1.88, 3.53) | 2.17 (1.02, 3.15) |
|                         | Kolla                         | 1626       | 1120          | 1.64 (1.25, 2.14) | 1.06 (1.00, 1.89) |
| **Household head**      | Female                        | 418        | 228           | 1.25 (1.07, 1.52) | 1.08 (0.76, 1.52) |
|                         | Male                          | 1702       | 1184          | 1             |               |
| **Fear of COVID-19**    | No                            | 242        | 121           | 1             |               |
|                         | Yes                           | 1118       | 370           | 1.51 (1.18, 1.94) | 1.23 (1.02, 1.50) |
| **Frustration with price inflation** | No | 127 | 116 | 1 |  |
|                         | Yes                           | 1570       | 677           | 2.13 (1.62, 2.77) | 1.89 (1.42, 2.56) |
| **Conflict**            | No                            | 149        | 32            | 1             |               |
|                         | Yes                           | 137        | 120           | 0.16 (1.09) | 0.02 (0.01, 1.03) |

**Coping strategies of non-resilience during COVID-19 pandemic and public emergency.** This study found that during the COVID-19 pandemic and public emergency, more than two-thirds of households did not consider any of the coping strategies to be resilient. As a coping strategy, nearly 17.5% limited their meal...
preparations per week. During the COVID-19 pandemic and public emergency, nearly 15% of households used daily food restriction as non-resilience coping strategy (Table 6).

**Challenges and opportunities to exit from household non-resilience to food security.** As of the respective bodies addressed, the challenges explained in the community were the degree of poverty, the COVID-19 pandemic, public emergency and lockdown, limited variety, and decreased crop productivity. On the other hand, there were opportunities to mitigate the deteriorating effects of household food insecurity, such as increased seed production for farmers and distribution of emergency food as early management of food insecurity (Debre Markos Social and Labor service department, Child and Women Department, Zonal COVID-19 prevention committee leader, and Zonal agriculture and seed lab department). The poorest of the poor households were the most difficult to break free from non-resilience, and they require special attention in future interventional strategies.

“…During this COVID 19 pandemic and public emergency, there are some challenges to address food insecurity among the vulnerable groups, especially in the kebele levels, who are the poorest of poor, and which sections of the community are most vulnerable to food insecurity…” (DM Social and Labor Service Department, 2020, Women and Child Department Office, 2020).

The COVID-19 pandemic is currently a challenge for developing countries due to international lockdown and movement restrictions, which have indirectly affected the movement of international aiding agencies. They also reported that some parts of Ethiopia including the study area, particularly the Abay Gorge areas and hilly and mountainous areas, are severely affected by the issue of food insecurity.

“…COVID 19 poses a significant food security problem compared to other hazards, but the problem caused by COVID 19 varies from urban to rural. It is not known to be widespread in rural areas and is not yet available, but I think it could be more dangerous in the future, but in the city, it has spread as I said before…” (COVID-19 prevention Committee Leader, 2020).

The key to overcoming such issues is to put in more effort on the community, such as by cultivating new seeds and increasing productivity. Especially in this society, which consumes the majority of grains such as barley, wheat, corn, and sorghum, and has little chance of producing other types of products such as fruits and vegetables.
Now, in our office, we need to control seed quality to solve the food security problem, and we will have more seed multiplication and new seeds to be imported and preserved in quality. Like mangoes and avocados, our seeds are our source of quality and health, and they can be produced in large quantities and distributed to the poorest community at an affordable price. However, due to the lack of quality and quantity of the produce of products, if we take Orange as an example, it costs 50 birr per kilo. Therefore, food security can be addressed by increasing production and productivity... (Zonal Agriculture and Seed Lab Department, 2020).

An alternative to addressing the issue of food security is for the state government to increase its productivity by inspecting the lands occupied by investors and transferring them to a development individual or organization for development. Similarly, there has been a significant increase in seed production this year to address such issues and ensure food security.

...Yes of course because the government has made relentless efforts to address food insecurity by asking for assistance from top to bottom. After assessing and selecting risk takers the government distributes food and other materials given from internal and external funding in order to prevent this pandemic... (Disaster Prevention and Preparedness Department, 2020).

Discussion
A number of household food insecurity studies were conducted in Ethiopia, demonstrating the alarming scale of food insecurity and its deteriorating effects on the population's health and socioeconomic status due to various shock exposures. As a result, the purpose of this study was to investigate households' resilience to food insecurity during the COVID-19 pandemic shock and public emergency declared by the Ethiopian government. According to the findings of this study, nearly two-thirds of the households were non-resilient due to household food insecurity during the COVID-19 pandemic and public emergency. This finding was consistent with Tehran-Iran studies and it revealed that it was nearly doubled compared to a previous study conducted before the pandemic across Northeast and North African countries. This could be because, in addition to geographical, social, cultural, and economic differences, the COVID-19 pandemic and public emergency exacerbated the problem of household non-resilience in the East Gojjam districts. The social and economic fallout magnified the public health crisis: job losses, school closures, and increased poverty. These consequences are borne primarily by vulnerable populations around the world, including those in Africa. The pandemic could undermine hard-won development gains and jeopardize household resilience to food insecurity, as well as have a more practical impact on international organizations working on household resilience to food security.

Figure 4. Hotspot areas of household non-resilience to food insecurity during COVID-19 pandemic in East Gojjam Zone, Northwest Ethiopia, 2021.
| Variables                                | Characteristics | No | %    |
|------------------------------------------|-----------------|----|------|
| Relay on less preferred food items       | Every day       | 232| 6.8% |
|                                          | Once a week     | 161| 4.6  |
|                                          | None            | 2917| 82.6 |
|                                          | 2–3 times/week  | 116| 3.3  |
|                                          | 4–6 times/week  | 106| 3.0  |
| Food borrowing                           | Every day       | 227| 6.4  |
|                                          | Once a week     | 388| 11.0 |
|                                          | None            | 2668| 73.8 |
|                                          | 2–3 times/week  | 179| 5.1  |
|                                          | 4–6 times/week  | 130| 3.7  |
| Purchasing food on credit                | Every day       | 144| 4.1  |
|                                          | Once a week     | 300| 8.5  |
|                                          | None            | 2774| 78.5 |
|                                          | 2–3 times/week  | 188| 5.3  |
|                                          | 4–6 times/week  | 126| 3.6  |
| Hunting wild animals                     | Every day       | 41 | 1.1  |
|                                          | Once a week     | 20 | 0.6  |
|                                          | None            | 3441| 97.4 |
|                                          | 2–3 times/week  | 11 | 0.3  |
|                                          | 4–6 times/week  | 19 | 0.5  |
| Consuming seed stocks                    | Every day       | 93 | 2.6  |
|                                          | Once a week     | 174| 4.9  |
|                                          | None            | 3192| 90.4 |
|                                          | 2–3 times/week  | 41 | 1.2  |
|                                          | 4–6 times/week  | 32 | 0.9  |
| Sending children for beg                 | Every day       | 62 | 1.8  |
|                                          | Once a week     | 86 | 2.5  |
|                                          | None            | 3434| 97.2 |
|                                          | 2–3 times/week  | 6 | 0.2  |
|                                          | 4–6 times/week  | 6 | 0.2  |
| Sending children elsewhere to eat        | Every day       | 42 | 1.2  |
|                                          | Once a week     | 320| 9.1  |
|                                          | None            | 3050| 86.4 |
|                                          | 2–3 times/week  | 96 | 2.7  |
|                                          | 4–6 times/week  | 24 | 0.7  |
| Limiting meal proportions                | Every day       | 201| 5.7  |
|                                          | Once a week     | 617| 17.5 |
|                                          | None            | 2186| 61.9 |
|                                          | 2–3 times/week  | 366| 10.4 |
|                                          | 4–6 times/week  | 162| 4.6  |
| Restricting adult's food consumption     | Every day       | 478| 13.6 |
|                                          | Once a week     | 87 | 2.5  |
|                                          | None            | 2742| 77.6 |
|                                          | 2–3 times/week  | 73 | 2.1  |
|                                          | 4–6 times/week  | 152| 4.3  |
| Feeding more the working group of the family | Every day | 298| 8.5  |
|                                          | Once a week     | 97 | 2.7  |
|                                          | None            | 2830| 80.1 |
|                                          | 2–3 times/week  | 114| 3.2  |
|                                          | 4–6 times/week  | 193| 5.5  |
| Reducing meal number                     | Every day       | 233| 6.7  |
|                                          | Once a week     | 377| 10.7 |
|                                          | None            | 2387| 67.6 |
|                                          | 2–3 times/week  | 350| 9.9  |
|                                          | 4–6 times/week  | 184| 5.2  |
| Continued                                |                 |    |      |
insecurity⁴¹,⁵⁹. This finding was also lower than among a multi-country cross-sectional survey conducted across nine African countries ( Chad, Djibouti, Ethiopia, Kenya, Malawi, Mali, Nigeria, South Africa, and Uganda)⁶⁰, and one of the pocket study conducted in Addis Ababa town administration⁵. This is due to the fact that the COVID-19 pandemic and public emergency primarily affected urban settings and were more vulnerable for non-resilience to household food insecurity than the rural settings. However, when compared to other similar studies, the current study included different agro-ecological areas, as well as urban and rural settings, which directly affects the prevalence of non-resilience of household food insecurity. Divorce was associated with non-resilience to food insecurity during the COVID-19 pandemic and public emergency, especially for women-headed households, according to this study. This could be explained by the fact that married people are expected to have a stable family life, which may have a positive impact on household food security, whereas divorcees may face several socioeconomic challenges because their previous household assets and other properties could be divided or lost following the divorce⁶¹. As a result, special consideration must be given to this segment of the population in order to communicate with and capacitate them in terms of responding to household non-resilience to food insecurity during this time of COVID-19 pandemic and public emergency. Similarly, monthly income was found to be one of the main associated factors with households’ non-resilience to food insecurity during the COVID-19 pandemic shock. This could be attributed to the pandemic and public emergency, which had an impact on the labor market and reduced household income, particularly in urban areas⁶²,⁶³. Moreover, during lockdown periods and public movement restrictions during the COVID-19 pandemic, means of earning income were reduced, limiting households’ purchasing power of food consumptions, which is one of the resilient mechanisms against transient food insecurity. Data published elsewhere show that low-income households and those reliant on labor-intensive income earners were more vulnerable to income shock and consumed less food during the COVID-19 pandemic⁶⁴–⁶⁶. This implies that during times of public emergency such as COVID-19, decision-makers, policymakers, and others should place special emphasis on households that rely on labor-intensive jobs.

Furthermore, market inflation was strongly linked to household vulnerability in the face of food insecurity. This could be due to deterioration in the food value chain, hoarding by local market dealers, and panic buying by the community at the start of the COVID-19 pandemic, resulting in a supply shortage to the market⁶¹,⁶³,⁶⁷. This implies that the national government, local governments, communities, as well as other concerned bodies should collaborate, design and implement rigorous mechanisms to reduce price inflation during the COVID-19 pandemic and public emergency, specifically setting a fixed price for foods and commodities for consumption. The most hotspot areas identified in the agro-ecological analysis of household food insecurity resilience were Debre Markos town and Kurar kebele (in the Abay valley with lowland and hot weather conditions), which was consistent with Alemu and his colleagues’ previous food insecurity level study⁶⁶. During the COVID-19 pandemic and public emergency, transportation from town to town, even across borders, was restricted, affecting the resilience status of households. Price inflation in Debre Markos, in particular, may affect households’ purchasing power of basic food commodities. Prior to the occurrence of the COVID-19 pandemic and public emergency, the lowland areas, particularly the kebeles settled in the Abay Gorge, were identified as the hottest spot areas affected by household food insecurity, which could be exacerbated by the pandemic⁶⁴–⁶⁶. In terms of household occupation, daily laborers and government employees were more affected by household food insecurity and were less resilient. It was the fact that, during the COVID-19 pandemic and public emergency, the government-imposed lockdown and movement restrictions had resulted in a loss of income, particularly for individuals whose lives were dependent on daily wages. Similarly, in Ethiopia, the lives of government employees are entirely dependent on the products of rural farmers. Farmers’ availability of basic foods and commodities to urban communities, including government employees, was hampered by movement restrictions⁶¹.

In this study, more than two-thirds of the households chose no coping strategies to deal with the occurrence of food insecurity. Less than one-fifth of the households relied on food consumption changes/adjustments, primarily limiting food consumption and using less preferred or low-quality foods, as these strategies are easily adjustable. However, these coping strategies are harmful to people’s health and which will affect the capacity of resilience negatively⁶⁸. The main reason for households’ reliance on coping strategies for food consumption adjustments was associated with the level of asset ownership, which was discovered to be the main determinant factor of food

### Table 6. Coping strategies of non-resilience during COVID-19 pandemic and public emergency, Northwest Ethiopia, 2021.

| Variables                  | Characteristics | No  | %   |
|----------------------------|-----------------|-----|-----|
| Skipping meals in a day    | Every day       | 58  | 1.6 |
|                            | Once a week     | 163 | 4.6 |
|                            | None            | 3254| 92.1|
|                            | 2–3 times/week  | 39  | 1.1 |
|                            | 4–6 times/week  | 18  | 0.5 |
| Harvesting immature crops | Every day       | 59  | 1.6 |
|                            | Once a week     | 214 | 6.1 |
|                            | None            | 3154| 89.3|
|                            | 2–3 times/week  | 68  | 1.9 |
|                            | 4–6 times/week  | 37  | 1.0 |
insecurity resilience. The poor chose food consumption strategies to cope with the shocking exposure (in this case, the COVID-19 pandemic) because the poor are usually affected by shocks56,57. The challenges posed by the COVID-19 pandemic on household resilience to food insecurity in East Gojjam Zone, as elaborated by responsible government and non-governmental bodies, were the degree of poverty at the household level, the government’s declaration of public emergency and lockdown, limited variety and decreased productivity of farmers’ crops. While there were opportunities in disguise that could help to address the shadow of household food insecurity, such as increased seed production to distribute to farmers and emergency food distribution as early management of food insecurity (Debre Markos Social and Labor service department, Child and Women Department, Zonal COVID-19 prevention committee leader, and Zonal agriculture and seed lab department).

Theoretical and practical implication of this study
It is real that non-resilient households for food insecurity are more vulnerable to social, political, and economic crises, necessitating a comprehensive package of assistance from the federal government and international relief organizations to alleviate acute household food shortages. Furthermore, the households’ coping strategies identified during this pandemic and public emergency must be strengthened and incorporated as core mitigation strategies of household non-resilience to food insecurity for the study area and similar settings across the country. Furthermore, this study found that urban households and households in the low-land areas of the Nile gorge were hotspot areas and more prone to non-resilience to food insecurity, which deserves more attention and requires integrated services that can minimize the cost of living, mitigates repeated drought attacks among Nile gorge households, and other COVID-19 induced non-resilience mitigation strategies.

Strength and limitation of this study
The strength of this study was that it used mixed methods research to answer the various research questions in a comprehensive manner and attempted to provide the prevalence of household non-resilience to food insecurity, identified the associated factors, hotspot areas, household coping strategies used during the pandemic, and the opportunities and challenges to exit from this critical issue in a single article for the scientific community. It also used electronic assisted and GPS linked data collection techniques, both of which were critical for maintaining data quality throughout the data collection period. Another advantage of this study was that it included both urban and rural households by taking into account the different agro-ecologies classified in previous studies43. This study looked at hilly and mountainous areas in cold and hot weather, which are both more vulnerable to soil erosion and drought, respectively, and bear the triple burden of household non-resilience to food insecurity, in addition to the COVID-19 pandemic and public emergency. This study also included low-land areas with hot weather, as well as mid-land areas with brown, black, and red soil types, all of which are important for household resilience to food security in both rural and surrounding urban populations. Furthermore, this study also estimated the prevalence of household non-resilience to food insecurity by considering the large and representative sample size and by using the internationally standardized tool that is the Resilience Index Measurement and Analysis II (RIMA-II) validated by the United Nations Food and Agricultural Organization (FAO)32. However, this study may be limited by the social desirability bias because households during the COVID-19 pandemic and public emergency may believe that the government will provide assistance while undermining their income and other resources critical for household resilience to food security.

Conclusion and recommendations
In terms of spatial heterogeneity, the prevalence of non-resilience to food insecurity was found to be higher prior to the era of the COVID-19 pandemic and public emergency, which is a concerning issue in the study area and at the national level in general. Daily laborers and government employers, kola and Woyna-Dega climatic zones, highland and low land with hot areas, household monthly income, market price inflation, and being a female-headed household were significant factors associated with household non-resilience to food insecurity. As a result, there is a need to control market inflation for basic food commodities based on baseline research, as well as update international humanitarian agencies to provide food and consumables access in hotspot areas. The respective bodies should provide assistance and advice on agro-ecologically adapted and productive agriculture extension services. Female-headed households should be given assistance to increase their decision-making power in order to improve their resilience capacity. Moreover, People’s food eating patterns changed as a result of the coping mechanisms employed by households to fortify themselves against the startling COVID-19 pandemic exposure, which negatively impacted their health and reduced their resilience as they have a bi-directional influence. As a result, strategies tailored to minimize this issue should be considered and designed with the local context in mind.

Data availability
All data generated or analysed during this study are included in this published article (and its Supplementary Information files).

Received: 7 June 2022; Accepted: 7 September 2022
Published online: 15 September 2022

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Acknowledgements

The researcher would like to thank Debre Markos University, College of Health Sciences for the approval of the proposal and for providing the Ethical letter. Then also the researcher would like to thank study participants, supervisors, and data collectors who spent their valuable time responding to the questionnaire accordingly.

Author contributions

A.N. conceived and designed the study, performed analysis and interpretation of data. W.W., L.Y., Y.T., L.Y., T.Y.A., T.T., Y.N., Y.A.D., W.D.K., B.A., Y.H., D.D., B.W.S., M.Y.B. and H.T. supervised the design conception, analysis, interpretation of data and made critical comments at each step of research. A.N., T.G., B.T., A.T., H.M., A.T., T.G., and E.T. drafted the manuscript. W.K. and M.S. edited the draft, write-up, and finalized the manuscript. All authors read and approved the final manuscript.

Funding

This study was supported by Debre Markos University for data collection material. However, it had no role in study design, analysis, decision to publish, or preparation of the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-022-19963-2.

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