

Formal humanitarian food aid is spatially constrained, while informal food aid bridges the gap: Evidence from pastoral Ethiopia.

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**Formal humanitarian food aid is spatially constrained, while informal food aid bridges the gap:
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Abstract

Research shows that in Africa, spatial location significantly affects pastoral household access to goods and services. The influence of spatial location on access to food aid, both formal (distributed by a government-approved aid relief programme) and informal (sharing of food received from a formal source among and between households), remains underexplored. Filling this gap has important implications for designing effective humanitarian actions amid shocks. Using a balanced panel of 1,226 pastoral households surveyed in 2019 and 2025, we found that distance to aid distribution centre constrains household access to formal food aid. Each additional kilometre from a distribution centre is associated with approximately 3.5% lower odds of receiving formal food aid, compared with approximately 1.0% lower odds of receiving informal food aid. Beyond 30 km, the probability of receiving formal food aid declines sharply, whereas the odds of receiving informal food aid remain stable. Heterogeneity analysis shows that as drought exposure increases, access to formal food aid does not increase, while access to informal food aid increases significantly. These findings are robust to alternative measures of drought exposure, while results using road distance indicate some sensitivity to how spatial accessibility is measured. Our findings suggest that formal humanitarian food aid may extend beyond the spatial reach of the formal distribution system through secondary inter-household redistribution, particularly during droughts. Humanitarian actions could leverage this complementarity to strengthen spatially inclusive food aid targeting in the face of shocks.

Keywords: Spatial; Food aid; Drought; Pastoral; Ethiopia; Humanitarian

JEL Codes: O12, Q54, R12, I38, D64

26 **List of abbreviations**

27	CHIRPS	Climate Hazards Group InfraRed Precipitation with Station Data
28	GIS	Geographic Information Systems
29	GPS	Global Positioning System
30	LOESS	Locally estimated scatterplot smoothing
31	OCHA	United Nations Office for the Coordination of Humanitarian Affairs
32	PSNP	Productive Safety Net Programme
33	SPEI	Standardized Precipitation Evapotranspiration Index
34	TLU	Tropical Livestock Units
35	WMO	World Meteorological Organization

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1. Introduction

In pastoral regions in Africa, smallholders are vulnerable to shocks, including droughts. The 2020–2023 Horn of Africa drought had devastating impacts on pastoralists and agro-pastoralists, causing widespread livestock losses, the displacement of approximately 2.7 million people, and drought-related food insecurity affecting more than 23 million people across Ethiopia, Kenya, and Somalia (World Food Programme, 2023). As climate shocks become more frequent and severe, humanitarian agencies face increasingly constrained resources (Mbah et al., 2025; OCHA, 2023). In this context, understanding the pattern of access to aid is critical to help maximize the impact of humanitarian actions, resources, and the efficiency of aid delivery.

Studies have shown that aid allocation and distribution are often spatially uneven. Briggs (2018) found that development aid tends to be distributed in relatively more accessible areas, potentially limiting remote household access to aid. Whether such a pattern exists for humanitarian aid is less explored. Studies have also shown that spatial remoteness does not necessarily imply vulnerability because informal mechanisms, including inter-household aid sharing, may serve as an important complement to formal aid (Flintan et al., 2019). However, less is known about whether such complementarity between formal and informal aid varies across space, and whether it still exists amid shocks.¹

In this paper, we explore how household spatial location affects the receipt of food aid from both formal and informal sources. We use a unique balanced panel dataset from Ethiopia, with 1,226 households surveyed in 2019 and 2025, as our empirical testing ground.² We focus on household spatial location, particularly proximity to formal aid distribution centres, because spatial location is an observable and increasingly measurable characteristic using geographic information systems (GIS) or georeferenced surveys. It is also a “compound” variable that reflects many underlying factors affecting food aid access, including transport infrastructure, travel costs, remoteness, and service availability. Spatial location is therefore both an analytically useful indicator and a policy-relevant

¹ In this paper, informal food aid refers to official humanitarian food aid subsequently shared between households.

² Throughout this paper, the term “aid” refers specifically to food aid unless otherwise stated.

factor for humanitarian action planning, as it helps identify underserved remote households and informs the placement of aid facilities, while being especially relevant in pastoral systems where settlement locations are dynamic rather than permanent.

The results show that household proximity to formal food aid distribution centres is positively associated with a higher likelihood of receiving food aid. In contrast, this relationship is much weaker for receiving informal food aid. Here, formal food aid refers to aid distributed by a government-approved relief programme, and informal aid refers to sharing food received from a formal source and between households. Nonlinear relationships were observed between proximity to the aid distribution centre and the chance of receiving formal and informal food aid. Increasing exposure to drought does not necessarily lead to higher chances of receiving more formal food aid, but it is associated with receiving more informal food aid.

These findings contribute to three strands of the literature. The first concerns the impact of spatial location on household access to goods, services or other resources, primarily in the absence of shocks (Jalan & Ravallion, 2002; Barrett, 2008). For this strand, we extend the evidence base to humanitarian food aid, which differs from regular goods and is particularly important for household survival amid shocks. Second, we contribute to the literature examining the spatial pattern of aid delivery outcomes and efficiency, including the optimal choice of aid centre location at a more aggregate level (Balcik & Beamon, 2008; Briggs, 2018; Jung, 2023; Shon et al., 2024). For this strand, we examine household-level evidence rather than aggregate-level evidence, explicitly separating formal and informal food aid. The third strand examines heterogeneity in drought-related aid access across space and the relationship between formal and informal aid in the face of shocks (recent examples include Hassan et al., 2025). While formal aid has expanded in developing countries, many smallholders still rely on informal redistribution systems, such as community-based networks for survival and risk management (Stavropoulou et al., 2017). Our contribution is to test how spatial location affects this complementarity, especially amid drought, to better understand whether complementarity or substitution depends on households' distance to formal aid distribution centre.

From a practical perspective, our results suggest that, overall, formal aid sources are provided on a more stable basis than informal food aid, but are more constrained by spatial location, whereas distance constrains informal food aid only weakly. Formal food aid is relatively unresponsive to drought exposure, while informal food aid responds significantly to increasing drought episodes. We conclude with implications for improving the spatial inclusiveness of food aid while leveraging the informal aid system for more efficient humanitarian actions in the face of shocks.

2. Literature review

This study builds on three parallel bodies of literature: the impact of spatial location on household access to food, services, and other resources under normal conditions; the spatial patterns of aid delivery outcomes and efficiency; and the relationship between formal and informal aid.

In the first strand, the literature has long recognized the role of spatial location and proximity in shaping household access to services and resources and its implications for livelihoods. Jalan & Ravallion (2002) demonstrate how remoteness and weak infrastructure constrain access to economic opportunities and basic services, while Barrett (2008) shows that transaction costs and distance to infrastructure affect household participation in market and service systems. The World Bank highlighted how spatial inequality and connectivity influence access to opportunities and public services (World Development Report, 2009). Recent work has also shown similar influences on public goods provision, such as water infrastructure and governance (Song et al., 2025). This suggests that where households are located can substantially affect their ability to access external support and resources.

Within this first strand, the literature on how location affects household access to humanitarian aid is limited. Spatial location may also influence access to informal support systems. In many rural and pastoral settings, households rely on kinship, friendship, and community reciprocity to cope with shocks and periods of food insecurity. Informal mechanisms such as food sharing, labour exchange, and financial support provide flexible and responsive forms of aid that often complement formal humanitarian interventions (De Sardan, 2015). The spatial dimension of these informal channels

becomes particularly important when communities face covariate shocks, such as floods, disease outbreaks, or droughts. Localized informal insurance arrangements are often insufficient when entire communities experience losses at the same time. Extending support across geographic areas can help diversify risk and strengthen resilience. In pastoral societies, such spatially distributed support is facilitated by social ties that extend beyond local settlements, including kinship relations (Carmen, et al., 2022).

In the second strand of the literature, researchers have studied the location of humanitarian aid but from a logistics and planning perspective, usually at a more aggregate level (Shon et al., 2024). Jung (2023) studied the spatial distribution of development aid and found that aid tends to concentrate near easily accessible and less vulnerable areas. Balcik and Beamon (2008) modelled humanitarian distribution-centre location for quick-onset disasters under capacity limits. While humanitarian logistics research has primarily focused on optimizing the placement of aid facilities and distribution centres (Nappi et al., 2019), it has paid less attention to how household-level spatial patterns influence aid delivery. Spatial location affects not only whether formal aid programmes can reach households, but also the reliability, timeliness, and sustainability of delivery. Eligüzel et al. (2023) applied location-allocation models to the United Nations Humanitarian Response Depot network, demonstrating how spatial optimization can substantially improve humanitarian aid distribution efficiency by reducing travel distances. The impact of spatial location on humanitarian aid delivery is particularly relevant in Ethiopia's pastoral regions, where recurrent droughts constrain mobility and drive severe food insecurity and livestock losses (Wakeyo, 2024), and where location is linked to pre-existing resource-based conflicts (Song et al., 2024).

Finally, studies have demonstrated the complementarity between formal and informal systems and distribution channels. Evidence from post-earthquake Haiti shows that informal assistance, particularly family cash transfers, complemented formal humanitarian aid and was often viewed by recipients as more effective (Versluis, 2014). However, there is no spatial analysis on how the distance to formal sources is mediated by location and the complementarity of the two sources of assistance. In fact, informal aid sharing plays a crucial role in safeguarding households from being overwhelmed by

shocks (Fafchamps and Lund, 2003; Folke, 2006). Inter-household exchanges, including food aid, can spread through social networks and serve as an important risk-coping strategy (Baird & Gray, 2014).

Overall, existing studies show that spatial location influences access to resources, humanitarian logistics affects aid delivery efficiency, and formal and informal systems often complement one another. However, little is known about how a household's spatial location influences access to formal and informal food aid, especially in drought-prone pastoral communities.

3. Method

3.1 Regression specifications

We start by estimating random-effects panel logit models to examine the association between spatial location and receiving food aid. We specify the random effect at the household level to account for repeated observations of the same household. Standard errors are clustered at the household level to allow for within-household correlation across survey rounds. We do not cluster at the kebele level for inference because the sample contains only three kebeles, and conventional cluster-robust inference is unreliable. Spatial location is measured with distance (in kilometres) from each household to that kebele's food aid distribution centre.

We estimate models separately for all food aid sources (Equation 1), formal sources (Equation 2), and informal sources (Equation 3). We define food aid from formal sources as official humanitarian food aid received directly from government, PSNP, NGOs, UN agencies, or other humanitarian organizations, and food aid from informal sources as official humanitarian food aid that entered the community through these formal channels but was subsequently shared between households rather than received directly from an aid organization.

$$\begin{aligned} \text{logit}[Pr(\text{Receive food aid from all sources} = 1|X_{ikt}, \varepsilon_i)] \\ = \beta_0 + \beta_1 \text{Distance to distribution center}_{ikt} + X'_{ikt}\gamma + \varepsilon_i \end{aligned} \quad (\text{Equation 1})$$

$$\begin{aligned}
& \text{logit}[Pr(\text{Receive food aid from formal sources} = 1|X_{ikt}, \varepsilon_i)] \\
& = \beta_0 + \beta_1 \text{Distance to distribution centre}_{ikt} + X'_{ikt}\gamma \\
& + \varepsilon_i
\end{aligned} \tag{Equation 2}$$

$$\begin{aligned}
& \text{logit}[Pr(\text{Receive food aid from informal sources} = 1|X_{ikt}, \varepsilon_i)] \\
& = \beta_0 + \beta_1 \text{Distance to distribution centre}_{ikt} + X'_{ikt}\gamma \\
& + \varepsilon_i
\end{aligned} \tag{Equation 3}$$

In all three equations, the dependent variable takes a value of 1 for household i if the household receives the corresponding food aid in year t . *Distance to distribution center* $_{ikt}$ measures the distance of each household i to the aid distribution centre in each kebele k . X is a vector of right-hand-side independent variables, including household demographic characteristics and other controls such as kebele fixed effects. ε_i is the household random effect. It also includes an important independent variable *Drought* $_{it}$ which is the total number of months during the rainy season in year t that have SPEI between certain bands of values of that household's location, which indicate moderate drought under different accumulation periods.

We then repeat the same estimation, this time for food aid given to another household (Equation 4), and keep all other right-hand-side variables the same.

$$\begin{aligned}
& \text{logit}[Pr(\text{Give food aid to another household} = 1|X_{ikt}, \varepsilon_i)] \\
& = \beta_0 + \beta_1 \text{Distance to distribution centre}_{ikt} + X'_{ikt}\gamma \\
& + \varepsilon_i
\end{aligned} \tag{Equation 4}$$

As a robustness check for the measurement of spatial location, we also examine the association between distance to the nearest road and receiving food aid. To better capture the potential non-linearity of the effect of spatial location on how food aid is received, we also use locally estimated scatterplot smoothing (LOESS) to model the relationship above nonparametrically and plot the relationship between spatial location and access to and receipt of food aid.

Our empirical strategy is not intended to disentangle any causal effects. Food aid distribution centres are not randomly located. Typically, they are placed in more accessible or administratively central

199 areas. As a result, distance to distribution centres may capture both physical accessibility and
200 underlying placement decisions. In addition, household location is not exogenous. In pastoral systems,
201 households choose locations based on grazing conditions, mobility strategies, wealth, or social ties, all
202 of which may influence access to food aid. These factors introduce potential selection and omitted-
203 variable biases. Including kebele fixed effects and household characteristics helps account for some
204 observable, time-invariant differences. However, unobserved factors may still affect the estimates.
205 The results should therefore be interpreted as documenting systematic spatial patterns in food aid
206 access rather than any causal effects of distance.

207 3.2 Data and variables

208 *Sample*

209 The survey was implemented in three kebeles in Ethiopia in 2019 and 2025: Asli in the Somali
210 Region, Su'ula in the Afar Region, and Fuldowa in the Oromia Region. Kebeles are the smallest
211 administrative units in Ethiopia. These three kebeles were selected in 2019 as characteristic pastoralist
212 communities known to receive formal food aid, representing one kebele from each of the three
213 pastoralist-dominated regions. Although their climatic, geographic, and administrative characteristics
214 are somewhat similar, their social features differ, shaped by culture, ethnicity, exposure to education,
215 and other factors.

216 The survey used a census approach, interviewing all households in the selected kebeles. The first
217 survey was implemented in 2019, covering 1,983 household heads across the three kebeles. We
218 conducted a follow-up survey in 2025 with 1,805 household heads. For our analysis, we used
219 responses only from the 1,226 households that participated in both surveys to create a balanced panel
220 dataset.³ In all instances, we interviewed the household head present during the study fieldwork.
221 Among these households, approximately 69% were male-headed in both survey rounds, with the
222 remainder female-headed.

³ To assess potential attrition bias, we compared observable characteristics across households observed only in 2019, only in 2025, and in both survey rounds. Overall, the comparison does not reveal a consistent pattern of systematic differences across groups in the sex of the household head, formal food aid, spatial proximity to aid distribution centres, and drought exposure, although differences are observed in age and informal food aid.

Variables

For spatial location, the primary measurement is the household's distance to the humanitarian aid distribution centre. In each kebele, there was an aid distribution centre where households could collect food aid. The three centres were all near major roads. In Su'ula, the centre lies along the A1 Awash-Assab Highway south of the households surveyed. In Asli, the centre is near a local mosque. In Fuldowa, the centre is near a medical centre in a built area at the intersection of two roads. Figure A1 in the appendix shows details of these aid distribution centres. We then measured the distance from each household to its corresponding kebele aid distribution centre along major roads using geospatial methods. As a robustness check, we also measured the distance to the nearest roads as an alternative specification for measuring spatial location.

While the survey also collected information on other forms of informal aid between households, such as labour, we focused on food aid because it directly addresses household food insecurity and constitutes the primary form of humanitarian aid amid shocks. Moreover, in our dataset, households report food aid more consistently and completely than other forms of aid, making it well suited to answer our research question. We further distinguished food aid variables into formal and informal sources.

The variable 'Receiving Food Aid (Formal)' takes the value 1 if a household reports receiving food aid from any of the following sources: the Ethiopia Productive Safety Net Programme (PSNP), a government agency, NGOs, or United Nations agencies, and 0 otherwise. 'Receiving Food Aid (Informal)' takes the value 1 if a household reports receiving official humanitarian food aid that was subsequently shared by another household, rather than receiving it directly from a formal aid provider. To further examine reciprocity-based behaviour, we constructed a variable 'Giving Food Aid', which equals 1 if the household reports providing food aid to another household, and 0 otherwise.

To measure drought, we first drew a 5 km radius buffer zone around each household's GPS coordinates, then used threshold values in the Standardized Precipitation Evapotranspiration Index (SPEI) to identify a drought event for each household in the 2019 and 2025 rainy seasons. The SPEI is a widely used drought index incorporated into the World Meteorological Organization (WMO)

drought monitoring guidance. The SPEI measures anomalies in the climatic water balance (precipitation minus potential evapotranspiration) relative to the historical distribution at a given location. It is calculated monthly for a moving window of n months of accumulation. For example, the SPEI for a moving window of six months of accumulation is denoted as SPEI-6.

Following WMO guidance, we define a drought month as a month in which the six-month Standardized Precipitation Evapotranspiration Index (SPEI-6) falls between -1.5 and -1.0 , corresponding to moderate drought conditions. We then count the number of drought months in each year under each SPEI threshold. As robustness checks, we use SPEI-1 to capture short-term moisture conditions, SPEI-3 to capture medium-term conditions, and SPEI-9 to capture longer-term drought conditions. We obtain monthly precipitation data from Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) version 2.0 (Funk et al., 2015) and merge them with household buffer zone data.

3.3 Robustness check

We conducted two sets of robustness checks. First, as an alternative measure of spatial location, we used distance to the nearest road. Second, for measuring drought, we constructed an alternative measure using a 30 km buffer. This larger buffer accounts for the fact that many households in the study area, particularly those engaged in pastoralism, may rely on resources beyond their immediate surroundings and may move livestock across wider areas in response to changing pasture and water availability.

3.4 Descriptive statistics

Table 1 summarizes the descriptive statistics of key variables between 2019 and 2025. While household demographic characteristics remained relatively stable over time, our study area experienced an increase in drought exposure.⁴ Drought frequency increased between survey rounds. The proportion of households receiving food aid also increased. Across the kebeles surveyed, food aid

⁴ Tropical Livestock Unit (TLU) data were not collected in the 2019 survey. For descriptive purposes, the 2025 TLU values were assigned to the corresponding households in 2019; therefore, comparisons of TLU across survey years should not be interpreted as reflecting temporal change.

coverage was generally high in both 2019 and 2025, though clear spatial disparities are observed (Table A1).

Table 1 Summary statistics of the surveyed households

Variable	Unit	2019		2025	
		Mean	SD	Mean	SD
Age	Year	44.8	15.8	50.9	15.3
Male household head	proportion of all households	0.6	0.4	0.6	0.4
Food aid received from formal sources = 1	proportion of all households	0.8	0.3	0.9	0.3
Moderate drought (SPEI-6)	Number of months in a year	0.9	2.1	1.2	2.9
Distance to food aid distribution centre	km	10.4	15.1	9.3	16.5
Food aid received from another household = 1	proportion of all households	0.7	0.4	0.6	0.4
Food aid given to other households = 1	proportion of all households	0.6	0.4	0.5	0.4
Tropical Livestock Units (TLUs)	1 TLU = 250 kg of live animal weight	19.0	21.6	19.0	21.6

4. Results

4.1 Distance to aid distribution centres is more strongly associated with receiving formal food aid than with informal food aid.

Table 2 summarizes the results of three sets of models. Model (1) examines receiving food aid from all sources, including formal and informal sources. Model (2) focuses on formal sources only, and Model (3) considers informal sources only. Across all specifications, households nearer to centres are more likely to receive more food aid. The estimated coefficients range from -0.036 to -0.010 and are statistically significant at the 1% level. Converting these estimates to odds ratios, each additional kilometre from the distribution centre is associated with 3.5% lower odds of receiving formal food aid, 2.6% lower odds of receiving food aid from all sources, and 1.0% lower odds of receiving informal food aid. These results indicate a substantially stronger association between distance to distribution centres and receiving formal food aid than with informal food aid.

Moderate drought exposure is positively associated with receiving food aid from all sources and from informal sources. The positive, statistically significant coefficients in Models 1 and 3 indicate that greater moderate-drought exposure is associated with higher odds of receiving food aid from all

sources and through informal household-to-household redistribution. In contrast, the drought measure is not statistically significant for formal food aid (Model 2). This pattern is consistent with informal food aid being more responsive to moderate drought exposure than direct formal food aid. The full regression specifications, including household characteristics and other control variables, are reported in Tables A2–A4 in the appendix.

Table 2 Logit estimates of receiving food aid (5 km buffer)

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
	Receive food aid from all sources	Receive food aid from formal sources	Receive food aid from informal sources
Distance to distribution centre (km)	−0.026*** (0.002)	−0.036*** (0.004)	−0.010*** (0.002)
Number of months with moderate drought ($-1.5 < \text{SPEI-6} < -1$) ⁵	0.099*** (0.033)	−0.028 (0.037)	0.074*** (0.020)
Unique households	1,226	1,226	1,226
Total observations	2,452	2,452	2,452

*Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parentheses. All regressions include kebele fixed effects. The distance to the distribution centre is measured relative to the distribution centre in each household's kebele. Drought is measured using an SPEI-based 5 km buffer zone around each household. Formal sources include food aid from PSNP, NGOs, government agencies, and humanitarian agencies. Informal sources include food aid from other households.*

While the logit regressions estimate the average effect of distance on receiving food aid, they impose a linear relationship between distance and the odds of receiving aid. To test whether this assumption obscures important nonlinear patterns, Figure 1 presents locally estimated scatterplot smoothing (LOESS) regressions of the relationship between distance to the aid distribution centre and the odds of receiving food aid (separated by formal and informal sources).

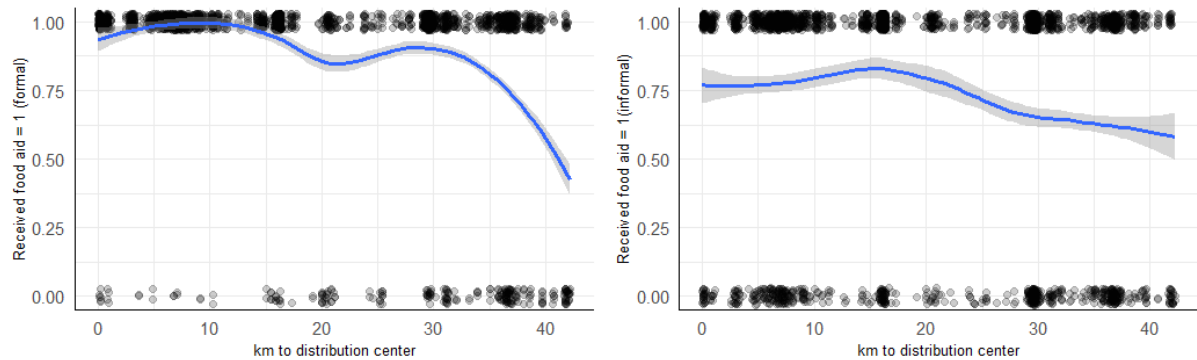
The probability of receiving formal food aid remains high for households located close to distribution centres and is relatively stable over shorter distances. Beyond 15–20 km, however, the probability declines, with a particularly sharp drop after 30 km. In contrast, the probability of receiving informal food aid varies much less with distance. It shows only a modest increase at intermediate distances before gradually declining at greater distances, indicating a weaker distance gradient. Overall, the

⁵ SPEI: Standardized Precipitation Evapotranspiration Index

figure suggests that spatial distance is a stronger barrier to accessing formal food aid than informal food aid and displays a nonlinear pattern over the distance.

Figure 1 Predicted probability of receiving food aid by distance to distribution centre.

(Left: formal sources. Right: informal sources)



4.2 Probability of receiving informal food aid increases with drought exposure, while formal food aid remains relatively stable.

Figure 2 presents the predicted probability of receiving food aid from formal and informal sources as the number of moderate drought months increases under four alternative drought measures (SPEI-1, SPEI-3, SPEI-6, and SPEI-9). The predicted probability of receiving formal food aid remains high and almost unchanged as drought exposure increases, indicating that formal food aid is relatively insensitive to increasing drought exposure. In contrast, the predicted probability of receiving informal food aid increases steadily with the number of drought months, rising from 0.70 to over 0.82 across all SPEI measures.

Figure 2 Predicted probability of receiving food aid by drought exposure.

(Left: formal sources. Right: informal sources)

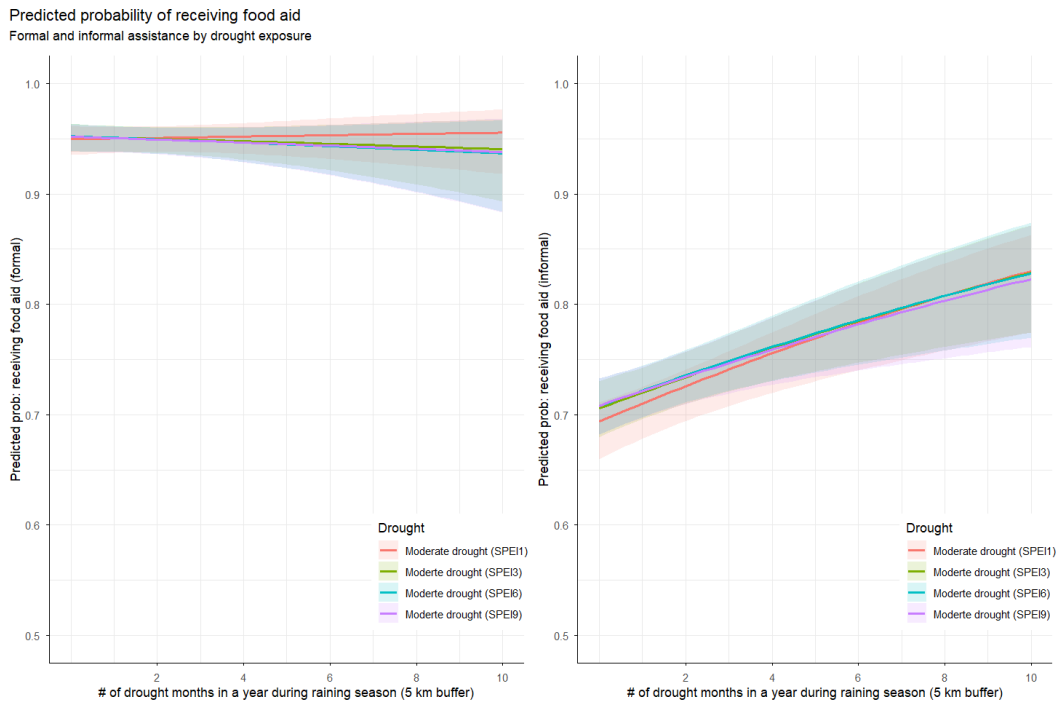
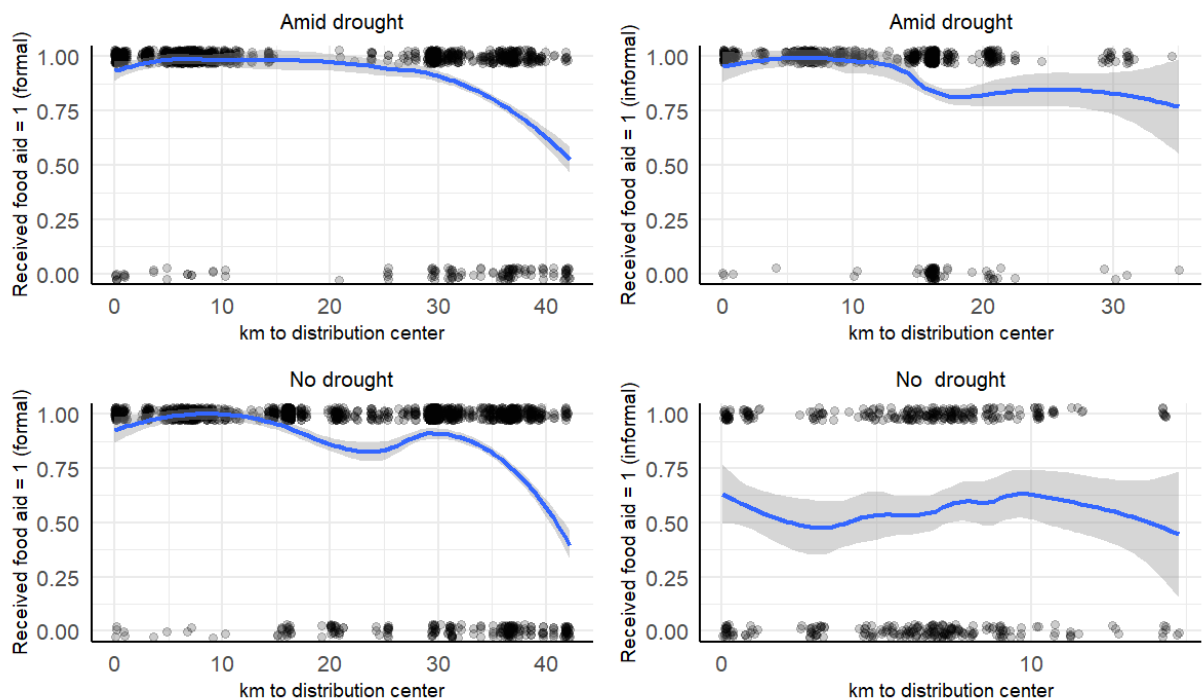


Figure 3 further examines whether the relationship between distance to the aid distribution centre and the probability of receiving food aid differs between drought and non-drought conditions. The estimated probability of receiving both formal and informal food aid is generally higher under drought conditions than under non-drought conditions, while formal food aid remains more prevalent than informal food aid.

However, the spatial patterns differ across food aid sources. The probability of receiving formal food aid declines sharply with distance under both drought and non-drought conditions, suggesting that distance remains a major barrier to accessing formal aid. In contrast, informal food aid exhibits a much weaker relationship with distance during drought, with stable probabilities across space. This pattern suggests that informal food aid is less constrained by proximity to distribution centres and may rely on decentralized social ties rather than centralized delivery systems. During non-drought periods, informal food aid is less common and shows no clear relationship with distance.

Figure 3 Estimated probability of receiving food aid by distance to distribution centre with drought/non-drought split.

(Top left: formal sources amid droughts. Top right: informal sources amid droughts. Bottom left: formal sources without drought. Bottom right: informal sources without drought)



Taken together, the results show that formal food aid appears to operate through geographically centralized distribution mechanisms that are effective but spatially uneven, to the disadvantage of households located further from distribution centres. Informal transfers, by contrast, appear more reactive to local drought conditions and less sensitive to spatial barriers, suggesting that they may complement formal aid during climatic shocks.

4.3 Reciprocity

Based on the results, we suggest that reciprocity may underlie the impact of spatial location on food aid receipt. Table A8 in Appendix 1 presents logit estimates in which the dependent variable takes the value 1 if a household gives food aid to another household (i.e. informal aid). The results show that households located far from food distribution centres are significantly more likely to provide food aid to other households. This pattern suggests that households in more remote areas may participate more

actively in reciprocal food aid giving, consistent with the conjecture that reciprocity-based informal mechanisms may help partially offset the spatial disadvantage of accessing formal humanitarian food aid.

4.4 Robustness check

To assess the robustness of our findings, we conducted two additional analyses.

First, we replace distance to the food distribution centre with distance to the nearest road as an alternative measure of spatial accessibility. The results (Table 3) reveal some sensitivity of the main findings to the choice of spatial measure. For food aid received from all sources, the negative association with distance becomes smaller, while for formal food aid the coefficient becomes statistically insignificant. In contrast, the association between road distance and informal food aid remains statistically significant. Thus, the finding that formal food aid is more spatially constrained than informal food aid does not generalize to These factors introduce road-based measures of accessibility. Rather, the stronger spatial effect for formal food aid appears specific to households' distance from food aid distribution centres. This distinction suggests that the spatial patterns identified in the main analysis are more closely tied to the location of the formal distribution system than to general road accessibility.

Table 3 Logit estimates of receiving food aid (distance to road)

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
	Receive food aid from all sources	Receive food aid from formal sources	Receive food aid from informal sources
Distance to road (km)	−0.01** (0.005)	−0.001 (0.004)	−0.01** (0.005)
Number of months with moderate drought (−1.5 < SPEI-6 < −1) ⁶	0.16*** (0.03)	0.06 (0.04)	0.080*** (0.022)
Unique households	1,226	1,226	1,226
Total observations	2,452	2,452	2,452

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parentheses. All regressions include kebele fixed effects. Drought is measured based on a 5 km buffer zone around each household.

⁶ SPEI: Standardized Precipitation Evapotranspiration Index

Our second robustness check recognizes the fact that pastoral households in Ethiopia rely on communal grazing areas and seasonal mobility, making highly localized drought measures potentially inappropriate. We therefore recalculated drought exposure using a 30 km buffer around each household, instead of the 5 km buffer used in the main specification, and re-estimated the regression models.

Table 4 shows that the main findings remain robust to this alternative buffer zone definition. The coefficient for distance to the distribution centre remains negative and statistically significant across all three models and is similar to the main specification. Under the 30 km buffer, the estimated coefficients are -0.027 , -0.037 , and -0.011 for all, formal, and informal food aid, respectively, compared with -0.026 , -0.036 , and -0.010 in the main specification. The similar estimates indicate that the association between distance to aid distribution centres and receiving food aid is robust to the alternative buffer specification. Compared with the 5 km specification, the drought coefficients in the informal aid regression increased slightly (from 0.099 to 0.109), while the coefficients for informal food aid increased more noticeably (from 0.074 to 0.110). Both remain statistically significant at the 1% level. In contrast, the drought coefficient for formal food aid remains statistically insignificant under both specifications. The complete robustness results, including the full set of control variables, are reported in Tables A5–A7 in Appendix 1.

Table 4 Logit estimates of receiving food aid (30 km buffer)

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
	Receive food aid from all sources	Receive food aid from formal sources	Receive food aid from informal sources
Distance to distribution centre (km)	-0.027^{***} (0.002)	-0.037^{***} (0.004)	-0.011^{***} (0.002)
Number of months with moderate drought ($-1.5 < \text{SPEI-6} < -1$) ⁷	0.109^{***} (0.034)	-0.082 (0.057)	0.110^{***} (0.022)
Unique households	1,226	1,226	1,226
Total observations	2,452	2,452	2,452

⁷ SPEI: Standardized Precipitation Evapotranspiration Index

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parentheses. All regressions include kebele fixed effects. Distance is measured from the distribution centre in each household's kebele. We measure drought using a 30 km buffer zone around each household.

We also re-estimate the predicted odds of receiving food aid, this time using a 30 km buffer zone and separating formal and informal food aid sources. Numerically, we see similar results to the main specification using a 5 km buffer zone. We see slightly stronger effects for some drought measurements on receiving food aid. Together, these findings suggest that larger buffer zones may better capture the broader climatic shocks affecting pastoral livelihoods and the possible spatial range of a household's movements. Figure A2 in Appendix 1 presents more details.

4.5 Caveats

Our study has several limitations to consider when interpreting the findings. First, key household characteristics, including Tropical Livestock Units (TLU) and household size, are unavailable for the 2019 survey round. Because of this, we include their 2025 values as time-invariant household characteristics in both survey rounds. However, we acknowledge these variables are likely time-variant. The estimated effect of spatial location may thus partly capture unobserved differences in household asset endowments.

Second, our measures of location rely primarily on the distance to the aid distribution centre. While informative, this measure does not capture other relevant dimensions of accessibility to aid, such as proximity to community hubs, food markets, or traditional meeting points that can affect information diffusion and the functioning of informal support networks. Moreover, precise distribution-center locations were unavailable for 2019, so we assume centre remained in the same locations. Although plausible given logistical constraints, this assumption may overlook relocations or temporary changes in distribution sites that could affect access. Distribution centres are typically sited in central or more established areas, which tend to have better infrastructure and resources. This may systematically benefit already connected households, influencing both food aid access and observed spatial patterns.

Another limitation is how household location is measured. The analysis relies on the reported location of the household's core camp, which represents a semi-permanent residence rather than the full spatial footprint of pastoral production. In many pastoral systems, livestock are managed through satellite

camps and mobile grazing routes that may extend well beyond the core camp, particularly during drought periods. Because data on satellite camp locations, herd movements, and seasonal grazing routes are not available, the analysis cannot directly observe where livestock are located amid drought, nor whether herders' effective locations during these periods are closer to or farther from other households or food aid sources. Consequently, the distance measures used in the analysis should be interpreted as approximations of household spatial exposure rather than precise indicators of their realized grazing or interaction spaces. To partially account for this uncertainty, we estimated the models using a larger spatial buffer (30 km rather than 5 km) around each household to capture a broader range of potential mobility and interaction.

Finally, our data cannot fully capture household-level reciprocity dynamics. Receiving food aid may also reflect previous exchanges, obligations, and social ties. While the econometric specification can partially control for those dynamics, our analysis may capture only part of the complementarity between formal food aid and informal reciprocity.

5. Conclusion and implications for humanitarian actions

From a humanitarian perspective, our findings suggest several implications for more efficient actions. First, improving spatial accessibility should become an objective when designing humanitarian distribution. Additional temporary distribution points beyond the major centre, mobile distribution units, and decentralized delivery mechanisms could improve access for spatially remote households that currently face substantial barriers.

Second, humanitarian agencies should recognize that informal food aid and its distribution (sharing between households) provide an important complement to formal aid distribution, particularly during droughts. Rather than viewing informal support as a substitute for humanitarian aid, programmes could be designed to strengthen existing community-based support mechanisms while ensuring that the most remote households are not systematically excluded from formal aid.

More broadly, as droughts and other climate shocks become more frequent and humanitarian resources become increasingly constrained, integrating more spatial considerations into humanitarian

action will be essential for improving the inclusiveness and effectiveness of food aid in pastoral regions.

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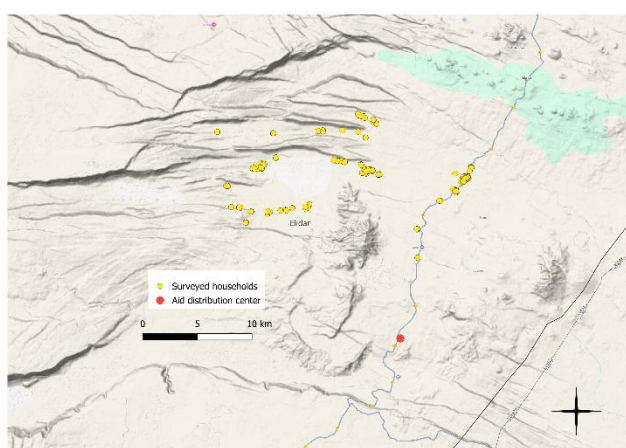
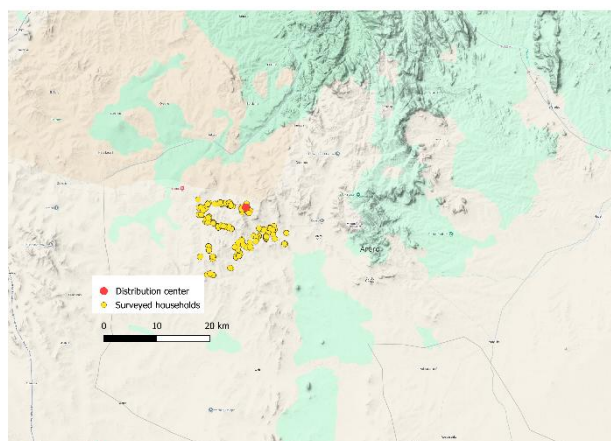
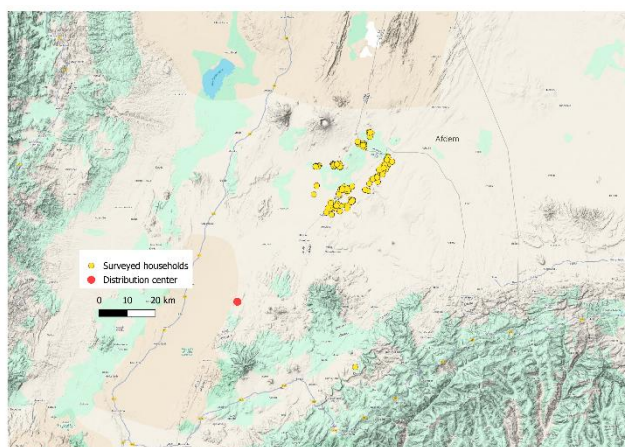
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Appendix 1

Figure A1 Aid distribution centre location in each surveyed kebele



Predicted probability of receiving food aid
Formal and informal assistance by drought exposure

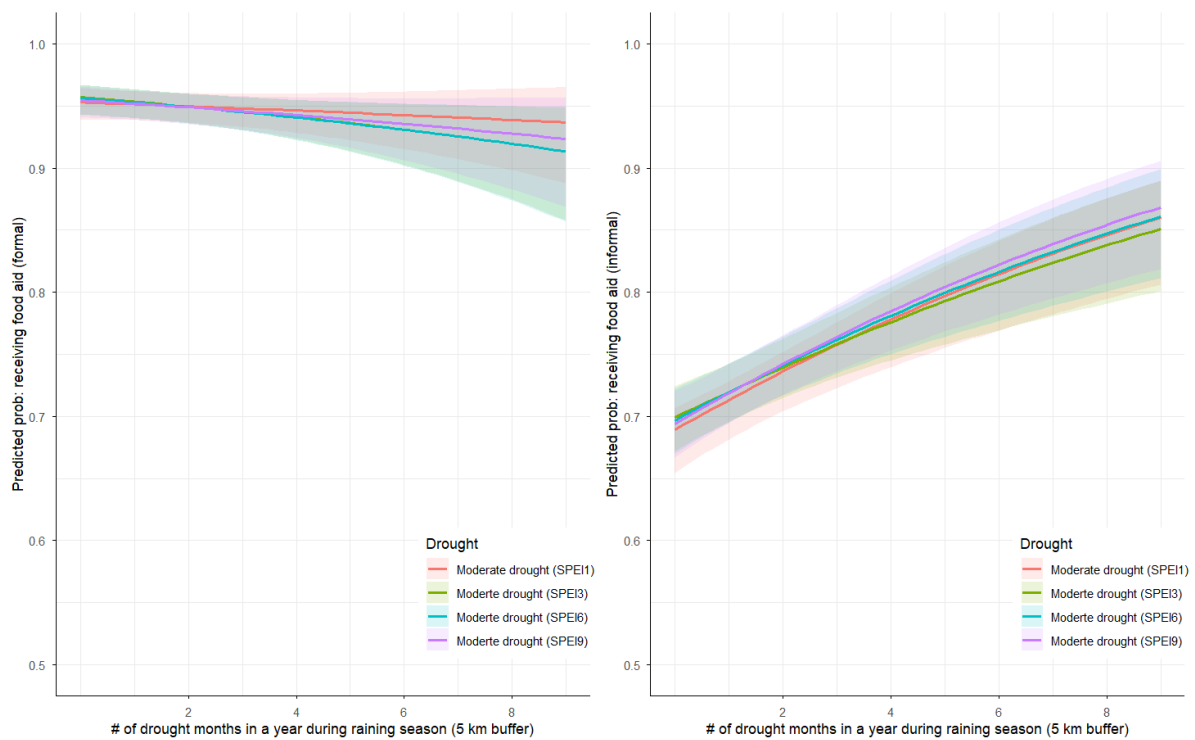


Table A1 Spatial distribution of proportion of households that received food aid

Kebele	Year	Number of households included in the analysis	Proportion household received food aid
Su'ula	2019	235	99.0%
	2025	235	88.2%
Fuldowa	2019	501	86.5%
	2025	501	96.6%
Asli	2019	490	65.8%
	2025	490	76.2%

Table A2 Regression results: all sources (Buffer zone = 5 km)

<i>Dependent Variable: receive food aid (both informal and formal) = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.029*** (0.002)	-0.026*** (0.002)	-0.026*** (0.002)	-0.026*** (0.002)	-0.026*** (0.002)
Age of the household head	0.021*** (0.004)	0.022*** (0.004)	0.021*** (0.004)	0.021*** (0.004)	0.021*** (0.004)
Male household head = 1	0.176 (0.144)	0.151 (0.144)	0.155 (0.144)	0.145 (0.144)	0.146 (0.145)
TLU	-0.011*** (0.003)	-0.009*** (0.003)	-0.009*** (0.003)	-0.010*** (0.003)	-0.009*** (0.003)
Number of females in the family	-0.013 (0.055)	-0.001 (0.055)	-0.003 (0.055)	-0.006 (0.055)	-0.007 (0.055)
Household size	0.056 (0.039)	0.077* (0.040)	0.072* (0.040)	0.071* (0.040)	0.073* (0.040)
Polygamous family = 1	0.291 (0.307)	0.244 (0.308)	0.125 (0.314)	0.036 (0.321)	-0.039 (0.328)
Number of months in the year during the rainy season with moderate drought (-1.5<SPEI1 ⁸ < -1)		0.113*** (0.031)			
Number of months in the year during the rainy season with moderate drought (-1.5<SPEI3 < -1)			0.096*** (0.031)		
Number of months in the year during the rainy season with moderate drought (-1.5<SPEI6 < -1)				0.099*** (0.033)	
Number of months in the year during the rainy season with moderate drought (-1.5<SPEI9 < -1)					0.110*** (0.035)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	1.332*** (0.457)	0.923** (0.468)	1.133** (0.463)	1.261*** (0.462)	1.307*** (0.462)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-913.473	-905.331	-907.604	-907.421	-906.288
AIC (Akaike Information Criterion)	1842.947	1828.662	1833.207	1832.842	1830.577

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

⁸ SPEI: Standardised precipitation evapotranspiration index

Table A3 Regression results: formal sources (Buffer zone = 5 km)

<i>Dependent Variable: receive food aid (formal) = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.035*** (0.003)	-0.035*** (0.004)	-0.036*** (0.004)	-0.036*** (0.004)	-0.036*** (0.004)
Age of the household head	0.003 (0.005)	0.003 (0.005)	0.002 (0.005)	0.003 (0.005)	0.003 (0.005)
Male household head = 1	0.044 (0.186)	0.042 (0.186)	0.051 (0.186)	0.052 (0.186)	0.051 (0.186)
TLU	-0.013*** (0.003)	-0.013*** (0.003)	-0.013*** (0.003)	-0.013*** (0.003)	-0.013*** (0.003)
Number of females in the family	0.078 (0.074)	0.079 (0.074)	0.076 (0.074)	0.077 (0.074)	0.079 (0.074)
Household size	0.078 (0.051)	0.080 (0.052)	0.074 (0.052)	0.073 (0.052)	0.075 (0.052)
Polygamous family = 1	-0.363 (0.316)	-0.367 (0.316)	-0.322 (0.321)	-0.284 (0.330)	-0.301 (0.336)
Number of months with moderate drought (SPEI ⁹ 1)		0.012 (0.036)			
Number of months with moderate drought (SPEI 3)			-0.024 (0.036)		
Number of months with moderate drought (SPEI-6)				-0.028 (0.037)	
Number of months with moderate drought (SPEI 9)					-0.019 (0.039)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	3.624*** (0.562)	3.570*** (0.586)	3.695*** (0.574)	3.647*** (0.564)	3.612*** (0.563)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-586.349	-586.296	-586.006	-585.708	-585.677
AIC (Akaike Information Criterion)	1188.698	1190.592	1190.011	1189.416	1189.355

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

⁹ SPEI: Standardised precipitation evapotranspiration index

Table A4 Regression results: informal sources (Buffer zone = 5 km)

<i>Dependent Variable: receive food aid (informal) = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.011*** (0.002)	-0.009*** (0.002)	-0.010*** (0.002)	-0.010*** (0.002)	-0.010*** (0.002)
Age of the household head	0.015*** (0.003)	0.016*** (0.003)	0.015*** (0.003)	0.016*** (0.003)	0.016*** (0.003)
Male household head = 1	0.217** (0.108)	0.201* (0.108)	0.198* (0.108)	0.185* (0.108)	0.190* (0.108)
TLU	-0.005** (0.002)	-0.004* (0.002)	-0.004* (0.002)	-0.004* (0.002)	-0.004* (0.002)
Number of females in the family	-0.013 (0.042)	-0.003 (0.042)	-0.006 (0.042)	-0.007 (0.042)	-0.007 (0.042)
Household size	0.012 (0.030)	0.035 (0.030)	0.031 (0.030)	0.029 (0.030)	0.029 (0.030)
Polygamous family = 1	0.723** (0.287)	0.718** (0.287)	0.616** (0.289)	0.553* (0.291)	0.527* (0.293)
Number of months with moderate drought (SPEI ¹⁰ 1)		0.079*** (0.018)			
Number of months with moderate drought (SPEI 3)			0.075*** (0.018)		
Number of months with moderate drought (SPEI-6)				0.074*** (0.020)	
Number of months with moderate drought (SPEI 9)					0.072*** (0.020)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	-0.231 (0.381)	-0.644 (0.392)	-0.454 (0.387)	-0.354 (0.385)	-0.330 (0.384)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-1,424.197	-1,413.377	-1,412.716	-1,410.468	-1,409.633
AIC (Akaike Information Criterion)	2,864.394	2,844.753	2,843.431	2,838.937	2,837.267

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

¹⁰ SPEI: Standardised precipitation evapotranspiration index

Table A5 Regression results: all sources (Buffer zone = 30 km)

<i>Dependent Variable: receive aid from all sources = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.029*** (0.002)	-0.026*** (0.002)	-0.027*** (0.002)	-0.027*** (0.002)	-0.027*** (0.002)
Age of the household head	0.021*** (0.004)	0.021*** (0.004)	0.021*** (0.004)	0.020*** (0.004)	0.020*** (0.004)
Male household head = 1	0.176 (0.144)	0.164 (0.147)	0.170 (0.147)	0.146 (0.147)	0.134 (0.148)
TLU	-0.011*** (0.003)	-0.010*** (0.003)	-0.010*** (0.003)	-0.010*** (0.003)	-0.009*** (0.003)
Number of females in the household	-0.013 (0.055)	-0.010 (0.056)	-0.012 (0.056)	-0.012 (0.056)	-0.011 (0.056)
Household size	0.056 (0.039)	0.081** (0.040)	0.075* (0.040)	0.078* (0.040)	0.081** (0.040)
Polygamous family = 1	0.291 (0.307)	0.260 (0.398)	0.194 (0.402)	0.066 (0.408)	-0.055 (0.413)
Number of months with moderate drought (SPEI ¹¹ 1)		0.115*** (0.035)			
Number of months with moderate drought (SPEI 3)			0.084*** (0.032)		
Number of months with moderate drought (SPEI-6)				0.109*** (0.034)	
Number of months with moderate drought (SPEI 9)					0.139*** (0.037)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	1.332** (0.457)	0.939* (0.532)	1.124** (0.528)	1.241** (0.529)	1.313** (0.531)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-913.473	-886.228	-888.440	-885.970	-882.819
AIC (Akaike Information Criterion)	1842.947	1790.457	1794.880	1789.941	1783.637

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

¹¹ SPEI: Standardised precipitation evapotranspiration index

Table A6 Regression results: formal sources (Buffer zone = 30 km)

<i>Dependent Variable: receive aid from formal sources = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.035*** (0.003)	-0.036*** (0.004)	-0.037*** (0.004)	-0.037*** (0.004)	-0.036*** (0.004)
Age of the household head	0.003 (0.005)	0.001 (0.006)	0.001 (0.006)	0.002 (0.006)	0.002 (0.006)
Male household head = 1	0.044 (0.186)	0.078 (0.191)	0.095 (0.191)	0.107 (0.191)	0.099 (0.191)
TLU	-0.013*** (0.003)	-0.013*** (0.003)	-0.014*** (0.003)	-0.014*** (0.003)	-0.014*** (0.003)
Number of females in the household	0.078 (0.074)	0.066 (0.076)	0.064 (0.076)	0.067 (0.076)	0.068 (0.076)
Household size	0.078 (0.051)	0.080 (0.053)	0.072 (0.053)	0.072 (0.053)	0.076 (0.053)
Polygamous family = 1	-0.363 (0.316)	-0.339 (0.404)	-0.235 (0.407)	-0.154 (0.413)	-0.187 (0.416)
Number of months with moderate drought (SPEI ¹² 1)		0.035 (0.040)			
Number of months with moderate drought (SPEI 3)			-0.083 (0.067)		
Number of months with moderate drought (SPEI-6)				-0.082 (0.057)	
Number of months with moderate drought (SPEI 9)					-0.062 (0.039)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	3.624*** (0.562)	3.769*** (0.645)	3.871*** (0.633)	3.713*** (0.622)	3.642*** (0.621)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-586.349	-565.183	-563.054	-562.936	-563.830
AIC (Akaike Information Criterion)	1,188.689	1148.365	1144.109	1143.871	1145.661

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

¹² SPEI: Standardised precipitation evapotranspiration index

Table A7 Regression results: informal sources (Buffer zone = 30 km)

<i>Dependent Variable: receive aid from another household = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	-0.011*** (0.002)	-0.010*** (0.002)	-0.011*** (0.002)	-0.011*** (0.002)	-0.011*** (0.002)
Age of the household head	0.015*** (0.003)	0.017*** (0.003)	0.016*** (0.003)	0.016*** (0.003)	0.016*** (0.003)
Male household head = 1	0.216** (0.108)	0.193* (0.110)	0.190* (0.110)	0.165 (0.110)	0.164 (0.110)
TLU	-0.005** (0.002)	-0.003 (0.002)	-0.004 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Number of females in the household	-0.013 (0.042)	0.002 (0.042)	-0.002 (0.042)	-0.002 (0.042)	-0.001 (0.042)
Household size	0.012 (0.030)	0.043 (0.030)	0.037 (0.030)	0.038 (0.030)	0.038 (0.030)
Polygamous family = 1	0.723* (0.287)	0.630* (0.361)	0.527 (0.363)	0.420 (0.366)	0.362 (0.367)
Number of months with moderate drought (SPEI ¹³ 1)		0.118*** (0.022)			
Number of months with moderate drought (SPEI 3)			0.100*** (0.021)		
Number of months with moderate drought (SPEI-6)				0.110*** (0.022)	
Number of months with moderate drought (SPEI 9)					0.118*** (0.023)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	-0.231 (0.381)	-0.717 (0.449)	-0.493 (0.446)	-0.369 (0.445)	-0.332 (0.445)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-1,424.197	-1378.324	-1379.157	-1374.366	-1371.691
AIC (Akaike Information Criterion)	2864.394	2774.648	2776.315	2766.732	2761.381

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

¹³ SPEI: Standardised precipitation evapotranspiration index

Table A8 Regression results: given food aid to another household (Buffer zone = 5 km)

<i>Dependent Variable: given food aid to another household = 1</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Distance to distribution centre (km)	0.008* (0.004)	0.005** (0.002)	0.006** (0.002)	0.006** (0.002)	0.006** (0.002)
Age of the household head	0.015*** (0.003)	0.016*** (0.003)	0.016*** (0.003)	0.016*** (0.003)	0.016*** (0.003)
Male household head = 1	-0.005 (0.100)	-0.030 (0.101)	-0.025 (0.101)	-0.040 (0.101)	-0.034 (0.101)
TLU	0.004** (0.002)	0.002 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)
Number of females in the family	-0.087** (0.040)	-0.075* (0.040)	-0.074* (0.040)	-0.075* (0.040)	-0.075* (0.040)
Household size	0.077*** (0.028)	0.115*** (0.029)	0.106*** (0.029)	0.103*** (0.029)	0.102*** (0.029)
Polygamous family = 1	0.176 (0.303)	0.245 (0.304)	0.099 (0.304)	0.010 (0.306)	-0.016 (0.307)
Number of months with moderate drought (SPEI ¹⁴ 1)		0.098*** (0.016)			
Number of months with moderate drought (SPEI 3)			0.089*** (0.016)		
Number of months with moderate drought (SPEI-6)				0.089*** (0.017)	
Number of months with moderate drought (SPEI 9)					0.087*** (0.018)
Kebele fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	0.344 (0.389)	-0.293 (0.403)	-0.049 (0.396)	0.094 (0.394)	0.127 (0.393)
Unique households	1,226	1,226	1,226	1,226	1,226
Observations	2,452	2,452	2,452	2,452	2,452
Log Likelihood	-1522.59	-1501.01	-1504.74	-1503.03	-1502.45
AIC (Akaike Information Criterion)	3061.171	3020.026	3027.486	3024.061	3022.898

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis. All regressions include kebele fixed effects. The distance to the distribution centre is with respect to the distribution centre in the kebele of each household.

¹⁴ SPEI: Standardised precipitation evapotranspiration index