Complex Decision-Making Rules for Famine Forecasting

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Introduction

The Integrated Phase Classification 2.0 system defines **famine** as extreme food emergency characterized by the following criteria: (1) at least 1/5 households facing extreme food shortage; (2) over 30% of children under 5 suffering from acute malnutrition or wasting (below –2 SD WFH); and (3) death rate of at least 2 in 10,000 persons.

The USAID Famine Early Warning System (FEWS-NET) periodically assesses famine risk across several countries. However, FEWS-NET predictions are not updated in real-time, and reports provide insufficient information on causality. While famine has a technical definition, the declaration of famine often manifests a political process that may lack transparency. Robust assessment of food security depends on quality and completeness of primary data, and the lack of timeliness leads to a significant lag time between observed worsening conditions and political and humanitarian actions. Price ratios are a simple way to reflect the affordability of food in an area, and the tradeoffs made by those most at risk of food insecurity. Ratios allow for the comparison of prices without adjusting for inflation or currency conversion across markets, thereby allowing for a robust snapshot of food security.

Objectives

- Develop grain-to-starch, animal-to-grain, and grain-to-wage ratios of key commodity prices to characterize food insecurity
- Characterize correlations between ratios
- Identify changepoints from time series

Methodology

Monthly commodity data by market was extracted from the WFP Global Food Prices and the FAO Global Information and Early Warning System datasets. Each commodity was classified into food categories per Table 1, and the cheapest commodity for each month and category was selected to develop a time series for each variable. Available variables were divided to develop grain-to-starch, animal foods-to-grain, and grain-to-wage ratios as harmonized indicators of food security. The Armed Conflict Location & Event Data Project (ACLED) dataset was used to geocode markets and develop kernel density maps of conflict fatalities. In markets located in high-fatality areas, changepoint methods were used to identify points of significant changes in mean and variance of available ratios. All analysis was conducted using ArcMap 10.6.1, R 3.5.1, and RStudio 1.1.463.

Table 1 | Available commodities and grouped food categories (variables) used to develop food price ratios

Variables	Components
Grains	Maize, Barley, Pasta, Rice, Teff, Sorghum, Wheat, Bread, Millet
Starch	Beans, Peas, Gari, Groundnuts, Yam, Lentils
Animal Source Foods	Milk, Meat, Livestock, Goat, Sheep
Wage	Wage

Milk to Grain Ratio in Somalia

The 2011 famine in Somalia was driven by a variety of environmental, political and socioeconomic factors, including drought, affected livelihoods, and poor governance. Al Shabaab's presence in southern Somalia and slow donor mobilization impacted humanitarian access and relief efforts.

July 2011: After 11 months of escalating warnings, UN declared famine in south central Somalia.

Jan 2012: IRC declares end of food crisis

2016-2018: Drought recovery required extensive food aid; country suspected to be at brink of famine
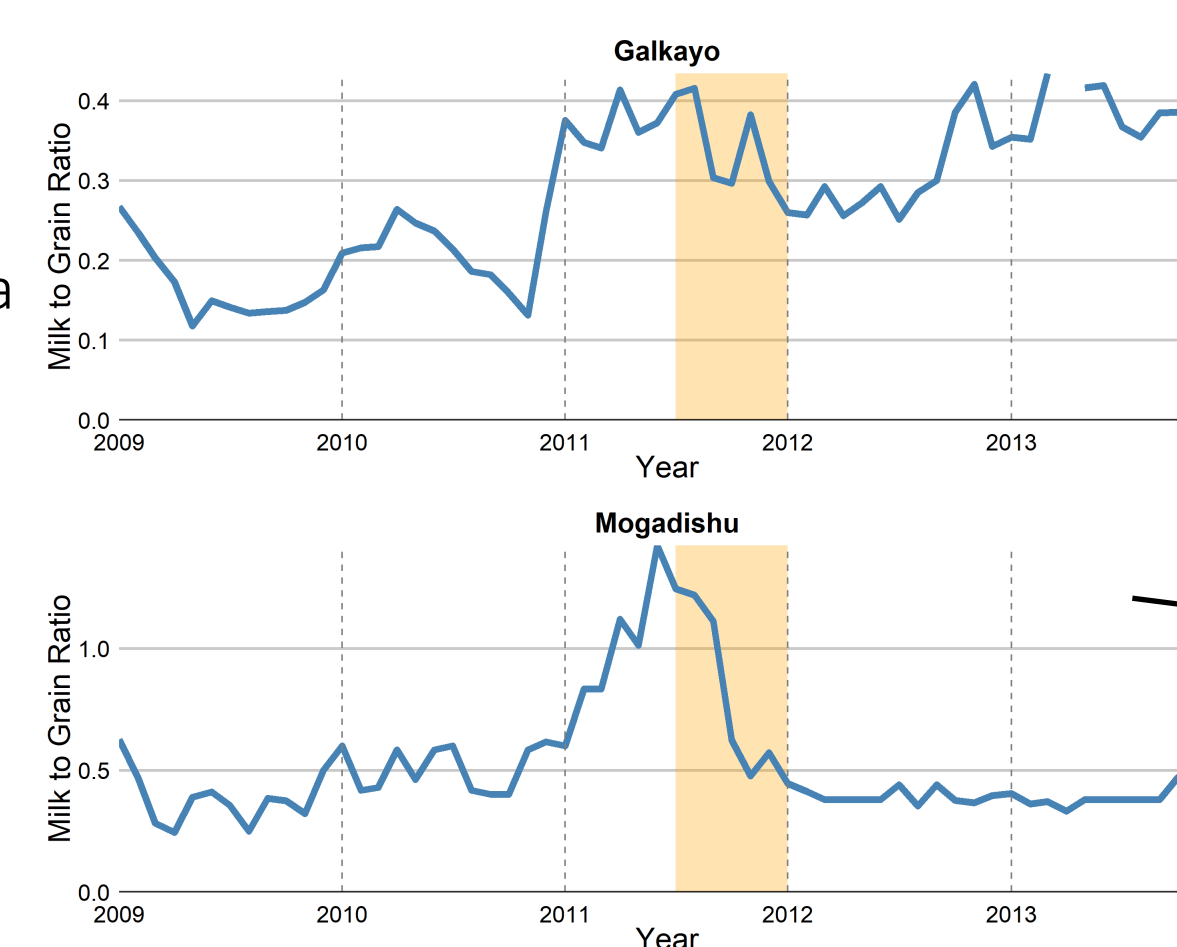

Fig. 1 | (top) Milk to Grain Ratio in Galkayo Market and **(bottom)** capital city of Mogadishu. Orange sections indicate the duration of formally declared famine.
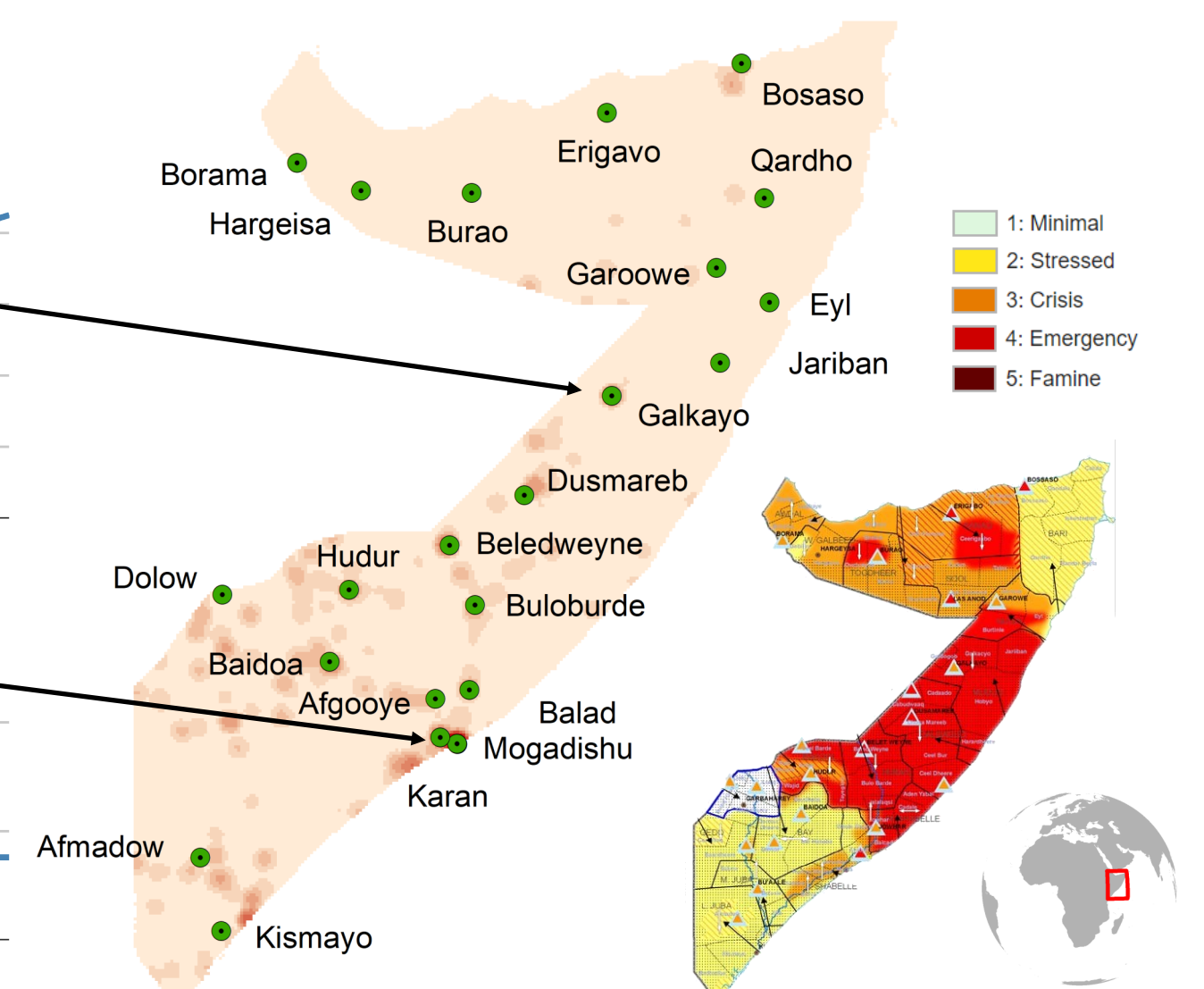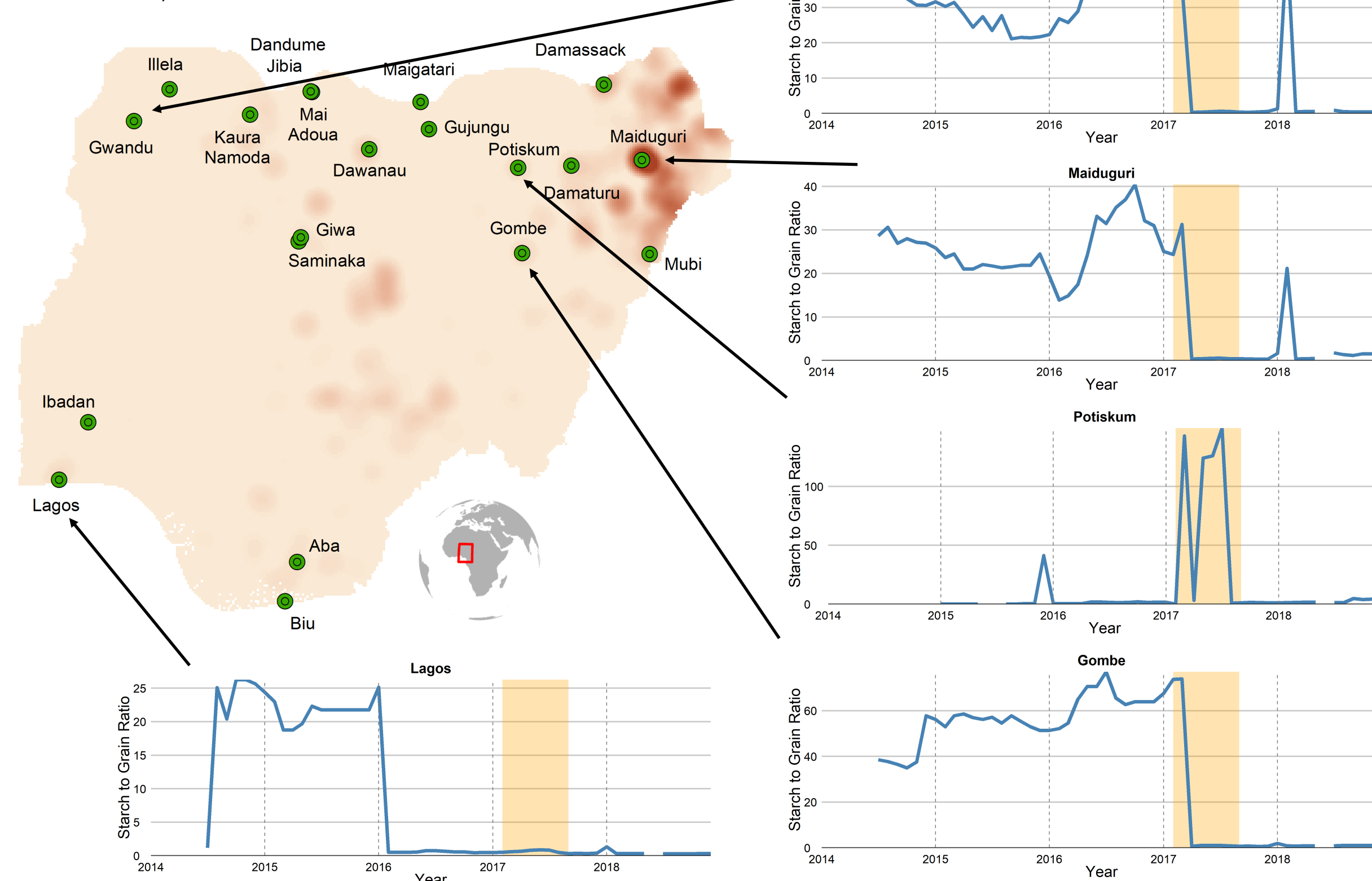

Fig. 2 | (left) Map of conflict fatality density (2009-2013) and WFP market locations; **(right)** IPC Phase classification during January—June 2010

Fig. 3 | Map of conflict fatality density (2014-2018) and WFP market locations in Nigeria. Surrounding graphs present the starch to grain ratio observed in key markets

Starch to Grain Ratio in Nigeria

Northeast Nigeria has experienced three protracted conflicts across its landscape. The Northeast has experienced almost a decade of accelerated conflict due to incursions against Boko Haram.

Feb 2017: UN Appeal for $4.4 billion by March 2017 to address famine in Nigeria, Somalia, South Sudan and Yemen.

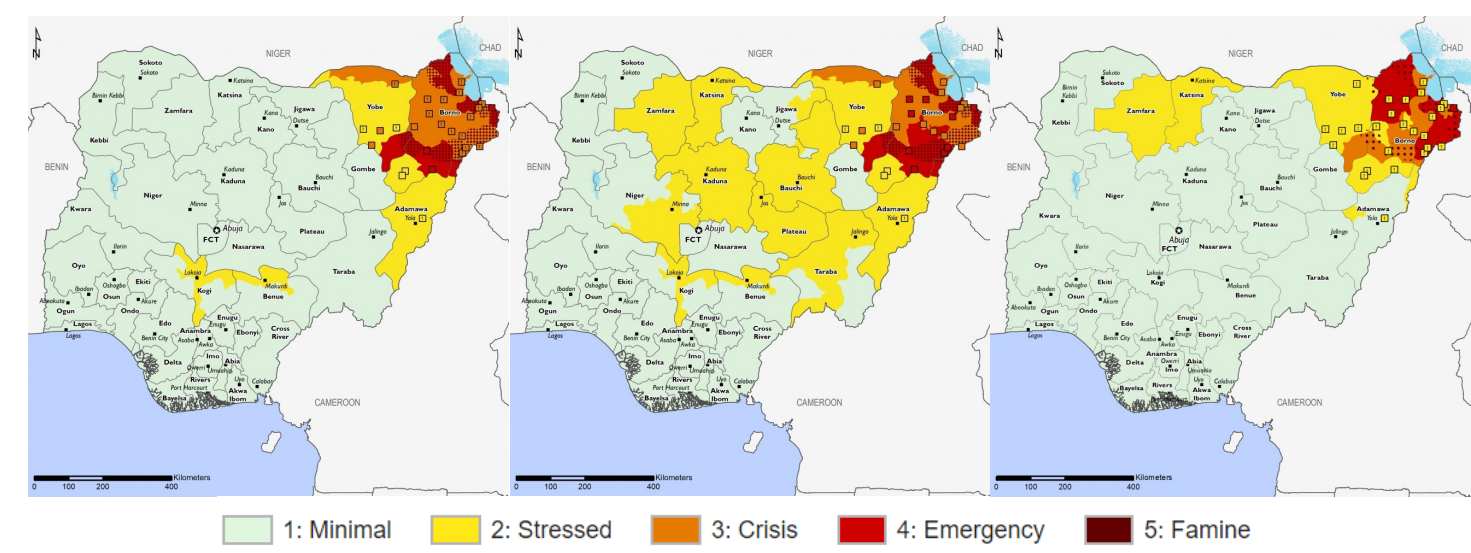*Sep 2017*: Famine declared averted, but situation remains precarious to present

Fig. 4 | FEWSNET Near-Term Forecast, from left: October 2017—January 2018, February 2018—May 2018, and December 2018—January 2019

Multiple Scaled Ratios in Yemen

Saudi intervention in Yemen has drastically reduced food production within the country. The blockade of Al Hudaydah port and ongoing bombing has led to severe disruption of local markets and lack of humanitarian access.

Dec 2017: UN declared 8 million people at risk of famine

Feb 2019: IPC estimates that in the presence of food aid, about 53% of the population is at risk of food insecurity. Formal famine not declared, but significant population remains under near-famine conditions

No clear changepoints observed yet due to lack of significant changes in mean or variance from any ratio.
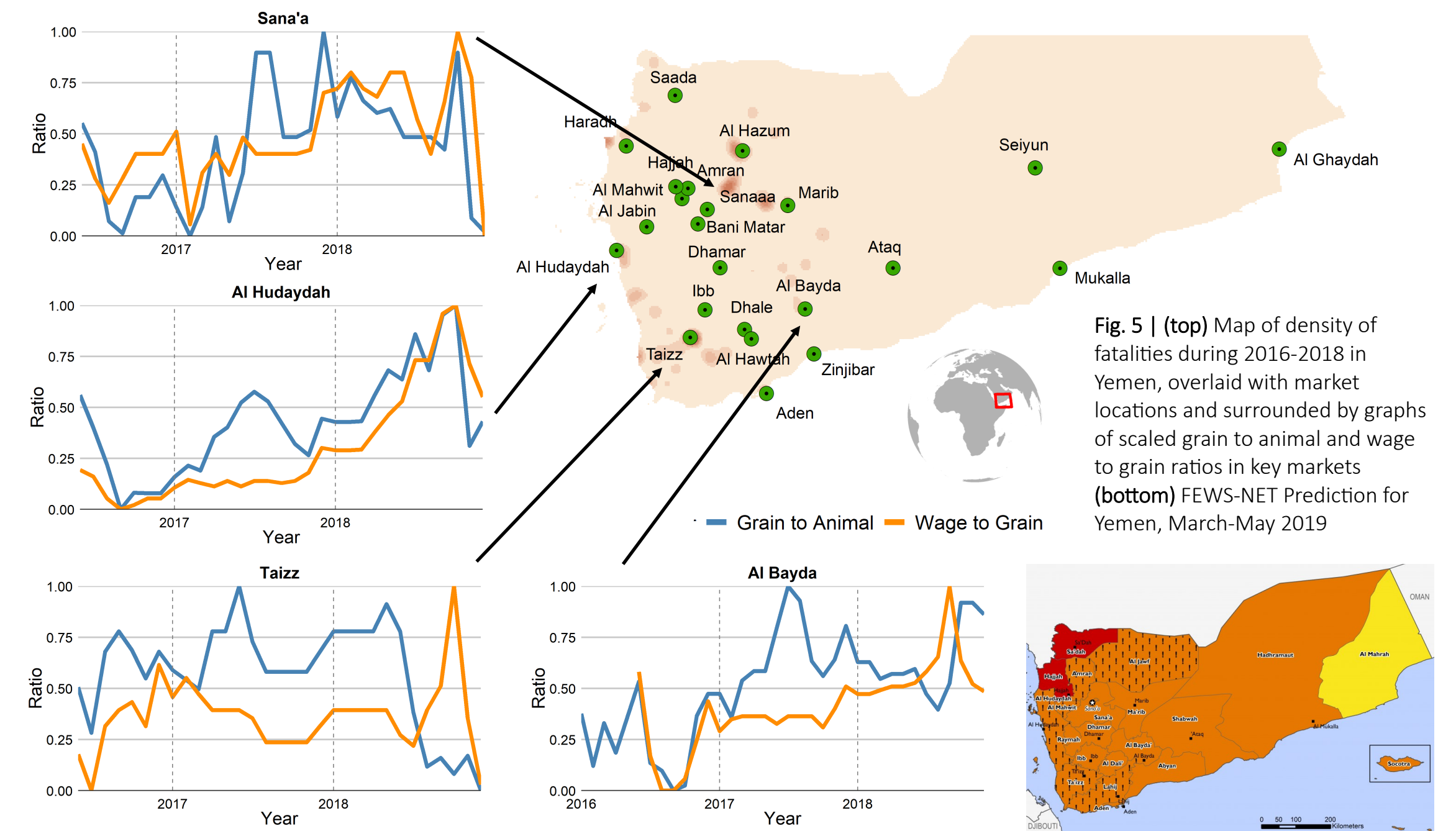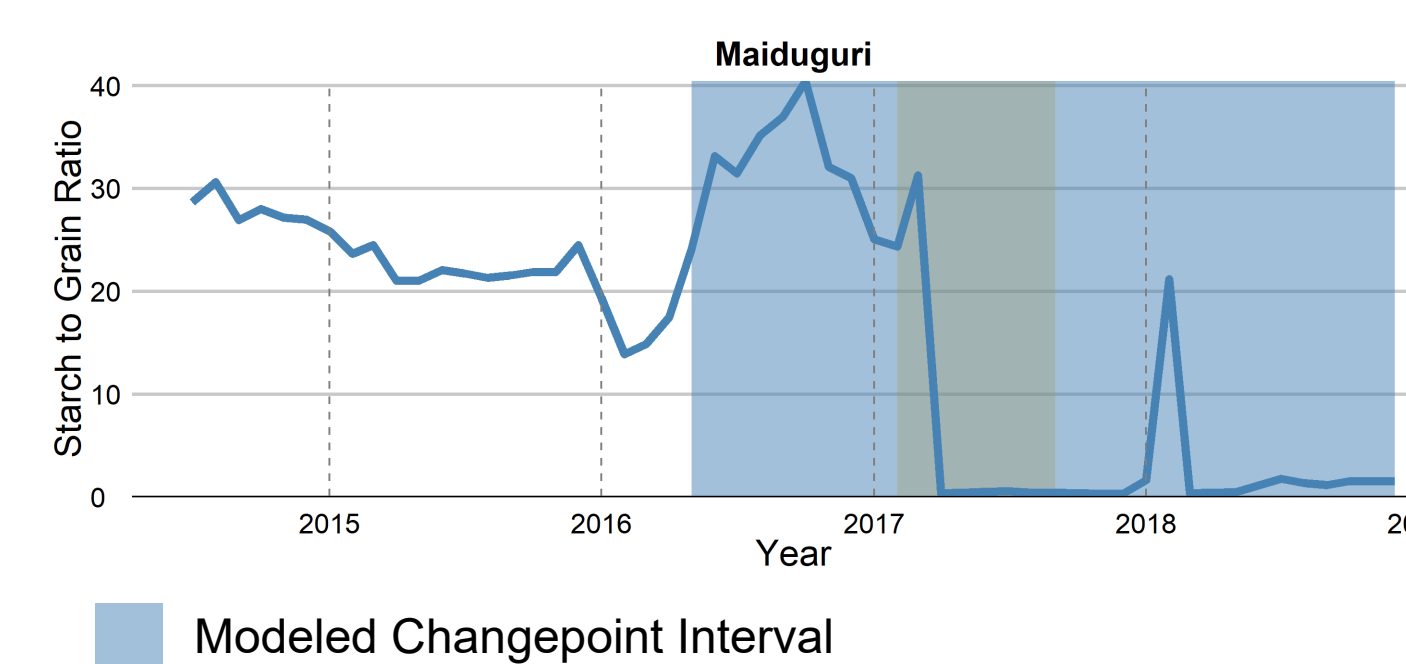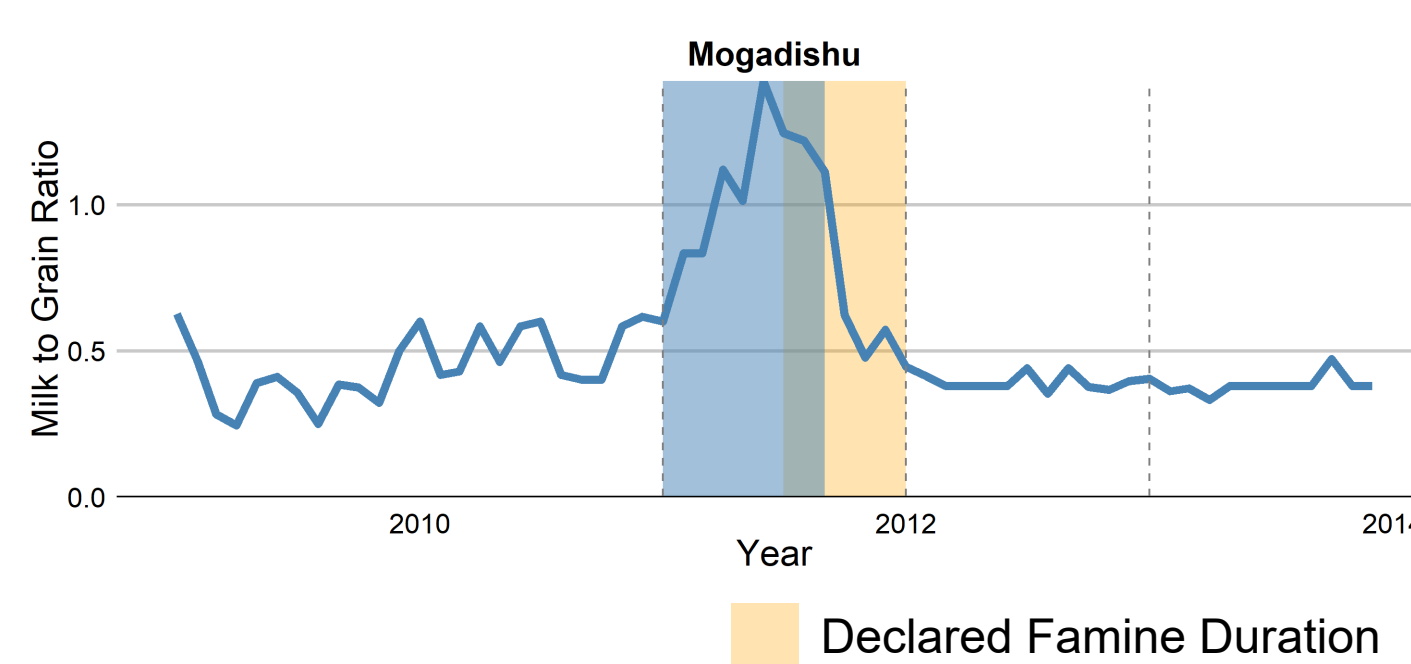

Fig. 5 | (top) Map of density of fatalities during 2016-2018 in Yemen, overlaid with market locations and surrounded by graphs of scaled grain to animal and wage to grain ratios in key markets **(bottom)** FEWS-NET Prediction for Yemen, March-May 2019

Changepoints

The Pruned Exact Linear Time (PELT) algorithm with AIC penalty can be used to identify significant changes in the variance of price ratios, marking potentially significant periods of food insecurity

Conclusions and Future Directions

This analysis proves the value of price ratios as leading indicators of food insecurity. Changepoint analysis of price ratios of various food categories can be applied to evaluate and predict food insecurity. Complex decision-making around food insecurity can thus be simplified by studying food price volatility over time, in conjunction with the spatial distribution of violent events. This analysis can elucidate shocks in terms of trade which affect food production and purchase decisions, as well as substitution, distress sales of livestock, migration, and ultimately health and nutrition outcomes.

Further work will explore various changepoint algorithms to evaluate predictive capability for famine. Data with higher temporal resolution, potentially at the weekly scale, can improve the predictive capacity of these price ratios, and help target markets and communities at highest risk of food insecurity for further data collection efforts. These ratios can also serve as high-frequency indicators for FEWS-NET and other humanitarian organizations aimed at alleviating hunger and improving health.

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