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Data Article

Visualizing trends in food security across Africa, 2009–2020: Data and animations at a grid-cell level

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ABSTRACT

The Famine Early Warning Systems Network (FEWS NET) has been appraising food security in numerous countries around the world since 1985. Multiple times per year, FEWS NET reports scores for current situation assessments and future projections of food security. The scores are measured on a five-level index scale and gauged for the geographic units of livelihood zones. These zones vary in size and do not remain static, which complicates comparison of food security within and across countries and over time. To facilitate such analysis and interoperability with other sources, we transformed available raw data to the units of geospatial grid-cells that have a uniform, static resolution of 0.5° × 0.5°, a common format of data used in research across diverse disciplines. FEWS NET provides public online access to shapefiles reflecting reports back to 2009. Separate shapefiles capture assessments and projections, with further delineation by the index score. Each shapefile can comprise a complex (multi)polygon, without clear differentiation among livelihood zones. Overlaying a geospatial grid allows disaggregation of the (multi)polygons to standard units. We performed the transformation to grid-cells on the shapefiles for

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all 25 countries (including Yemen) that FEWS NET tracked within regional groupings of East, Southern, and West Africa from July 2009–October 2020. For each report cycle, each grid-cell was assigned scores of the assessment and near-term and medium-term projections, based on the raw data for the corresponding livelihood zone. In addition, we calculated a value of bias in medium-term projections relative to subsequent assessments, which can be used as a metric for validation of accuracy. This article provides access to the grid-cell data on assessment and projection scores and bias values. In addition, we present time-lapse animated maps as tools to visualize historical patterns and trends in these indicators across Africa. Our related research article employed the grid-cell data to evaluate the accuracy of FEWS NET projections, including as a function of variation in humanitarian assistance, climate conditions, and violent conflict (Backer and Billing [1]). Researchers can likewise use the grid-cell data to conduct further validation of food security projections and to examine the relationship of assessments and projections to potential drivers and consequences. The data and animations are also valuable to stakeholders throughout the international community seeking to learn and disseminate knowledge about the tendencies of food security projections on a broad scale.

Specifications Table

Subject	Public Health and Health Policy; Earth and Environmental Sciences; Social Sciences
Specific subject area	Food security
Type of data	Table Figures Maps (with time-lapse animation)
How data were acquired	The primary source is raw shapefiles of FEWS NET's Food Security Classification Data (https://fews.net/fews-data/333), which were downloaded via the FEWS NET Data Center (https://fews.net/data).
Data format	Processed Analyzed
Parameters for data collection	The scope comprises all 25 countries (including Yemen) that FEWS NET tracked for regions of Africa in multiple Outlook Reports released on a regular schedule from July 2009–October 2020.
Description of data collection	FEWS NET regularly reports current situation assessments and future projections of food security scored on an index scale. Scores are gauged for livelihood zones, which vary in size. We transform the data to geospatial grid-cells with a uniform, static resolution. In addition, we calculate a validation metric of bias reflecting the difference between a given assessment and the corresponding medium-term projection in the previous report cycle. Assessments, projections, and bias are displayed on maps with time-lapse animation as a means to visualize changes over time across Africa.
Data source location	The data cover countries in three regions of Africa as defined by FEWS NET: East Africa – Djibouti, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania, Uganda, Yemen Southern Africa – Democratic Republic of Congo, Madagascar, Malawi, Mozambique, Zambia, Zimbabwe West Africa – Burkina Faso, Chad, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Sierra Leone

(*continued on next page*)

Data accessibility	Repository name: Visualizing Trends in Food Security across Africa, 2009–2020: Data and Animations at a Grid-Cell Level [on Harvard Dataverse] Data identification number: https://doi.org/10.7910/DVN/LMSYG5 Direct URL to data: https://doi.org/10.7910/DVN/LMSYG5
Related research article	D. Backer, T. Billing, Validating Famine Early Warning Systems Network projections of food security in Africa, 2009–2020, Global Food Security. DOI: 10.1016/j.gfs.2021.100510.

Value of the Data

- Transforming FEWS NET assessments and projections of food security to a consistent, granular grid-cell format ensures comparability of geospatial units that facilitates cross-sectional analysis of patterns across geographic areas and trend analysis over time, as well as the calculation of a bias metric used in the validation of the accuracy of projections.
- These data are of value to stakeholders in the international community involved in monitoring food security conditions, implementing early warning systems to forestall crises that could result in famine, and making decisions related to development policies and allocations and implementation of humanitarian assistance in dozens of countries around the world. In addition, researchers seeking to study patterns and trends of food security, the validity of early warning systems, and their relationships to salient drivers and consequences can capitalize on the data.
- The transformed and calculated data offer a resource for further analysis (including validations of accuracy), the identification of patterns and trends with relevance to evaluating and strategizing about development and humanitarian practice, and the investigation, diagnosis, and remediation of shortcomings in early warning systems.
- The animations synthesize data into visualizations that assist with undertaking situational reviews on a large scale (spanning 25 countries over a period of 12 years), learning about food security, and delivering illuminating presentations on the topic to diverse audiences.
- The grid-cell format of the transformed and calculated data allows for interoperability with geospatially resolved data on other indicators obtained from different sources, to conduct analysis of relationships to food security. We have already demonstrated this potential in using the transformed and calculated data to evaluate the validity of FEWS NET projections as a function of variation in humanitarian assistance, climate conditions, and violent armed conflict (Backer and Billing [1]).
- Our choice of the particular geospatial resolution for the grid-cell format maximizes the ease of interoperability of the transformed and calculated data with a number of important existing sources of data used widely in interdisciplinary research that have the same resolution. A notable example is the Demographic and Health Survey (DHS) Program Spatial Data Repository (https://spatialdata.dhsprogram.com/covariates/), which links the global positioning system (GPS) locations of DHS survey clusters to external datasets of geospatial covariates, including population, climate, and environmental variables (Mayala et al. [7]). Another example is PRIO-GRID (https://grid.prio.org/#/), which provides measurements of indicators of accessibility, socioeconomic characteristics, natural resources, land use, and climate (Tollefsen, Strand and Buhaug [8]).

1. Data Description

1.1. Context

FEWS NET releases regular Outlook Reports about food security across much of Africa and select countries in Central America, the Caribbean, and Central Asia. These reports and the

Table 1
FEWS NET index of food insecurity. The index scale has been compatible with the Integrated Food Security Phase Classification (IPC) scale since April 2011. Previously, FEWS NET adopted a distinctive approach and labelled the levels slightly different from the IPC, but they were largely analogous. This table is reproduced from the related research article (Backer and Billing [1]).

Level	FEWS NET Label (July 2009–January 2011)	IPC Label (April 2011–present)
5	Famine	Catastrophe/Famine
4	Extremely food insecure	Emergency
3	Highly food insecure	Crisis
2	Moderately food insecure	Stressed
1	No acute food insecurity (2009: generally food secure)	Minimal/none

assessments and projections they contain are widely used by stakeholders throughout the international community to anticipate emergent food insecurity crises and to guide interventions.

From 2009 through 2015, FEWS NET released Outlook Reports in January, April, July, and October of each year. Since 2016, reports have usually been released in February, June and October. The exception is December 2018, when reports were released only for a sub-set of regions and countries. A centerpiece of the reports is three indices of food security:

- *CS score* is a current situation assessment as of the month when a report was released.
- *ML1 score* is a near-term projection for the one month (in December 2018 reports), two months (in reports from July 2009 through October 2015) or three months (in the normal cycle of reports since February 2016) immediately after the month when a report was released.
- *ML2 score* is a medium-term projection for a period 3–5 months (in reports from July 2009 through October 2015), 3–6 months (in December 2018 reports), or 4–7 months (in the normal cycle of reports since February 2016) subsequent to the month when a report was released.

In each report cycle, FEWS NET produces scores for these indices following a structured process during which analysts review and interpret extensive empirical data, including forecasts of conditions. These data capture inputs (e.g., food production and prices), factors (e.g., climate and conflict), and outcomes (e.g., acute malnutrition) relevant to food security (FEWS NET [4]).

Throughout the 2009 – 2020 timeframe, FEWS NET assigned scores on a 5-level scale, numbered in ascending order of food insecurity (see Table 1). Since 2011, the scale used by FEWS NET has been compatible with the Integrated Food Security Phase Classification (IPC). The IPC, which was originally developed in 2004 to be used in Somalia by the United Nations Food and Agriculture Organization's Food Security and Nutrition Analysis Unit, has evolved into a global partnership of 15 organizations that aims to improve food security and nutrition analysis and decision-making (IPC Global Partners [6]).

FEWS NET gauges food security for the units of livelihood zones. Each zone is a distinct geographic area within which the residents are judged to share similar patterns of access to food and income (e.g., growing the same crops or keeping the same types of livestock) and similar access to markets. An underlying assumption is that variation in predominant livelihoods across zones has implications for expectations about the dynamics of food security.

Geospatial differences among zones complicate comparisons of food security within and across countries and over time. Zones inherently vary in terms of their geographic sizes, shapes, and dimensions. The existence and specific boundaries of zones can also evolve with changing circumstances over time, which affect the defining characteristics of zones.

Features of the FEWS NET data further complicate comparisons. The CS assessments and ML1 and ML2 projections for a given report are each stored in separate shapefiles archived in FEWS NET's online Data Center. A shapefile includes a maximum of five (multi)polygons, differentiated by scores. For example, a single (multi)polygon denotes livelihood zones categorized at level 1. (Multi)polygons can span country and subnational administrative boundaries, in addition to livelihood zones. Multipolygons – consisting of multiple, non-contiguous polygons – are common. With both polygons and multipolygons, the specific geographic units for which FEWS NET generated assessments and projections are not necessarily known from the shapefiles. A (multi)polygon may encompass one or more such assessments, and/or one or more projections. While the most basic unit for generating assessments and projections is geographically disaggregated livelihood zones, the (multi)polygons in FEWS NET's shapefiles of assessments and projections imperfectly map onto the (multi)polygons in FEWS NET's livelihood zone shapefile (see http://fews.net/fews-data/335). Also, not all (multi)polygons remain static from report to report. Consequently, a unit from one report may lack a unit in the next report whose boundaries correspond exactly.

For all these reasons, we were motivated to transform the available raw shapefile data to the units of geospatial grid-cells. Overlaying a geospatial grid allows us to disaggregate the (multi)polygons to standard units with uniform dimensions that remain static. The data transformed to a grid-cell format thereby facilitate comparisons of units for purposes of cross-sectional and trend analyses. Furthermore, the grid-cell format facilitates interoperability with other existing sources of geospatial data, especially those that have the same resolution. Our outputs are secondary data products, which rely on processing and analyzing the original primary data obtained from FEWS NET.

We opted to restrict the scope of the data processing to the 25 countries that FEWS NET has tracked in Africa since 2009. The set of countries comprises the majority of FEWS NET's coverage worldwide. In addition, we used the grid-cell data for purposes of evaluating the accuracy of FEWS NET projections (Backer and Billing [1]). Our validation analysis was intended to establish a benchmark of performance for a research project with the central goal of advancing capabilities to predict acute malnutrition outcomes in African countries as a function of leading indicators, including climate and conflict conditions. The time period of the data that we processed reflects the extent of the data that FEWS NET had released as of when this article was written. The geographic and temporal scope of the transformed data could be extended using our approach and materials as a template.

1.2. Data files

The file df_grid_clean.Rdata (https://dataverse.harvard.edu/api/access/datafile/4417514) comprises the processed data of CS assessments and ML1 and ML2 projections of food security transformed to the grid-cell format, as well as the calculated values of bias. The scope of these data covers the 25 countries (including Yemen) that FEWS NET has included in the regions of East, Southern, and West Africa and produced multiple Outlook Reports about from July 2009 – October 2020. Not all of the countries are tracked in every report cycle during this timeframe.

Fig. 1 maps the CS assessments by grid-cell. The image represents an initial snapshot of the CS assessments in July 2009 and links to a time-lapse animation of the assessments by report cycle through October 2020 (https://dataverse.harvard.edu/api/access/datafile/4498208).

Fig. 2 maps the ML1 projections by grid-cell. The image represents an initial snapshot of the ML1 projections in July 2009 and links to a time-lapse animation of the ML1 projections by report cycle through October 2020 (https://dataverse.harvard.edu/api/access/datafile/4498209).

Fig. 3 maps ML2 projections by grid-cell. The image represents an initial snapshot of the ML2 projections in July 2009 and links to a time-lapse animation of the ML2 projections by report cycle through October 2020 (https://dataverse.harvard.edu/api/access/datafile/4498206).

Fig. 4 maps the bias in ML2 projections by grid-cell, accompanied by a table that shows the share of cases by the gradation of bias (row) relative to the level of the ML2 projection (column). The image represents an initial snapshot of the bias values in July 2009 and links to a time-lapse animation of the bias values by report cycle through June 2020 (https://dataverse.harvard.edu/api/access/datafile/4498207).

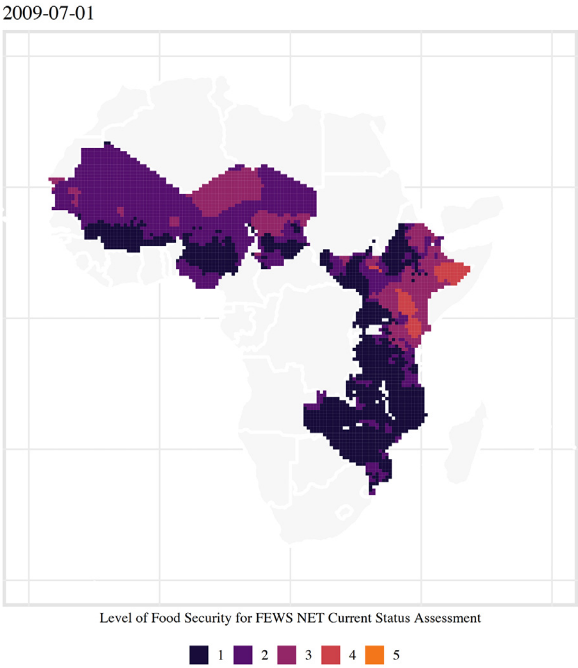

Fig. 1. Time-lapse animation of FEWS NET current situation assessments transformed to a grid-cell format. The animation maps the evolution of assessments across Outlook Reports for 25 countries in Africa from July 2009 to October 2020. To access the animation, click on the hyperlinked image, which will launch a separate file archived in a Harvard Dataverse repository.

On the Harvard Dataverse, we archived the files of the processed data; the time-lapse animations of assessments, ML1 and ML2 projections, and bias; and all the constituent snapshot images mapping assessments, projections, and bias by report cycle (Billing and Backer [2]). An advantage of offering this level of detail in the files is to provide a resource for anyone who wishes to focus on circumstances in specific report cycles. Some users may wish to employ single snapshots in written materials and visual presentations.

2. Experimental Design, Materials and Methods

Our starting place was to obtain the raw shapefile data of assessments and projections via the Download All Data link (http://shapefiles.fews.net.s3.amazonaws.com/ALL_HFIC.zip) in the Food Security Classification Data section (https://fews.net/fews-data/333) of the FEWS NET Data Center (https://fews.net/data) (FEWS NET [5]). We subsetted the available data to restrict the scope to countries in Africa for which FEWS NET released multiple Outlook Reports between July 2009 (the earliest cycle of reports that are archived online) and October 2020.

We developed several R programs (funs.R [https://dataverse.harvard.edu/api/access/datafile/4417525];

01_to_grid.R [https://dataverse.harvard.edu/api/access/datafile/4417526]; and

02_map_snippets.R [https://dataverse.harvard.edu/api/access/datafile/4417530]) to process the raw data and to create the visualizations that are referenced in the Data Description section. The programs perform the following tasks in sequence: (1) transformation of the FEWS NET shapefiles to the grid-cell format, (2) calculation of bias in projections, (3) production of

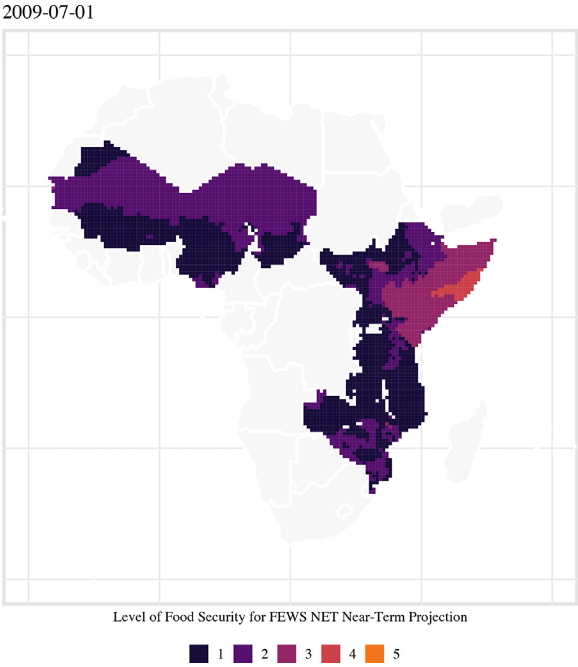

Fig. 2. Time-lapse animation of FEWS NET near-term projections transformed to a grid-cell format. The animation maps the evolution of projections across Outlook Reports for 25 countries in Africa from July 2009 to October 2020. To access the animation, click on the hyperlinked image, which will launch a separate file archived in a Harvard Dataverse repository. For details on the time period reflected in each projection, see Figure 5 below.

maps of assessments, projections, and bias, and (4) consolidation of time series of maps into animations. All these program files have also been archived on the Harvard Dataverse (Billing and Backer [2]).

2.1. Grid-cell transformation

We transformed the raw shapefile data to the level of a geospatial vector grid network with a uniform, static resolution of 0.5° × 0.5°, using the World Geodic System (WGS84) as the geographic coordinate system. A feature of these coordinate dimensions of decimal degrees is that grid-cells can vary in geographic size depending on the longitudinal location on the globe. At the Equator, each grid-cell is roughly 55 km^2. The size of grid-cells reduces when moving north or south away from the Equator. The extent of reduction is small among the countries reflected in the data we process, given these countries are concentrated between 30°N and 30°S. A primary rationale for our choice of the grid-cell format with the particular geospatial resolution is the correspondence to the geospatial attributes of other important sources of data that are used widely in interdisciplinary research. Analogous transformations to alternative projections may be completed in any Geographic Information System (GIS) software.

For each report cycle, each grid-cell was assigned scores of the CS assessment and the ML1 and ML2 projections, according to the raw shapefile data. A grid-cell entirely contained within the boundaries of a (multi)polygon in the raw data was assigned the scores for this corresponding (multi)polygon. Interpolation was performed only with any grid-cell that straddles the boundaries of more than one (multi)polygon in the raw data. For each such case, we assigned

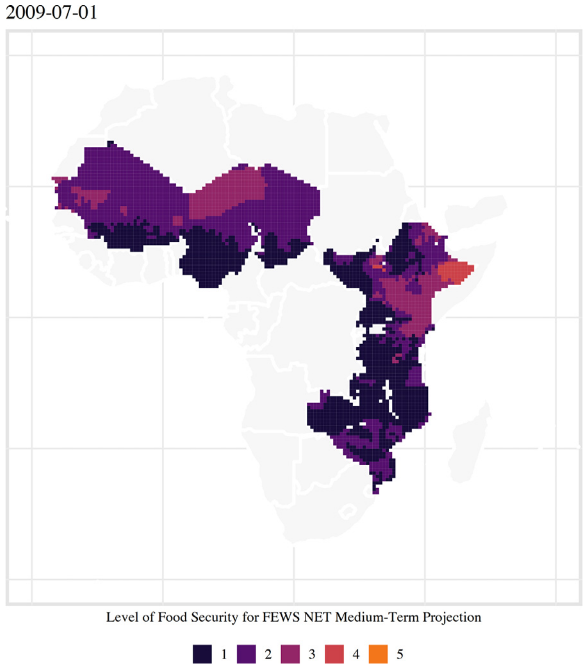

Fig. 3. Time-lapse animation of FEWS NET medium-term projections transformed to a grid-cell format. The animation maps the evolution of projections across Outlook Reports for 25 countries in Africa from July 2009 to October 2020. To access the animation, click on the hyperlinked image, which will launch a separate file archived in a Harvard Dataverse repository. For details on the time period reflected in each projection, see Figure 5 below.

the assessment and projection scores for the (multi)polygon that constitutes the majority of the area of the grid-cell. These assignment rules are most logical and straightforward to implement. All scores within the transformed and calculated data remain on the five-level index scale employed by FEWS NET, which strictly reflects integer values.

2.2. Calculation of bias

Following Choularton and Krishnamurthy [3], we calculated bias as a metric for validating the accuracy of FEWS NET projections. Specifically, bias is defined as the difference between the CS assessment for a grid-cell in a FEWS NET report cycle and the corresponding ML2 projection for the same grid-cell in the previous report cycle (CS_t – $ML2_{t-1}$). Since the grid-cells are uniform and static, they can always be matched one-for-one across consecutive report cycles. As Fig. 5 shows, the multi-month time period reflected in a given ML2 projection always overlaps with the month that the next CS assessment is designed to capture. In turn, Fig. 6 presents a basic illustration of the calculation of bias under several scenarios of projections and assessments. This calculation establishes whether or not a prediction (ML2 projection) deviates from an observed outcome (next CS assessment) – and, if so, to what degree. For orientation, a bias value of 0 implies that the FEWS NET prediction was generally accurate (leaving aside intervening influences that may account for the match between a projection and the subsequent assessment), as seen with the scenario displayed in the middle of Fig. 6. Positive values of bias imply underprojection – the observed level of food security was worse than FEWS NET analysts expected, as seen with the scenario displayed on the left in Fig. 6. Negative values of bias imply over-

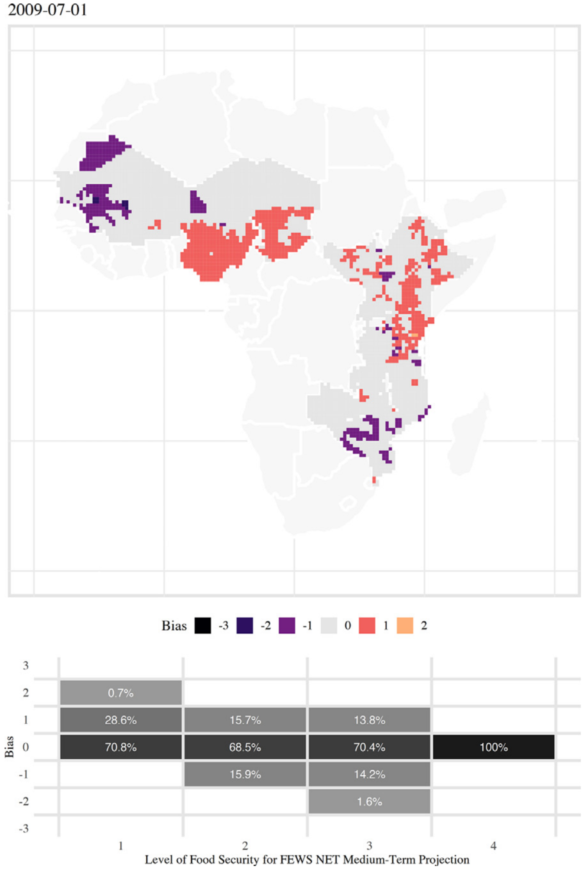

Fig. 4. Time-lapse animation of bias in FEWS NET medium-term projections at a grid-cell level. The animation maps the evolution of bias calculated for projections from July 2009 to June 2020 relative to subsequent current situation assessments. The values in the table are shares of grid-cells that fall within each gradation of bias (rows) by the level of projection (column). To access the animation, click on the hyperlinked image, which will launch a separate file archived in a Harvard Dataverse repository. This visualization is reproduced from the related research article (Backer and Billing [1]).

projection – the observed level of food security was better than FEWS NET analysts expected, as seen with the scenario displayed on the right in Fig. 6. As mentioned above, we have undertaken related research that engages in validation of the projections, evaluating accuracy and bias and their relationship to potential factors, including humanitarian assistance, climate conditions, and violent conflict (Backer and Billing [1]).

2.3. Production of maps

Next, we produced separate sets of maps displaying CS assessments, ML1 projections, ML2 projections, and bias. Each set consists of a lengthy time series of maps – one per FEWS NET report cycle, representing snapshots at regular points in time. The maps display the data for the 25 countries tracked by FEWS NET, set against the backdrop of the entire African continent, to maximize the comparative perspective on the data. Analogous maps that train attention on a single region or select countries could also be produced using the grid-cell data.

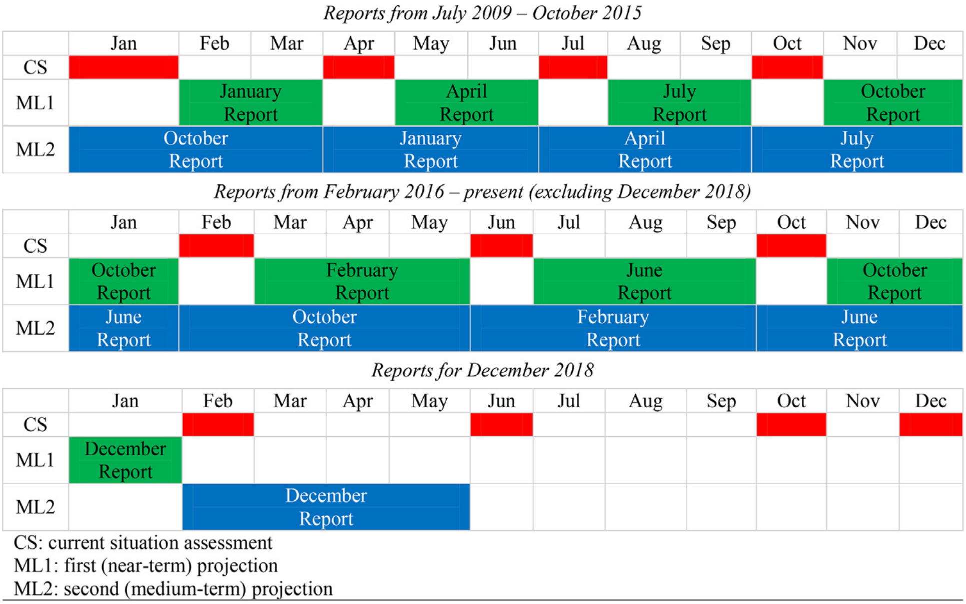

Fig. 5. Timing of FEWS NET assessments and projections. This graphic displays the standard structure of reporting cycles, which also defines the temporality and periodicity of the raw data. A feature is that the period covered by the medium-term projections (in blue) from a given report always overlaps with the month when the next report is released with latest current situation assessments (in red). The overlap provides a basis for calculating validation metrics. In contrast, the period covered by the near-term projections (in green) from a given report does not overlap with the month when the next report is released. (For interpretation of the references to color in the figure caption, the reader is referred to the open-access online version of the article.) This figure is reproduced from the related research article (Backer and Billing [1]).

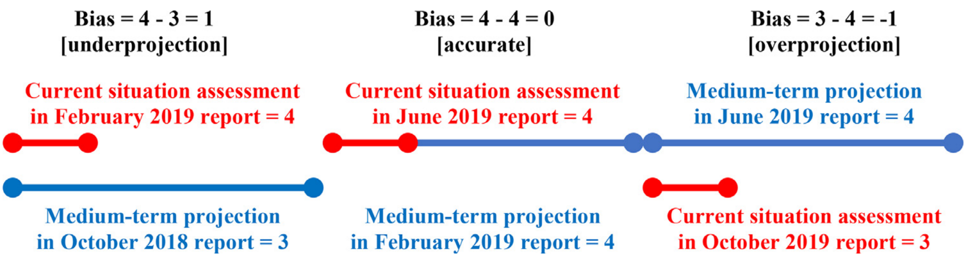

Fig. 6. Example of the calculation of bias in FEWS NET medium-term projections. This illustration shows how the validation metric of bias is calculated as a function of the difference between a current situation assessment (in red) from a given report and a corresponding medium-term projection (in blue) from the previous report. The calculation reflects the fact that the multi-month time period reflected in the medium-term projection always overlaps with the month of the subsequent current situation assessment. (For interpretation of the references to color in the figure caption, the reader is referred to the open-access online version of the article.)

2.4. Consolidating maps into animations

Finally, we combined each series of maps into a time-lapse animation to show dynamically how the CS assessments, ML1 projections, ML2 projections, and bias evolve. To augment the maps of bias with another informative graphical element, we cross-tabulate the distribution of grid-cells by the gradation of bias relative to the level of the ML2 projection. All these visualizations employ an interactive file format (mp4) that provides users with the functionality to initiate, pause, resume, and rewind the animation. In addition, the animations can be embedded into presentations or hyperlinked from documents, further expanding the opportunities for utilization.

Ethics Statement

This article conforms to Elsevier's standards of ethical publishing.

CRediT Author Statement

David Backer: Funding acquisition, Project administration, Conceptualization, Visualization, Writing - original draft preparation, Writing - reviewing and editing; **Trey Billing**: Methodology, Software, Formal analysis, Visualization, Data curation, Writing - reviewing and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that have or could be perceived to have influenced the work reported in this article.

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