Seasonal Patterns of Acute Malnutrition and Climatic Variability: Evidence from Africa

Aishwarya Venkat, Anastasia Marshak, Elena N. Naumova

AGU Chapman Conference on Climate and Health in Africa
June 12, 2023

Tufts University | Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy

Feinstein International Center

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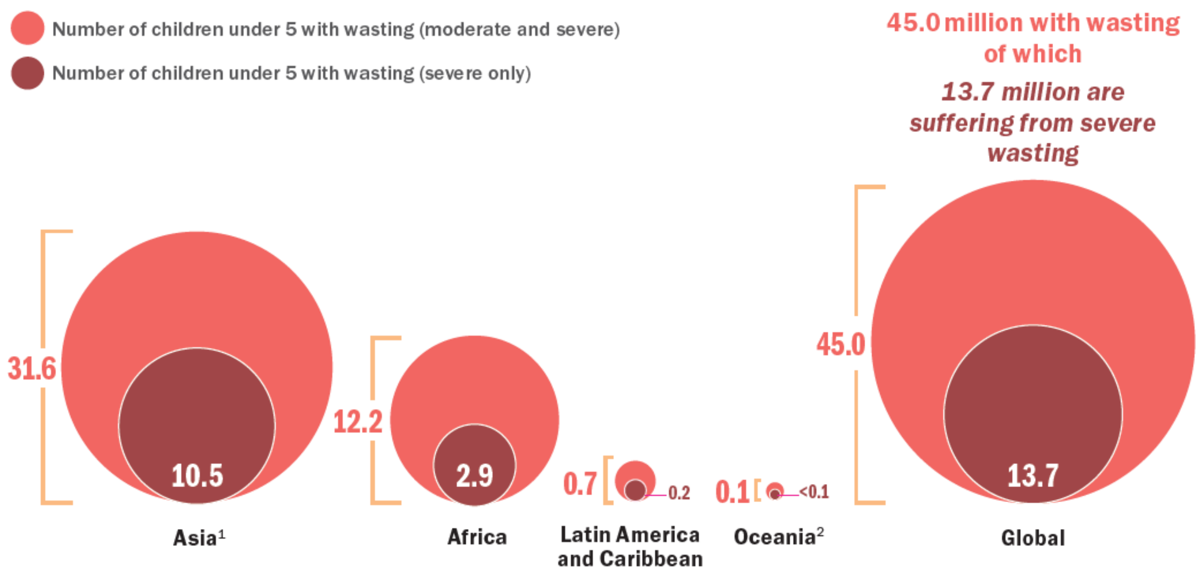
Undernutrition among children under five

- Stunting: 148.1 million (22.3%)
  - Low height-for-age
  - Result of chronic undernutrition
  - Associated with lower cognition, lower earnings, and increased morbidity in adulthood
- Wasting: 45 million (6.8%)
  - Low weight-for-height
  - Result of recent weight loss due to disease or acute food insecurity
  - Associated with increased mortality risk



The JME does not currently adjust for seasonal or other factors that can affect wasting prevalence estimates

Source: UNICEF, WHO, World Bank. (2023). *Joint Child Malnutrition Estimates*.

Reconsidering nutrition survey timings

- Measurement dependent on cross-sectional surveys
  - JME data sources: LSMS, MICS, DHS, SMART surveys
    - “the primary source dataset contained 1100 data sources from 160 countries and territories”… “global estimates are highly representative of the majority of children across the globe for the most recent period”
  - Occur at the same time each year (physical accessibility, intentionally not seasonal)
  - Timing based on discrete categories such as pre-harvest vs post-harvest, dry vs wet season, or hunger/lean vs plenty seasons
- Does acute malnutrition follow the agricultural calendar? **Not always!**
- “Food first hypothesis”: malnutrition driven primarily by lack of food (Pelletier, 1995)
- “Seasons” designed around assumptions and computational constraints of previous decades

Seasonal acute malnutrition

- Statistics emphasize country-level prevalence, BUT…
- Knowledge gaps
  - Continuous seasonal pattern
  - Link to livelihoods
  - Environmental drivers

  at subnational level
- “Over 50% of studies [in African drylands] rely on 2-4 time points within the year and/or the inclusion of time as a categorical variable in the analysis” (Marshak et al, 2021)

Challenges

- How can we develop subnational models of wasting?
  - Text matching to known spatial references
- How can we accurately model a continuous outcome which is observed infrequently?
  - Multiple harmonic regression
- Can we introduce meaningful partitions (income, livelihoods, measures of wealth) to contextualize observed patterns?
  - Split sample and fixed effects across population subsets

Fuzzy matching of survey locations

Spatial Reference from Survey

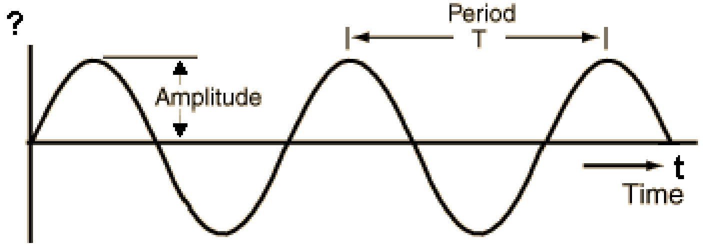
Fuzzy Matching

GADM
FAO GAUL
USAID DHS

- Systematically resolving similarities across languages
  - E.g. Nord vs. north vs. northern
- Allows for mixed order of geographic specificity, changing geographies
  - E.g. “gambia wuli basse” vs. “gambia basse” vs. “gambia upper river wuli”
- Some survey locations still require manual correction
  - E.g. D. I. Khan vs. Dera Ismail Khan region in Pakistan

Multiple Harmonic Regression

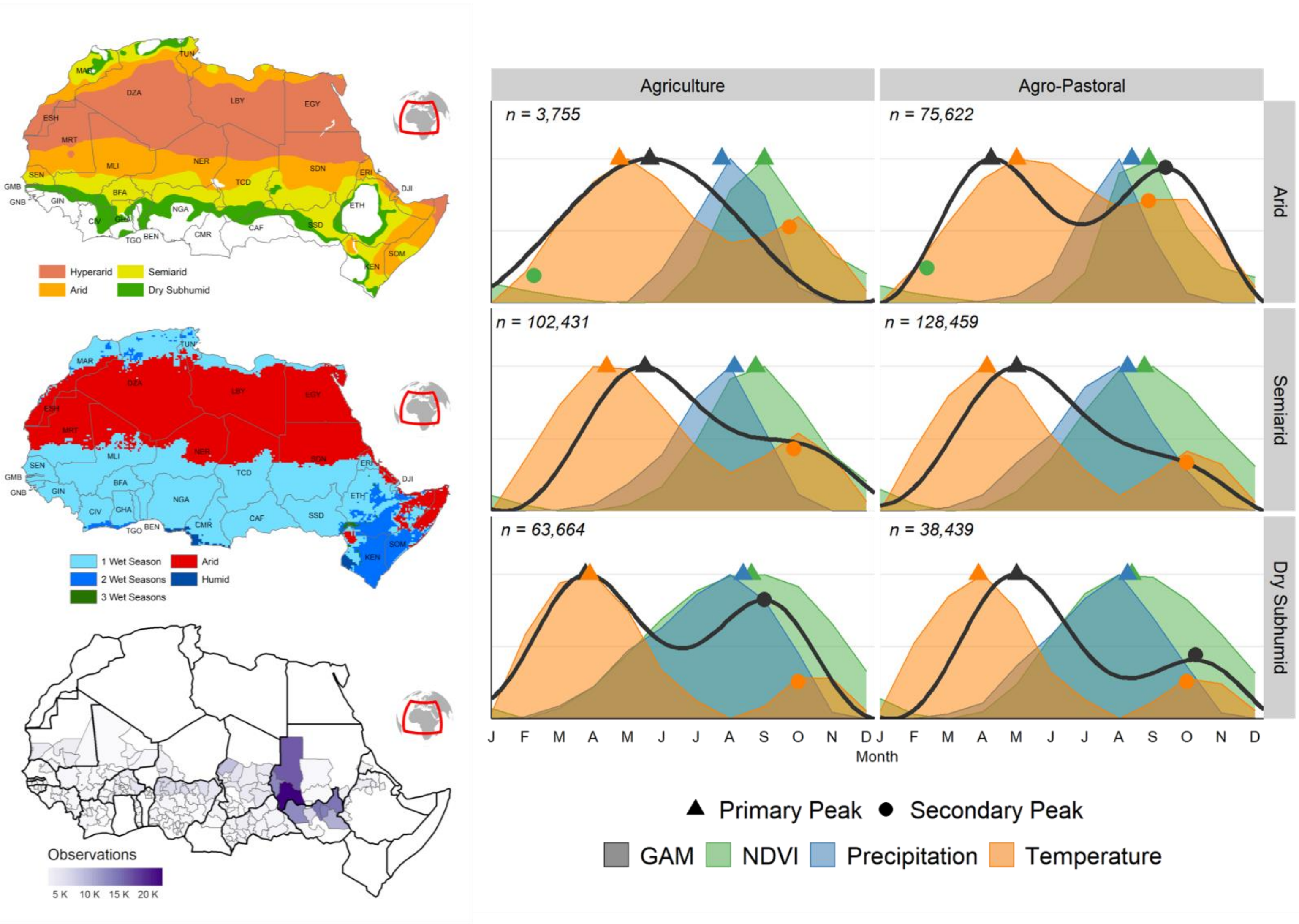
$$logit(Wasting) = \beta_0 + \beta_1 sin(2\pi\omega T) + \beta_2 cos(2\pi\omega T) + \beta_3 sin(4\pi\omega T) + \beta_4 cos(4\pi\omega T) + \beta_5 T + \beta_6 T^2 + \beta_7 T^3$$



Variable	Unimodal (2π)	Bimodal (4π)
Phase Shift **Θ**	Θ = atan($\frac{\beta_1}{\beta_2}$)	-
Peak Timing **P_T**	If $\beta_2 > 0$ and $\beta_3 > 0$, $P_T = \Theta\ (\frac{M}{2\pi})$ If $\beta_3 < 0$, $P_T = (\Theta + \pi)(\frac{M}{2\pi})$ If $\beta_2 < 0$ and $\beta_3 > 0$, $P_T = (\Theta + 2\pi)(\frac{M}{2\pi})$	Estimated arithmetically based on predicted seasonal curve P_{T1} = global maximum P_{T2} = local maximum

Source: Naumova, EN and MacNeill, IB (2006) *Seasonality assessment for biosurveillance systems*. In: Auget, JL, Balakrishnan, N, Mesbah, M and Molenberghs, G (eds). Advances in Statistical Methods for the Health Sciences. Boston, MA: Birkhauser, pp 437–450.

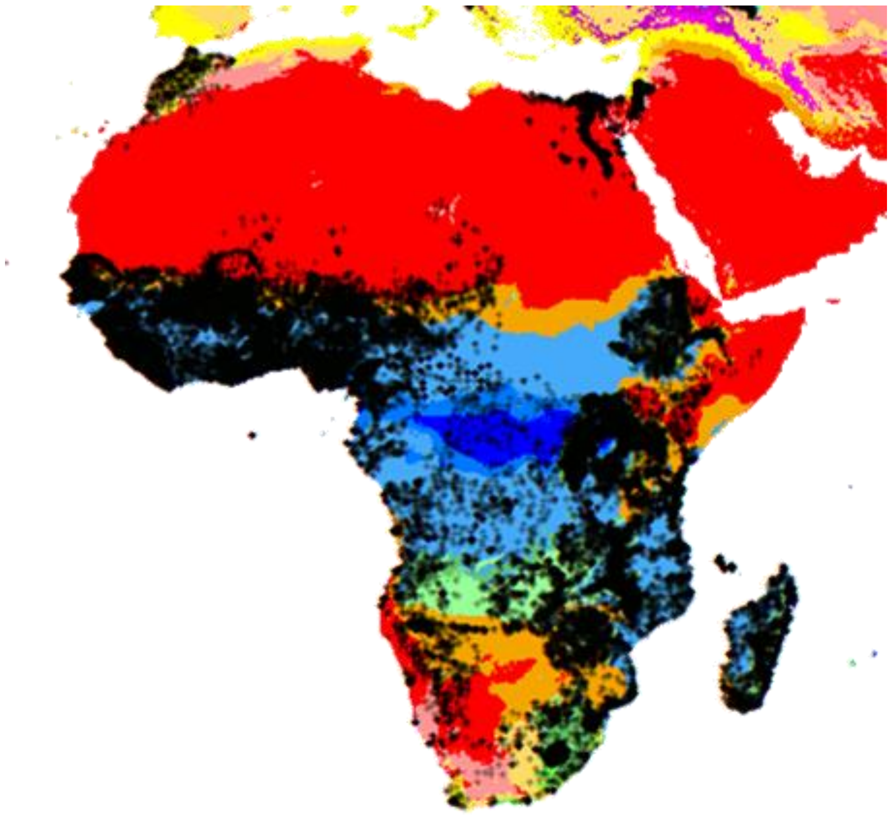
Seasonal wasting in North African drylands



Finding: largest wasting peak is associated with highest temperatures; smaller wasting peak occurs after peaks of rainfall + vegetation

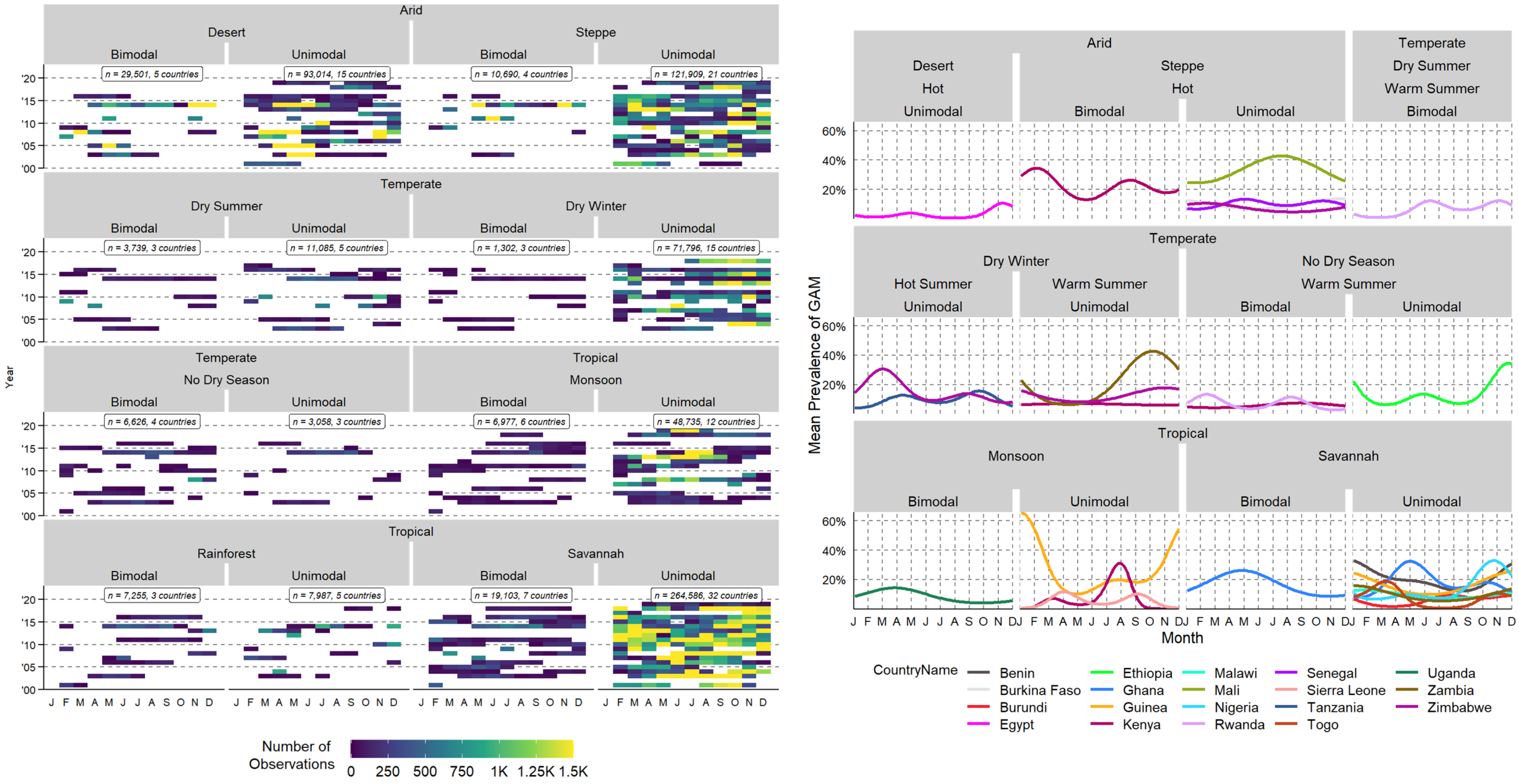
Source: Venkat et al, *Seasonality of Acute Malnutrition in African Drylands: Evidence from 15 Years of SMART Surveys. (forthcoming*)

Scaling up by combining data



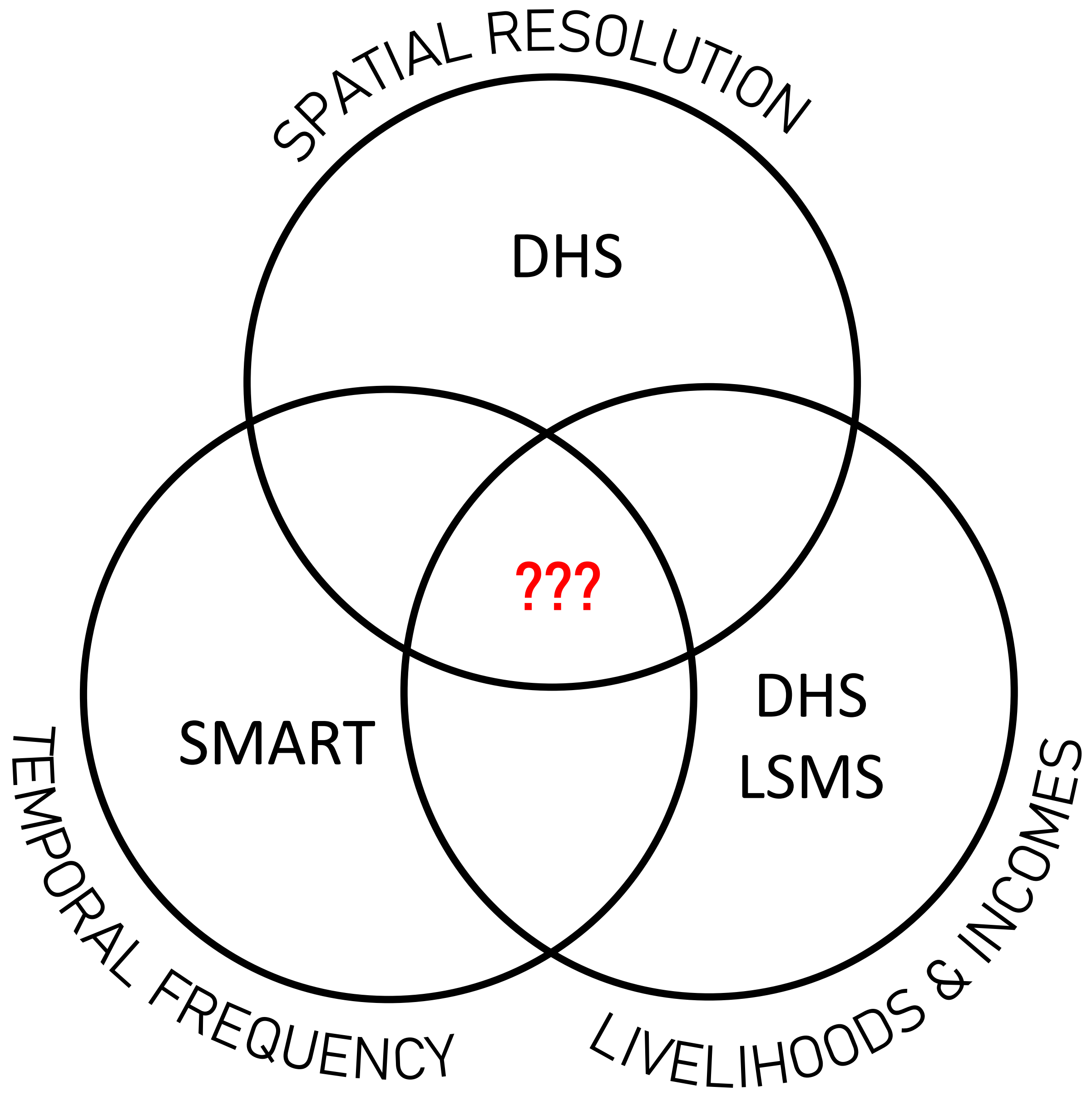
Map of DHS cluster locations (1999 – 2020) overlaid on map of Koppen climate zones

- Koppen climate classifications (Beck, 2018)
- Global rainfall modality (Knoben, 2019)
- Based on grid cells with population > 0 (GPW v4, SEDAC, 2018)
- Wasting outcomes: SMART + DHS + MICS

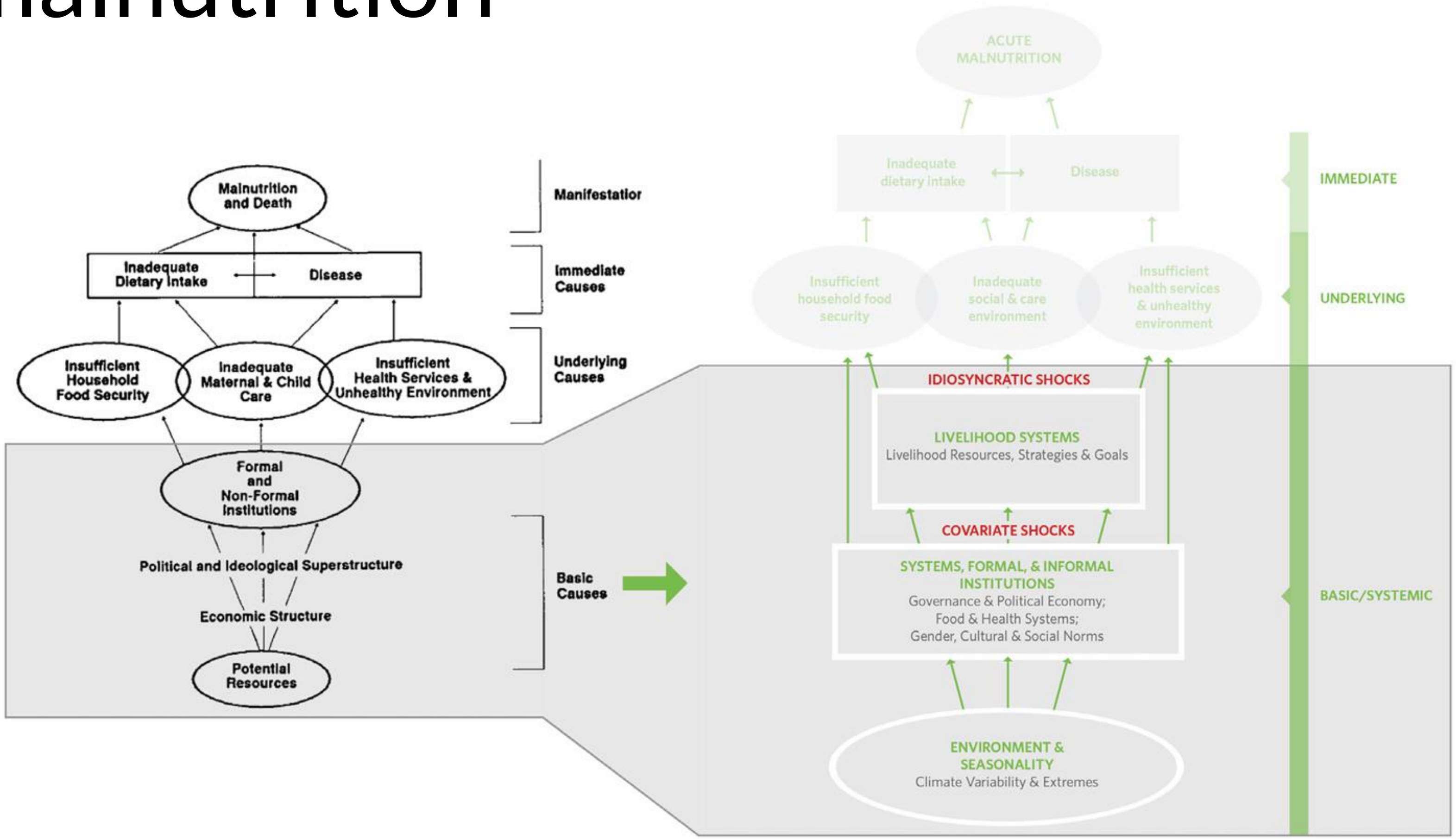

Arid
Desert
Steppe
Bimodal
Unimodal
n = 29,501, 5 countries
n = 93,014, 15 countries
n = 10,690, 4 countries
n = 121,909, 21 countries
Temperate
Dry Summer
Dry Winter
n = 3,739, 3 countries
n = 11,085, 5 countries
n = 1,302, 3 countries
n = 71,796, 15 countries
No Dry Season
Tropical
Monsoon
n = 6,626, 4 countries
n = 3,058, 3 countries
n = 6,977, 6 countries
n = 48,735, 12 countries
Rainforest
Savannah
n = 7,255, 3 countries
n = 7,987, 5 countries
n = 19,103, 7 countries
n = 264,586, 32 countries
Year
'20
'15
'10
'05
'00
J F M A M J J A S O N D
Number of Observations
0 250 500 750 1K 1.25K 1.5K
Hot
Warm Summer
Hot Summer
Mean Prevalence of GAM
60%
40%
20%
Month
CountryName
Benin
Burkina Faso
Burundi
Egypt
Ethiopia
Ghana
Guinea
Kenya
Malawi
Mali
Nigeria
Rwanda
Senegal
Sierra Leone
Tanzania
Togo
Uganda
Zambia
Zimbabwe

Ongoing challenges

- Spatial data availability
  - MICS, LSMS: no spatial data
  - Warehousing of SMART
- Nutrition surveillance
- Relevant drivers
  - Food prices/affordability?
  - Livelihood changes?



Towards seasonality as a basic driver of acute malnutrition



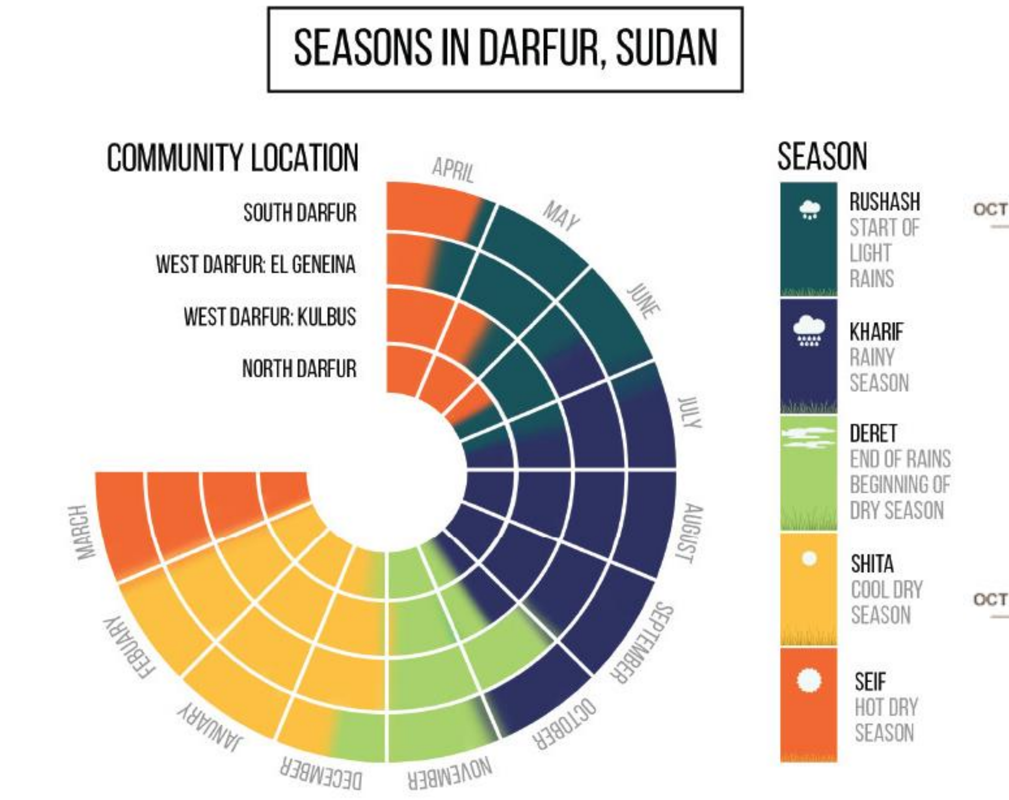
Source: Young, Helen. [Nutrition in Africa's drylands: A conceptual framework for addressing acute malnutrition](). Boston: Feinstein International Center, Tufts University, 2020.

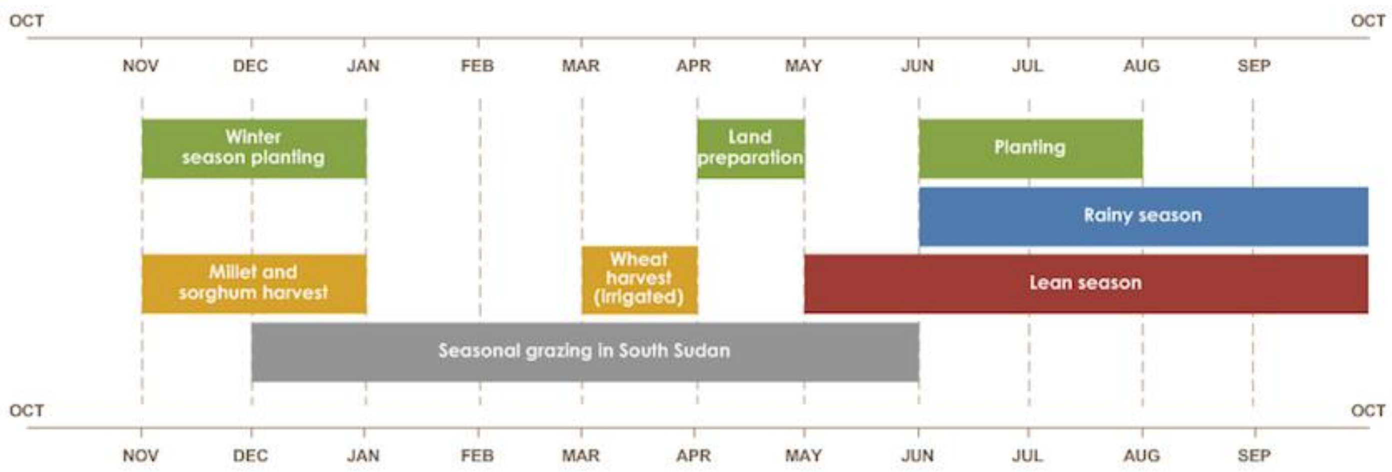
Thank you! Questions?

Aishwarya Venkat

Aishwarya.Venkat@tufts.edu | aish-venkat.github.io

Local vs. livelihoods-based calendars





Sources: (*left*) Young, H. & Ismail, M.A. 2019. [*Complexity, continuity and change: livelihood resilience in the Darfur region of Sudan*]. Disasters, 43(S3): S318–S344; (right) FEWSNET