FOODSECURE
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A Typology of Indicators on Production Potential, Efficiency and FNS Risk

Irfan Mujahid
Matthias Kalkuhl

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FOOD AND NUTRITION SECURITY

A Typology of Indicators on Production Potential, Efficiency and FNS Risk

Irfan Mujahid and Matthias Kalkuhl

Center for Development Research, University of Bonn, Germany

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Description for the Database and Typology
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Abstract

This paper provides background information for a database and typology on volatility and food nutrition security (FNS) relevant for modeling volatility effects on FNS. First, the data sources and derived indicators are discussed. Second, the typology consisting of three dimensions 'potential', 'efficiency' and 'FNS risk' is described and visualized in geographical maps and tables for each sub-indicator of the three dimensions. The linkages between the sub-indicators are also explored. Finally, a global mapping of hunger and volatility is provided to identify countries that are severely affected by malnutrition and/or market instability.

1. Introduction

Modeling food security risks on a short-term basis requires a solid empirical base for testing models and concepts as well as for assessing model uncertainties and reliability. This paper describes the underlying database which will be used to identify countries for in-depth analysis of food and nutrition security (FNS) risks. The data is based on monthly and annual observations and disaggregated over countries with almost universal country coverage. For the typology, however, only the period from 2000-2012 will be considered to identify countries that are *currently* vulnerable or show a high potential for increased production. The typology will help to highlight countries with unstable market conditions, high seasonality or acute and chronic malnutrition. It also identifies countries where these indicators are jointly affected or where they are dis-connected, which points to other determinants of malnutrition than volatility. The generated maps and the typology database can be used within the FOODSECURE project to motivate country selection or to visualize specific FNS indicators. Furthermore, it facilitates interpretation and policy conclusions from case studies for policymakers by reducing the complex heterogeneity of country characteristics (Pieters et al. 2014). Some basic analyses conducted in this paper give some first insights on the linkages between the indicators and their regional relevance.

2. Data and Methodology

Three key dimensions are identified to construct typology indicators. These include countries' *potential* to expand production, *efficiency* of grain production and *food and nutrition security* (FNS) risk. The *potential* of a country is addressed by estimating its *cereals yield gap, irrigation gap* and *arable land per inhabitant*. *Cereals yield gap* is estimated by the highest average yield among all countries by each country's average yield:

$$Yield_{gap} = \frac{Yield_{max}}{Yield_{av}}$$

where $Yield_{max}$ is the maximum yield over all countries' $Yield_{av}$, the latter being a 5-year moving average (to smooth-out shocks and outliers) over a weighted average grain yield from all considered crops of a country. The yield of crop i ($Yield_i$) is converted to kcal/ha; the yield per

country $Yield_{av}$ is calculated as a weighted average of yields from the relevant crops i in the considered country with the (caloric) production share γ_i as weight:

$$Yield_{av} = \sum_{i=1}^{n} \gamma_i \, Yield_i$$

with $\sum_{i=1}^{n} \gamma_i = 1$. The crops considered in this indicator are Barley, Maize, Millet, Oats, Rice, Sorghum, Soybean, Wheat and Cereals-nes. The yield data, production data and calorie conversion factors are obtained from FAOSTAT.

Irrigation gap is estimated by dividing a country's arable land to its total area equipped for irrigation:

$$Irrigation_{gap} = \frac{Arable\ land}{Area\ equipped\ for\ irrigation}$$

FAOSTAT is the main source for data on land availability including land area, agricultural area, arable land, irrigated agricultural area and total area equipped for irrigation. Population data to calculate *arable land per inhabitant* are also used from FAOSTAT.

Countries' *efficiency* is calculated as weighted average yield (in calorie equivalents), i.e. $Yield_{av}$ as defined above.

The *FNS risks* are addressed by anthropometric indicators on nutritional status, market stability and socio-economic indicators (following Kalkuhl et al. (2013)). The three *anthropometric indicators* considered are stunting (low height-for-age), underweight (low weight-for-age) and wasting (low weight-for-height) that come from the combined data of WHO-UNICEF-World Bank.

Market stability is addressed by calculating food price volatility as standard deviations of log-returns over the calendar year:[1]

$$Vol = \sqrt{Var}\left[\log\left(\frac{p_t}{p_{t-1}}\right)\right]$$

[1] See Kalkuhl et al. (2013) and Kornher (2014) for a discussion of different volatility measures.

Where monthly national food price indices from ILOSTAT are used for p_t (non-monthly price series were not considered). *Socio-economic indicators* are addressed by GDP per capita (PPP, in constant 2005 international $) and social protection index, both from the World Development Indicators Database of the World Bank. The database covers 222 countries over the period of 2000 to 2012. All data sources are summarized in Table 1.

Table 1. Data sources

Source	Data items	Link
FAOSTAT	Yield, production and area data	http://faostat.fao.org/
WORLD BANK	World Development Indicators	http://data.worldbank.org/data-catalog/world-development-indicators
LABORSTA	Monthly consumer and food price indices	http://laborsta.ilo.org/
UNICEF-WHO-WORLDBANK	Child malnutrition data	http://www.who.int/nutgrowthdb/estimates2012/en/

Food and nutrition security risks indicators are further used to build hunger and malnutrition maps across countries. Following Pieters et al. (2014), we first identify for each country in which quintile it belongs for each indicator for the period 2000-2012 average. The five quintals refer to 'very low', 'low', 'medium', 'high', and 'very high' (for quintiles 1 to 5, respectively).[2]

We then categorize the status of hunger and malnutrition of these countries using combinations of the indicators. Countries are categorized as suffering from *chronic malnutrition* when both stunting and underweight are in quintiles 4 and 5, while *acute malnutrition* refers countries that are in the quintiles 4 and 5 for wasting and underweight. We also identify countries with high food price volatility (quintiles 4 and 5) indicating high market instability and/or seasonality.

Countries are categorized as suffering from overall hunger and malnutrition when stunting, underweight, wasting and volatility are in quintiles 4 and 5. When stunting, underweight and wasting are in quintiles 4 and 5 but volatility is not in quintiles 4 and 5, countries are categorized

[2] For a comprehensive literature review and discussion of methodologies see also Pieters et al. (2014).

as hunger without volatility. In contrast, when volatility is in quintiles 4 and 5 but stunting, underweight and wasting are not in 4 and 5, countries are categorized as volatile without hunger.

3. Results

This section visualizes some key characteristics and patterns of the database and the typology. The tables and maps are based on the database which is related to this document.

3.1. Typology Indicators

As previously mentioned, from the three key dimensions in constructing the typology, we define ten typology indicators which include cereals yield gap, irrigation gap, arable land per capita, cereals yield efficiency, stunting, underweight, wasting, volatility, social protection and GDP per capita. The correlation between these indicators can be found in table 2 and table 3.

Table 2. Pearson Correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1. Cereals yield gap	1.00									
2. Irrigation gap	0.12	1.00								
	(0.13)									
3. Arable land /cap	-0.06	0.14	1.00							
	(0.47)	(0.06)								
4. Cereals yield	-0.55**	-0.16*	0.13	1.00						
	(0.00)	(0.04)	(0.08)							
5. Stunting	0.47**	0.20*	-0.08	-0.42**	1.00					
	(0.00)	(0.04)	(0.39)	(0.00)						
6. Underweight	0.36**	0.16	-0.07	-0.37**	0.85**	1.00				
	(0.00)	(0.09)	(0.48)	(0.00)	(0.00)					
7. Wasting	0.30**	0.17	-0.02	-0.35**	0.61**	0.86**	1.00			
	(0.00)	(0.08)	(0.81)	(0.00)	(0.00)	(0.00)				
8. Volatility	0.09	0.03	-0.04	-0.16*	0.20*	0.13	0.19	1.00		
	(0.28)	(0.70)	(0.59)	(0.03)	(0.04)	(0.17)	(0.05)			
9. Social protection	0.05	-0.35*	-0.12	0.35**	-0.21	-0.20	-0.19	-0.17	1.00	
	(0.71)	(0.01)	(0.34)	(0.00)	(0.11)	(0.14)	(0.15)	(0.19)		
10. GDP /cap	-0.35**	-0.12	0.02	0.40**	-0.59**	-0.47**	-0.38**	-0.29**	0.35**	1.00
	(0.00)	(0.14)	(0.83)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	

*Note: Significance levels are in parentheses, * p<0.05, ** p<0.01*

Table 3. Spearman rank correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1. cereals yield gap	1.00									
2. irrigation gap	0.32**	1.00								
	(0.00)									
3. arable land /cap	0.10	0.52**	1.00							
	(0.21)	(0.00)								
4. cereals yield	-0.76**	-0.20*	0.22**	1.00						
	(0.00)	(0.01)	(0.00)							
5. stunting	0.58**	0.25*	-0.02	-0.33**	1.00					
	(0.00)	(0.01)	(0.85)	(0.00)						
6. underweight	0.47**	0.16*	-0.07	-0.29**	0.84**	1.00				
	(0.00)	(0.09)	(0.44)	(0.00)	(0.00)					
7. wasting	0.43**	0.11	-0.04	-0.32**	0.62**	0.81**	1.00			
	(0.00)	(0.27)	(0.65)	(0.00)	(0.00)	(0.00)				
8. volatility	0.42**	0.09	0.11	-0.12	0.34**	0.31**	0.40**	1.00		
	(0.00)	(0.29)	(0.16)	(0.13)	(0.00)	(0.00)	(0.00)			
9. social protection	-0.18	-0.29*	-0.11	0.35**	-0.21	-0.20	-0.31*	-0.01	1.00	
	(0.15)	(0.03)	(0.39)	(0.00)	(0.12)	(0.14)	(0.02)	(0.92)		
10. GDP /cap	-0.71**	-0.25**	-0.14*	0.32**	-0.79**	-0.70**	-0.58**	-0.65**	0.33*	1.00
	(0.00)	(0.00)	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	

*Note: Significance levels are in parentheses, * p<0.05, ** p<0.01*

While the Pearson correlation coefficient measures the linear dependence between the values of the different indicator variables, the Spearman rank correlation coefficient measures the correlation between the rank of each country between the different indicators. The latter is in particular useful if the relationship is monotone but non-linear. The correlation coefficients are further tested against the null hypothesis of zero correlation.

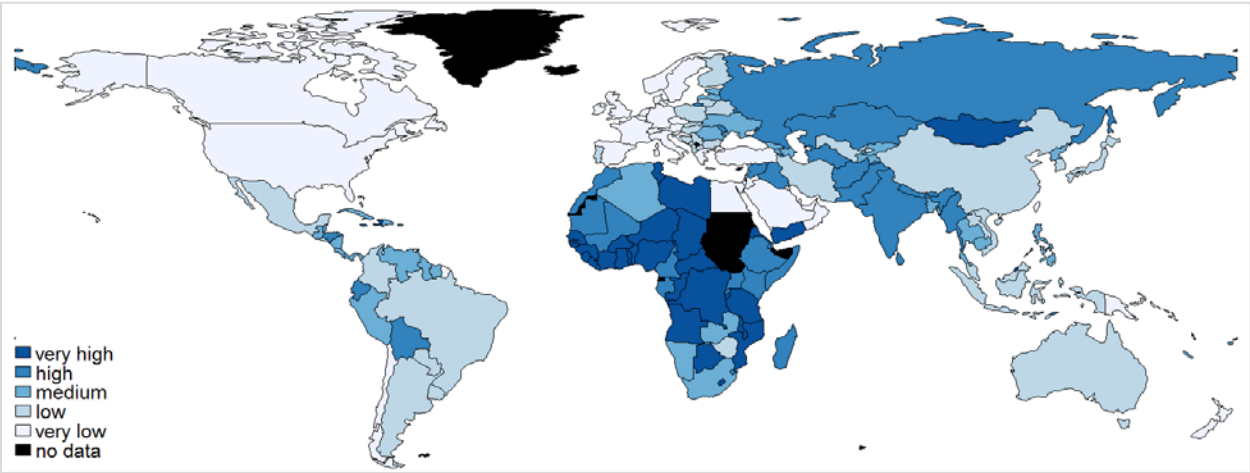
Table 4 depicts the top ten and bottom ten countries in each category. Figures 1–10 show the geographical maps for each of the indicator. It becomes visible that despites its large potential, yields in Africa are very low and hunger and volatility very high. This is also confirmed in Table 2 and Table 3: countries with high potential (large yield and irrigation gap) tend also to be countries with high hunger and volatility indicators.

Table 4. Country rank for each indicator

	Cereals yield gap	Irrigation gap	Arable land /cap	yield efficiency	Stunting	Under weight	Wasting	Volatility	Social protection	GDP /cap
Highest										
1	CPV	CAF	AUS	ARE	BDI	IND	IND	STP	CPV	QAT
2	ERI	LVA	KAZ	FRA	MWI	BGD	BFA	MWI	ARM	LUX
3	VUT	LTU	CAN	AUT	MDG	NER	NER	MDV	GEO	BRN
4	BRN	COM	NER	JOR	NER	BDI	TCD	BDI	AZE	NOR
5	BWA	COD	RUS	ITA	GTM	NPL	MDG	MNG	GHA	SGP
6	LBR	UGA	ARG	NZL	ZMB	MDG	PAK	TCD	MDV	MAC
7	AGO	BIH	UKR	BEL	NPL	YEM	LKA	TGO	BOL	USA
8	COG	TGO	LTU	EGY	RWA	LAO	BGD	YEM	LKA	KWT
9	LSO	COG	PRY	CHE	IND	ETH	YEM	COG	WSM	CHE
10	COD	CMR	NIU	ESP	LAO	KHM	LAO	IRQ	RWA	HKG
Lowest										
10	DEU	SUR	QAT	STP	CRI	SRB	ARG	MYS	AGO	RWA
9	GBR	TKM	ARE	PRI	JAM	BGR	PAN	ABW	CIV	SLE
8	QAT	LCA	OMN	ATG	TTO	TUV	COL	ANT	COG	TGO
7	IRL	STP	SYC	DMA	BLR	BIH	PRY	BHS	GNB	MDG
6	NZL	EGY	MDV	DJI	SGP	MKD	CRI	IRL	GMB	CAF
5	MUS	CHL	BRN	LBR	KWT	BLR	DEU	BRN	STP	ETH
4	JOR	NCL	KWT	GRD	USA	USA	TUR	AND	HTI	MOZ
3	NLD	OMN	BHR	BRN	CZE	CRI	PER	LUX	LAO	MWI
2	KWT	BHR	DJI	VUT	CHL	DEU	USA	ITA	VUT	NER
1	BEL	ARE	SGP	CPV	DEU	CHL	CHL	USA	CAF	BDI

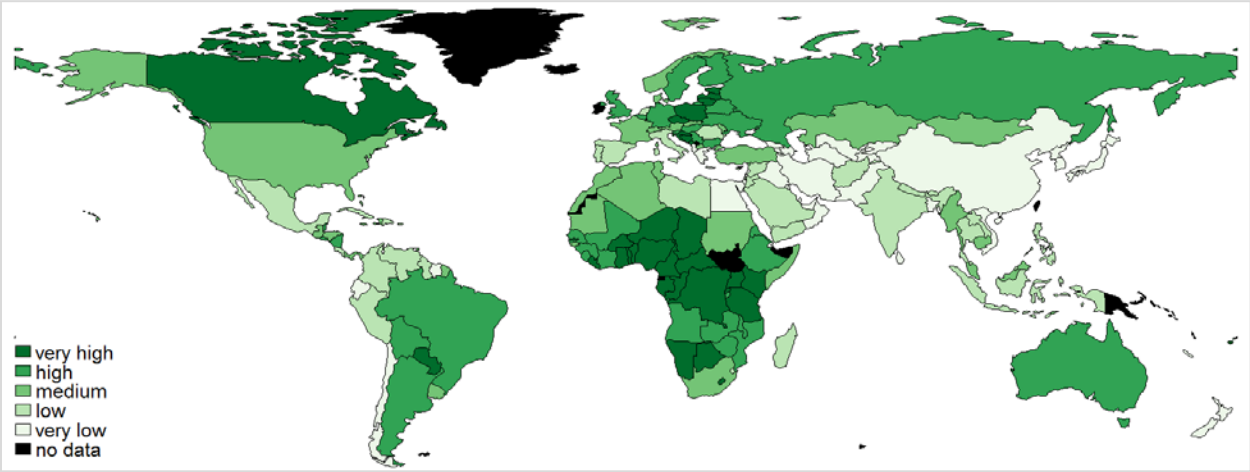
Note: ISO 3 is used for country codes
Source: Own calculation based on the combined dataset from different sources

Figure 1. Yield gap



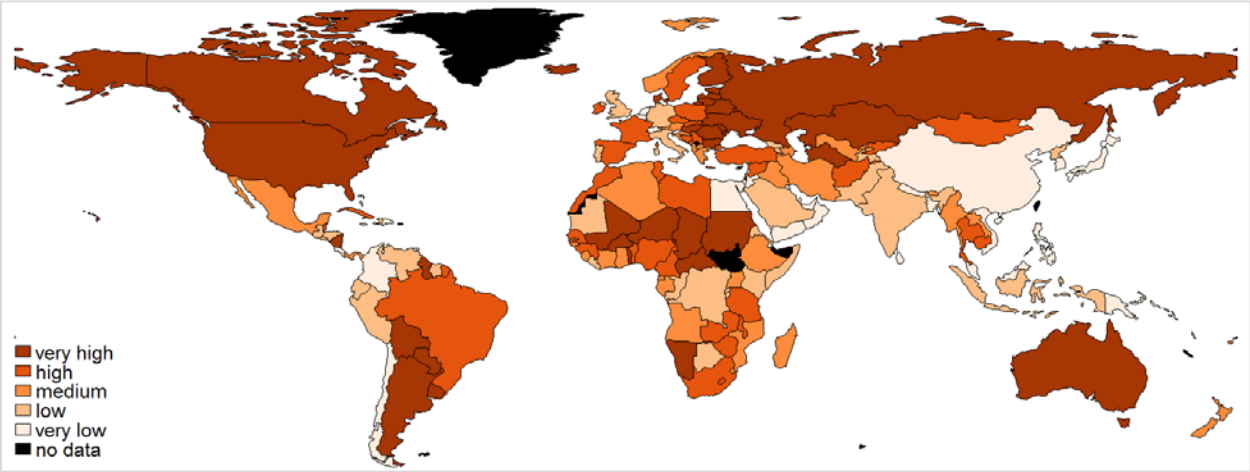
Note: Yield gap is measured by dividing maximum average yield over all countries by average yield of each country (yield in kcal/ha over all relevant food crops).
Source: Own elaboration based on data from FAOSTAT

Figure 2. Irrigation gap



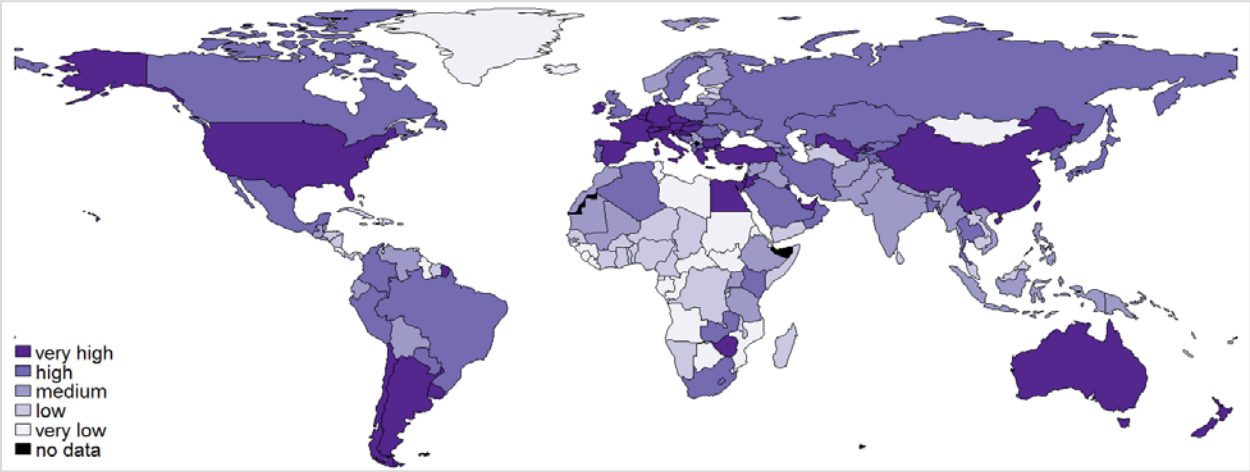
Note: Irrigation gap is measured by dividing arable land by area equipped for irrigation
Source: Own elaboration based on data from FAOSTAT

Figure 3. Arable land per inhabitant



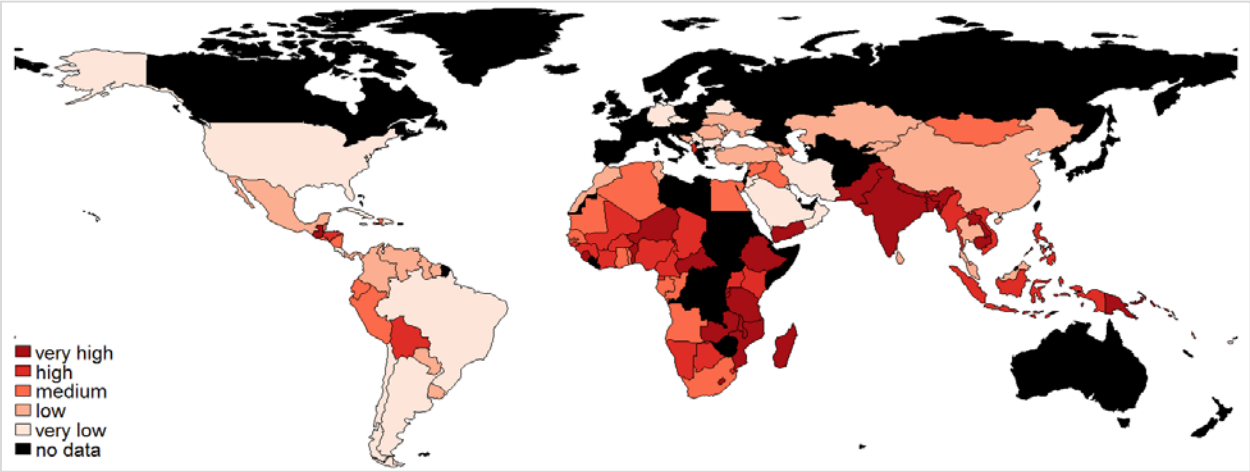
Note: arable land is calculated by dividing total arable land by population
Source: Own elaboration based on data from FAOSTAT

Figure 4. Yield efficiency



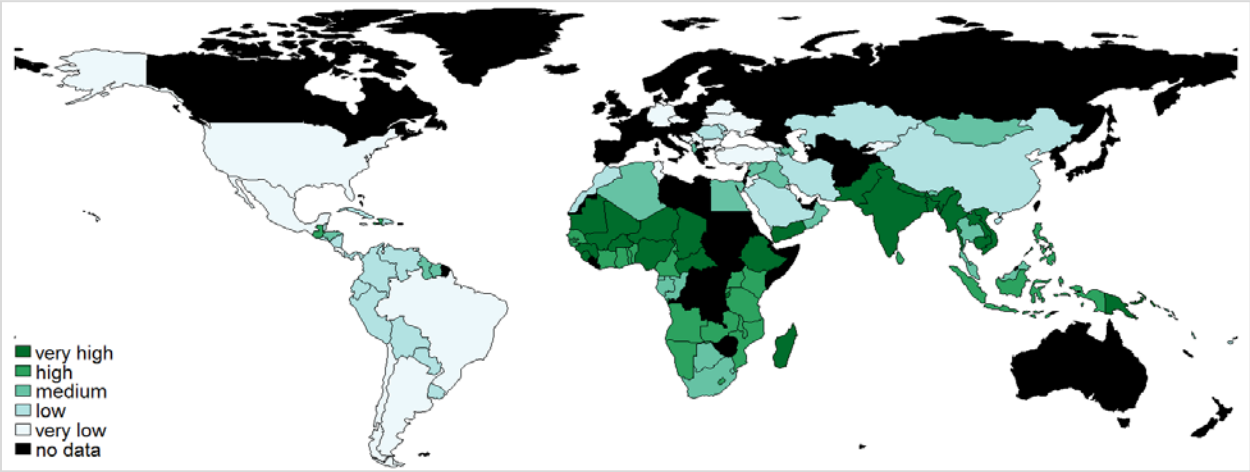
Note: Yield efficiency is weighted average yields (in kcal) per hectare
Source: Own elaboration based on data from FAOSTAT

Figure 5. Stunting



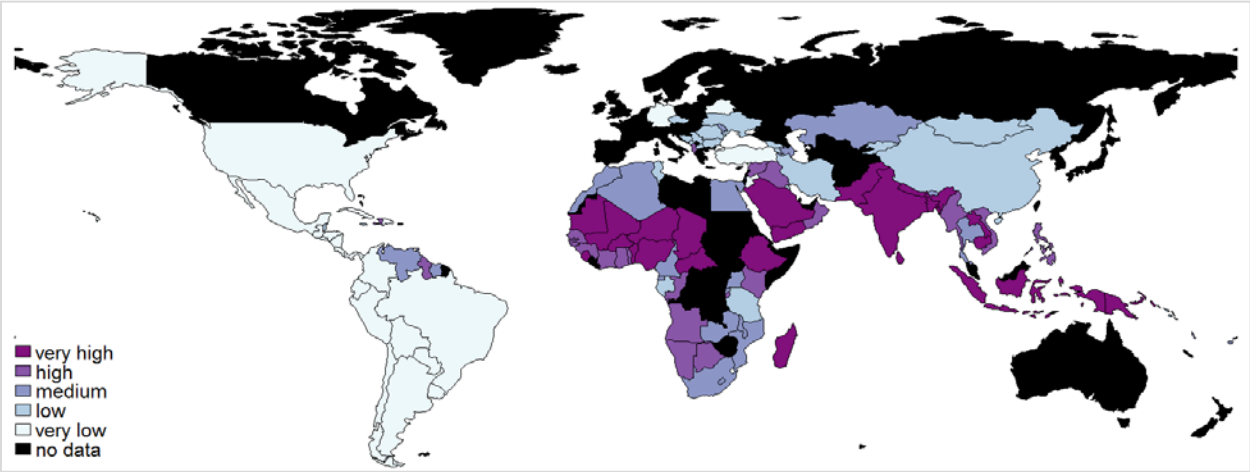
Note: Stunting is measured as low height for age
Source: Own elaboration based on data from WHO-UNICEF-World Bank

Figure 6. Underweight



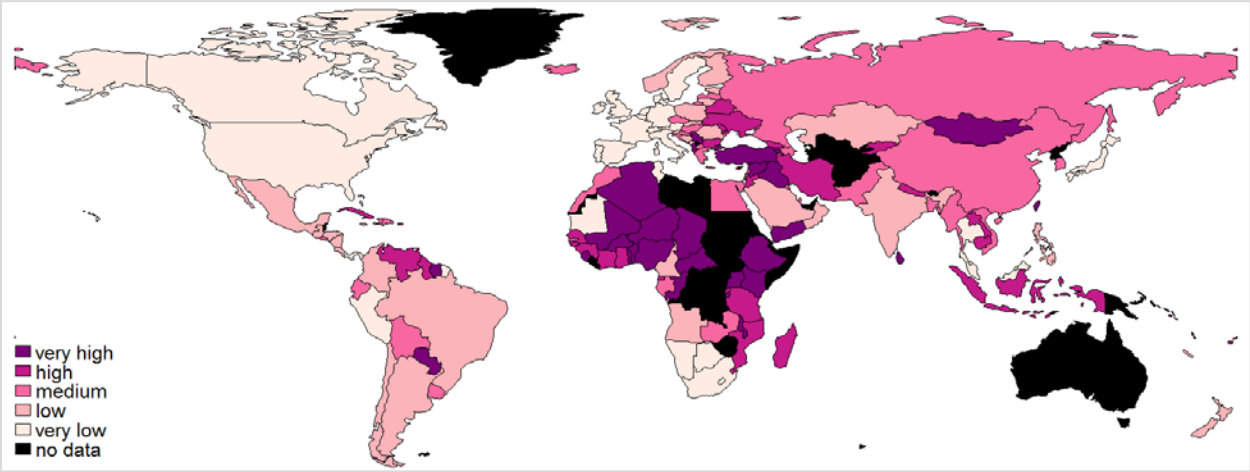
Note: Underweight is measured as low weight for age
Source: Own elaboration based on data from WHO-UNICEF-World Bank

Figure 7. Wasting



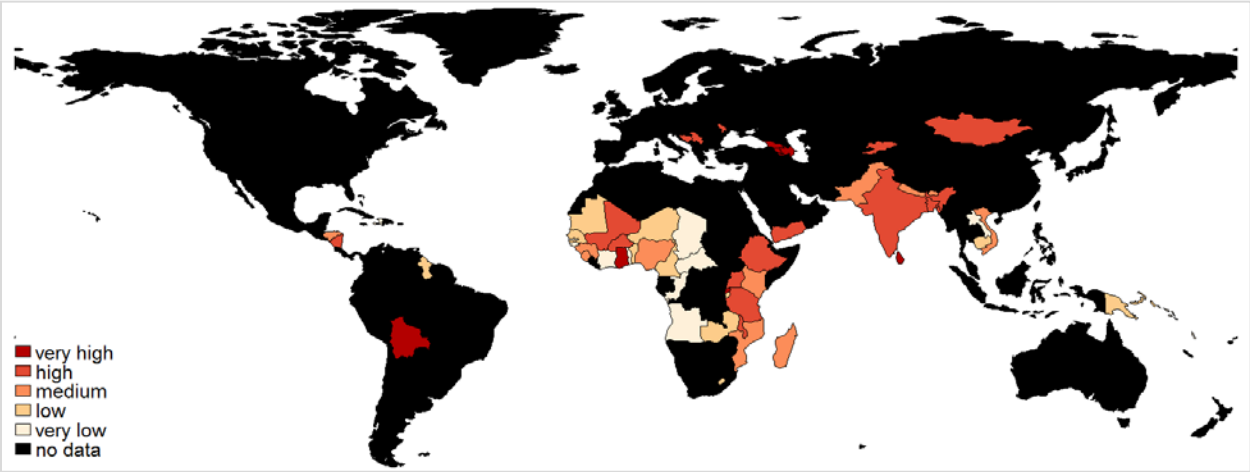
Note: Wasting is measured as low weight for height
Source: Own elaboration based on data from WHO-UNICEF-World Bank

Figure 8. Food Price Volatility



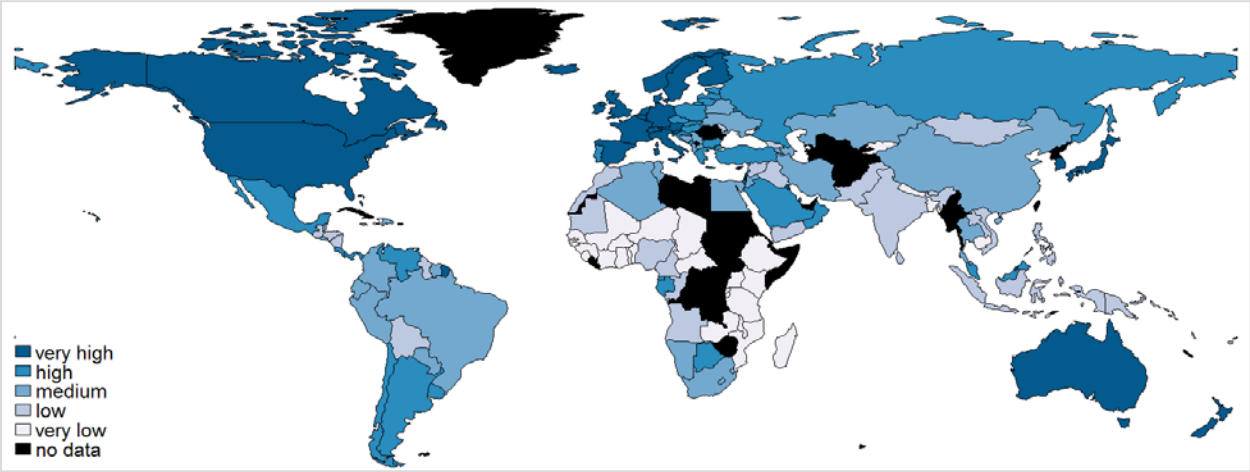
Note: volatility is measured as standard deviation of log returns
Source: Own elaboration based on data from LABORSTA

Figure 9. Social protection index



Source: Own elaboration based on data from World Bank

Figure 10. GDP per capita



Source: Own elaboration based on data from World Bank

3.2. Global hunger and malnutrition map

While Section 3.1 mapped each indicator separately, we provide in this section combinations of indicators as described in the end of Section 2. Figures 11–16 highlight countries where certain sets of hunger and FNS risk indicators are very high. It becomes apparent that countries with high or very high chronic malnutrition are often countries with high or very high acute malnutrition (which is confirmed also by the high correlation of these indicators in Table 2 and Table 3). These countries are typically located in Sub-Saharan Africa and Southeast Asia.

Figure 11. Chronic Malnutrition

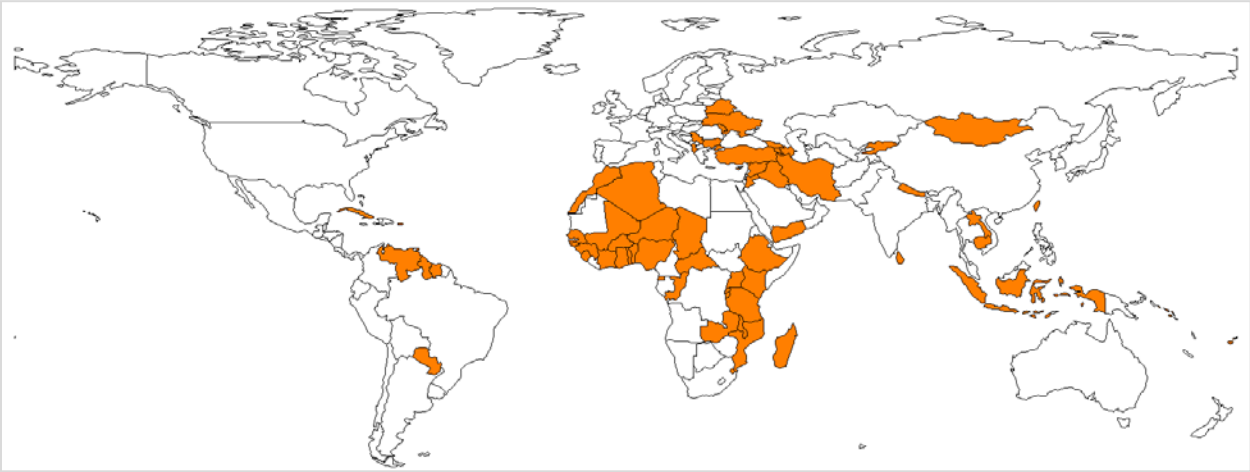
Note: Chronic malnutrition for countries where stunting and underweight are in quintiles 4 or 5
Source: Own elaboration based on data from WHO-UNICEF-World Bank

Figure 12. Acute Malnutrition

Note: Acute malnutrition for countries where wasting and underweight are in quintiles 4 or 5
Source: Own elaboration based on data from WHO-UNICEF-World Bank

Food price volatility is high or very high over the African continent and the Middle East (Figure 13). Countries with high or very high volatility as well as malnutrition are highlighted in Figure 14: most countries affected are again in Sub-Saharan Africa and lie in the Sahel zone.

Figure 13. Volatility



Note: Volatility for countries where food price volatility in quintiles 4 or 5
Source: Own elaboration based on data from LABORSTA

Figure 14. Overall Hunger and Malnutrition

Note: Overall hunger and malnutrition for countries where stunting, underweight, wasting and volatility are in quintiles 4 or 5
Source: Own elaboration based on data from WHO, UNICEF, World Bank, LABORSTA

Figure 15 and Figure 16 identify those countries where the volatility indicator departs from the malnutrition indicators, i.e. where hunger is not accompanied by high food price volatility and vice versa. India, Bangladesh and Pakistan as well as Namibia are, among others, countries with high prevalence of stunting or underweight although food price volatility is rather moderate. In the case of India, low price volatility is related to high public intervention into the agricultural

sector to stabilize prices while the high prevalence of malnutrition is typically attributed to the high disease burden (e.g. due to low sanitation infrastructure) and poor health care (Measham and Chatterjee 1999; Spears 2013). As shown in Figure 16, there are quite a few countries with high food price volatility but low prevalence of hunger, as it is the case for Cuba, Venezuela, Paraguay, Morocco, Algeria and other Middle East or CIS countries.

Figure 15. Hunger without volatility

Note: Hunger without volatility for countries where stunting, underweight, wasting are in quintiles 4 or 5 but volatility is not in quintiles 4 or 5
Source: Own elaboration based on data from WHO, UNICEF, World Bank, LABORSTA

Figure 16. Volatility without hunger

Note: Volatility without hunger for countries where volatility is in quintiles 4 or 5 but stunting, underweight and wasting are not in quintiles 4 or 5
Source: Own elaboration based on data from WHO, UNICEF, World Bank, LABORSTA

4. Conclusions

This paper describes the data and indicators used for a typology on malnutrition and volatility which can be used for selecting countries for in-depth analysis and informing policy makers. The typology reduces information complexity by focusing on relevant but aggregate indicators like the calorie-equivalent yield gap which considers the representative crops of a specific country. It also shows which countries are affected simultaneously by malnutrition or FNS risk indicators and for which countries the indicators depart. The typology revealed that Sub-Saharan Africa is the region most prone to malnutrition, hunger, low agricultural productivity and volatility. Although Southeast Asia also suffers from severe malnutrition, agricultural productivity is higher and volatility lower, hinting to other important determinants of nutrition and health (like sanitation). Instability of food markets (volatility) is strongly connected to malnutrition and low agricultural productivity but there are also countries where high volatility does not occur together with high prevalence of malnutrition. Further empirical research on modeling the impacts of volatility and price shocks on FNS will help to establish causalities and to estimate the magnitude of impacts; it will further provide the base for early warning systems on upcoming crises.

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The FOODSECURE project in a nutshell

Title	FOODSECURE – Exploring the future of global food and nutrition security
Funding scheme	7th framework program, theme Socioeconomic sciences and the humanities
Type of project	Large-scale collaborative research project
Project Coordinator	Hans van Meijl (LEI Wageningen UR)
Scientific Coordinator	Joachim von Braun (ZEF, Center for Development Research, University of Bonn)
Duration	2012 - 2017 (60 months)

Short description

In the future, excessively high food prices may frequently reoccur, with severe impact on the poor and vulnerable. Given the long lead time of the social and technological solutions for a more stable food system, a long-term policy framework on global food and nutrition security is urgently needed.

The general objective of the FOODSECURE project is to design effective and sustainable strategies for assessing and addressing the challenges of food and nutrition security.

FOODSECURE provides a set of analytical instruments to experiment, analyse, and coordinate the effects of short and long term policies related to achieving food security.

FOODSECURE impact lies in the knowledge base to support EU policy makers and other stakeholders in the design of consistent, coherent, long-term policy strategies for improving food and nutrition security.

EU Contribution	€ 8 million
Research team	19 partners from 13 countries

FOODSECURE project office
LEI Wageningen UR (University & Research centre)
Alexanderveld 5
The Hague, Netherlands

T +31 (0) 70 3358370
F +31 (0) 70 3358196
E foodsecure@wur.nl
I www.foodscecure.eu

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