Climate Change and Food Security in Namibia

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Abstract

Climate change and variability continue to threaten the efforts made towards achieving goal 1 of the MDGs that of halving hunger by 2015. The potential impact is less clear in countries such as Namibia, but it is likely that increased heat and limited precipitation will exacerbate food insecurity in areas vulnerable to hunger and malnutrition. Extreme weather such as drought and water scarcity diminish dietary diversity thereby changing the quantity and quality of food intake which may lead to malnutrition. This study combine meteorological data and malnutrition reported at health facilities in Namibia for the period 2008 – 2014 to explore the impact of climate change on food security outcome – malnutrition. Poisson regressions were fitted to explore the intra-regional variation. The results indicate that the highest risk of malnutrition was observed during March, the time about harvest and Kavango region also showed the highest risk of malnutrition.

Keywords: malnutrition, food security, climate change, Namibia

1. Background

Fifteen years into the MDGs and Africa still remains overwhelmed by food insecurity. A recent FAO report on The State of Food Insecurity in the World, states that: "A stock-taking of where we stand on reducing hunger and malnutrition shows that progress in hunger reduction at the global levels has continued but that food insecurity is a challenge to be conquered" (FAO, 2014: 4). Recent estimates put the total number of chronically undernourished people during the period 2012 – 2014 at 805 million down from 870 million in 2010 – 2012 but a disturbing 214 million undernourished live in Sub-Saharan Africa. In 1990 – 1992 and 2010 – 2012 the number of chronically undernourished as the proportion of the total population disturbingly increased in sub-Saharan Africa from 17 – 27 percent (FAO et al., 2012), but this proportion has declined from 33.3 percent in 1990-1992 to 23.8 percent in 2012/2014 (FAO et al. 2014). Despite this decline, there has been insufficient progress towards meeting international hunger targets in sub-Saharan Africa, where more than one in four people remain undernourished. The decline however, masks significant impacts of shocks such as food prices increase and extreme weather changes which have major implications on food security and livelihoods (Connolly-Boutin and Smit, 2015).

The United Nations Framework Convention on Climate Change (UNFCCC, 2011), Article 1, defines climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". This change results from the increased concentration in the atmosphere of gases such as carbon dioxide, methane, nitrous oxide and halo-carbons, which are gases that contain fluorine, chlorine and bromine. Climate change has moved beyond being an environmental challenge to one that threatens development around the world (Hamilton et al. 2008). Climate change threatens to exacerbate existing threats to food security and livelihoods due to a combination of factors that include the increasing frequency and intensity of climate hazards, diminishing agricultural yields and reduce production in vulnerable regions, rising health and sanitation risks, etc. (Schmidhuber and Tubiello, 2007). In particular, the Intergovernmental Panel on Climate Change (IPCC) projected that by 2050, global average temperature would rise in range from $1-2^0$ C. The effects of these are different between temperate latitudes, humid areas and drier areas (Schimdhuber and Tubiello, 2007). Changes in climate will be felt primarily through increasing temperatures and changing rainfall patterns (IPCC, 2014; Krishnamurthy et al. 2012). Evidence of climate change is indisputable, and several studies have shown that developing countries will bear the brunt of adverse consequences, largely because of exponential population growth; persistent high poverty levels; high levels of vulnerability and low levels of adaptation (Frayne, et al. 2012; Tacoli, et al. 2013; Ringler, et al. 2010, Thornton, et al. 2014; Connolly-Boutin, et al. 2015).

Like the rest of the world Namibia, is also experiencing significant climate change. An analysis of the country's climatic history by DRFN and the Climate System Analysis Group (2008) indicates that warmer temperature in the latter half of the 20th century, with a minimum of $1-2^0$C and a maximum of $2-3.5^0$C, will be experienced, warmer than the average as noted by Midgley et al. (2005). Rainfall is a local phenomenon, and the IPCC sheds little specific information on the expected rainfall changes of direct relevance to Namibia (IPCC, 2007; IPCC, 2007b). The country analysis uses global circulation models (GCMs), interactions between the land surface, atmosphere and the oceans to formulation projections for temperature and wind regimes for the period 2046 – 2065. Furthermore, the downscaled global circulation models (DGCMs) were used to project the effects of climate change on rainfall for the same period. Downscaling allows for large-scale GCM models to be used for projections at more local scales (DRFN and Climate Systems Analysis Group, 2008).

The analysis further shows that although there were difficulties in predicting trends in rainfall due to high variability in Namibia, the tendency is a later onset of rainfall and an earlier cessation of rains in the later years implying a shorter rainfall season consistent with the trends for longer dry seasons (DRFN and Climate Systems Analysis Group, 2008:10).

The impact of climate change in Namibia is already being felt. It is observed that ground water recharge has reduce throughout the country; agricultural dry-land crop productivity will be reduced by up to 50% in north-central areas and by about 20% in the north-eastern regions due to climate change (Wilhelm, 2012). This paints a gloomy picture for the agriculture sector which is an important pillar of the formal economy and a basis of livelihood of the majority of the people in the country. Although a considerable body of literature exist on the adverse effects of climate change on food security (Frayne et al. 2012; Jankowska, et al. 2012; Thornton, et al. 2014; FAO, 2008), very limited research in Namibia has analyzed the extent to which climate change affects nutrition(specifically nutrition outcome - malnutrition) as a food insecurity outcome. This paper therefore explores the impact of temperature and rainfall variability change on malnutrition in Namibia

Methods

Study areas: Data used was drawn from Erongo, Karas, Kavango, Khomas, Oshana, Otjozondjupa and Zambezi regions in Namibia, which have representative climatic and economic conditions similar to the other 6 regions not included in this analysis.

Data and analysis: Monthly admission data of malnutrition cases were extracted from the Health Information System (HIS). Using corresponding climatic data from the same areas, we fitted a parsimonious model to estimate the effects of rainfall, mean and maximum temperatures on risk of malnutrition. First, we generated time series plots, for each region, to determine the appropriate lag between disease manifesting and climatic variables. Second, we fitted a Poisson regression, for each region. This is followed by Poisson model, pooling all data, between 2008 and 2013. The Poisson model can be summarized as follows:

$$y_{it} = \alpha + \beta_{it} X_{it} + \cos(12\pi t) + \sin(12\pi t)$$

where y_{it} are reported disease counts in region i and time t, estimated with overall intercept of α; β are fixed regression effects corresponding to climatic variables X. The seasonal effects are captured using the cosinor function, $\cos(12\pi t) + \sin(12\pi t)$.

Results

Overall there is a declining pattern in the levels of malnutrition. However, Kavango region has persistent high malnutrition level, recording an all time high in 2008, followed by Ohangwena, Khomas and Omusati regions (Table 1).

Table 1. Distribution of malnutrition by region, Namibia 2008 - 2014

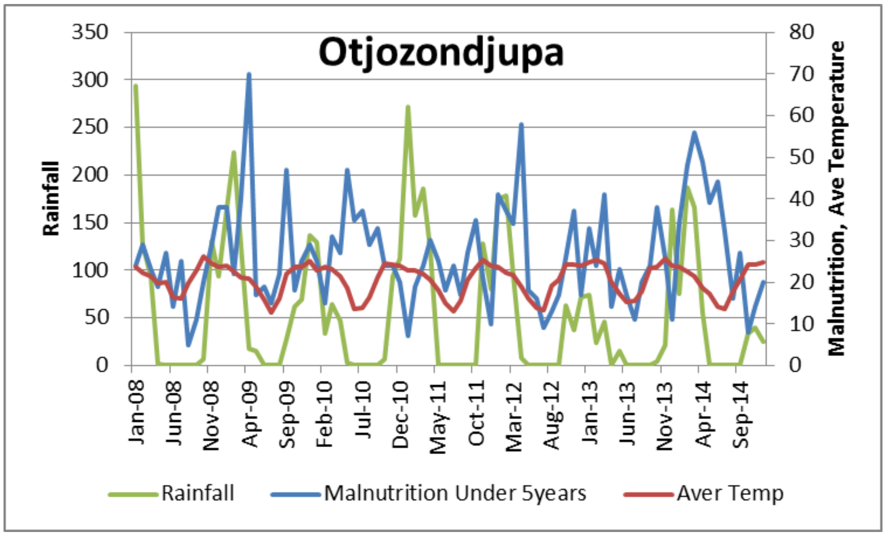
Region	2008		2009		2010		2011		2012		2013		2014	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Erongo	105	2.9	107	2.9	193	5.1	201	4.6	178	4.2	228	4.5	235	4.9
Hardap	188	5.1	236	6.4	172	4.5	332	7.6	179	4.2	298	5.8	299	6.2
Karas	130	3.6	162	4.4	137	3.6	148	3.4	115	2.7	141	2.8	120	2.5
Kavango	1061	29.0	693	18.9	861	22.6	965	22.2	1115	26.3	991	19.4	802	16.6
Khomas	432	11.8	328	8.9	352	9.3	371	8.5	376	8.9	474	9.3	547	11.3
Kunene	88	2.4	38	1.0	77	2.0	122	2.8	123	2.9	230	4.5	159	3.3
Ohangwena	367	10.0	464	12.6	569	15.0	543	12.5	579	13.6	699	13.7	708	14.6
Omaheke	359	9.8	307	8.4	197	5.2	296	6.8	295	6.9	377	7.4	379	7.8
Omusati	159	4.3	212	5.8	276	7.3	255	5.9	281	6.6	505	9.9	448	9.2
Oshana	111	3.0	219	6.0	142	3.7	180	4.1	144	3.4	171	3.3	206	4.3
Oshikoto	273	7.5	379	10.3	214	5.6	455	10.5	267	6.3	295	5.8	266	5.5
Otjozondjupa	264	7.2	362	9.9	347	9.1	257	5.9	323	7.6	282	5.5	387	8.0
Zambezi	121	3.3	165	4.5	268	7.0	225	5.2	270	6.4	425	8.3	289	6.0
Grand Total	3658	100.0	3672	100.0	3805	100.0	4350	100.0	4245	100.0	5116	100.0	4845	100.0

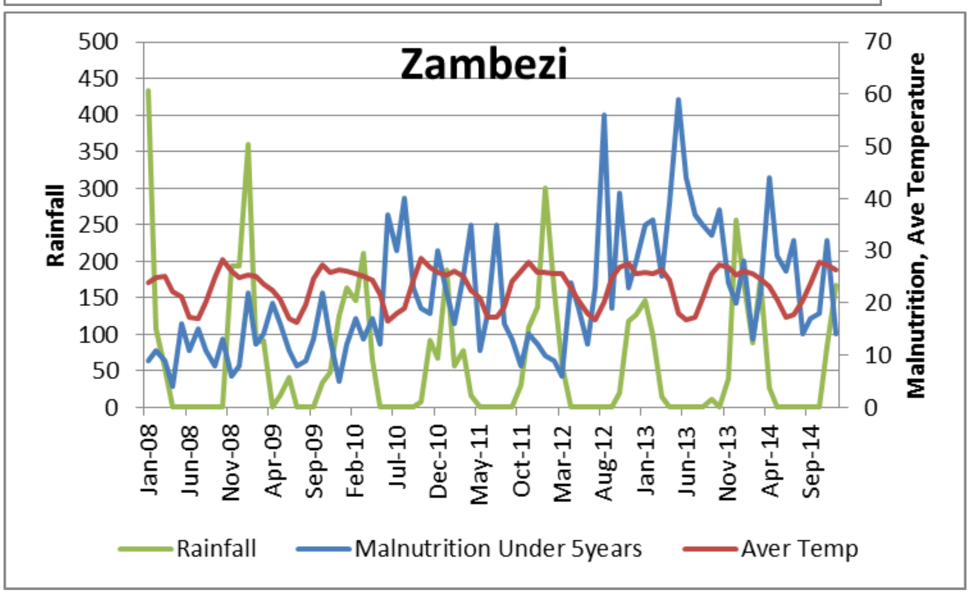
Figures 1 to 7 present time series plots of malnutrition cases against rainfall, and temperature variables. In all plots, there was evidence of lagged relationship between the peak of malnutrition and the environmental variables. An increase in temperature and a change in rainfall is followed by a rise in malnutrition. A test using Ling-Pearson indicates that at lag of 1, 2 months there is a strong relationship between malnutrition and both rainfall and temperature. Similar findings were observed using the correlogram plots. We therefore estimated models at lag 1 and 2 for all climatic variables.

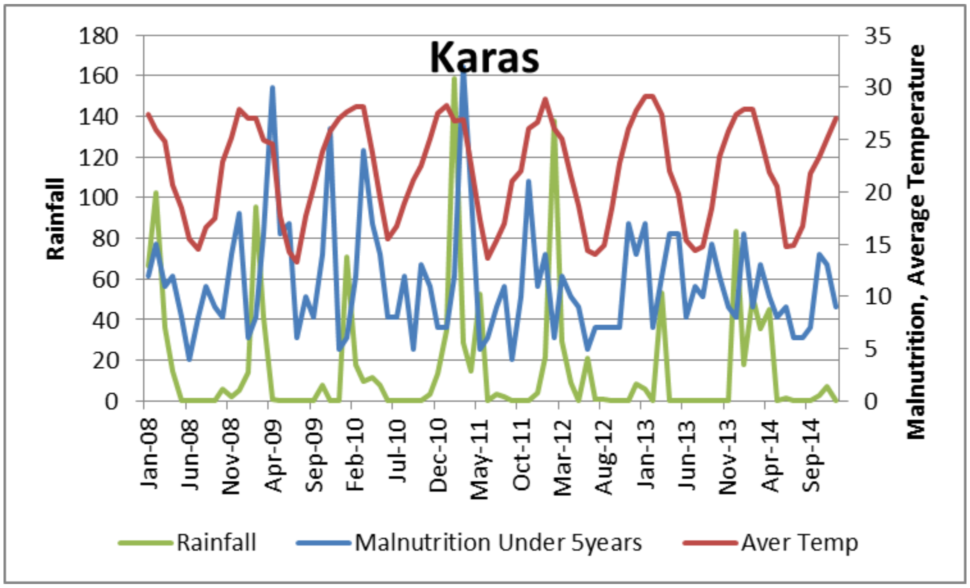
Table 2 presents results on relative risk (RR) for malnutrition for separate regions. In Erongo region, risk of malnutrition increased with increasing minimum temperature (at lag 1) and rainfall, at lag 2, while reduced risk with maximum temperature at lag 1. In general, the risk of malnutrition has been increasing since the year 2010, when compared to year 2014, but somewhat lower in 2008 and 2009. With regards to months, the odds of malnutrition increased in the month of June going forward to November, when these months are compared to the month of November.

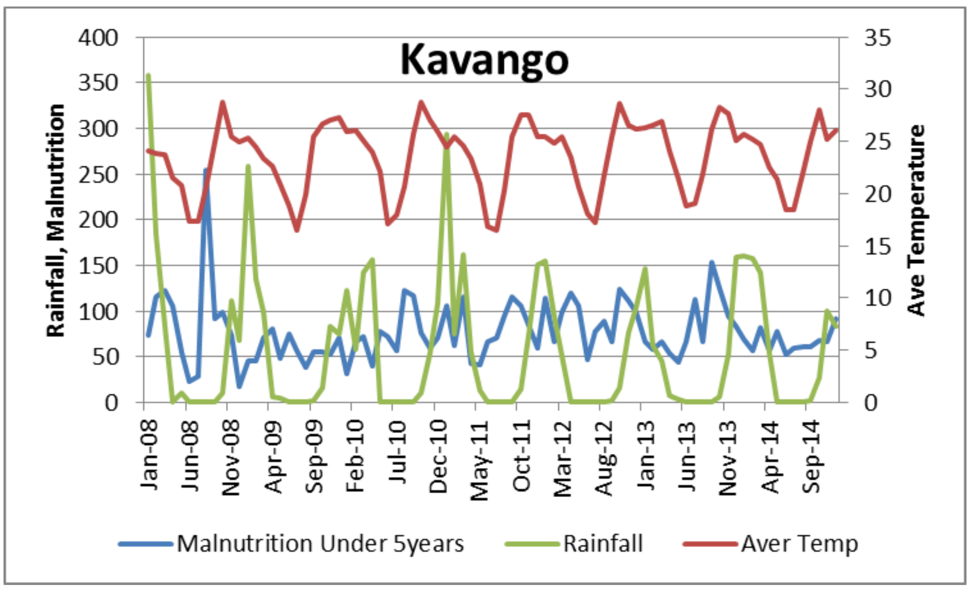
In Karas and Zambezi regions, the pattern of association is similar to that in Erongo region. In Karas region, the months of April to November are likely to lead to more malnutrition cases, nevertheless, significant findings are observed in the month of November only (RR=1.92, 95% CI: 1.27-2.89).

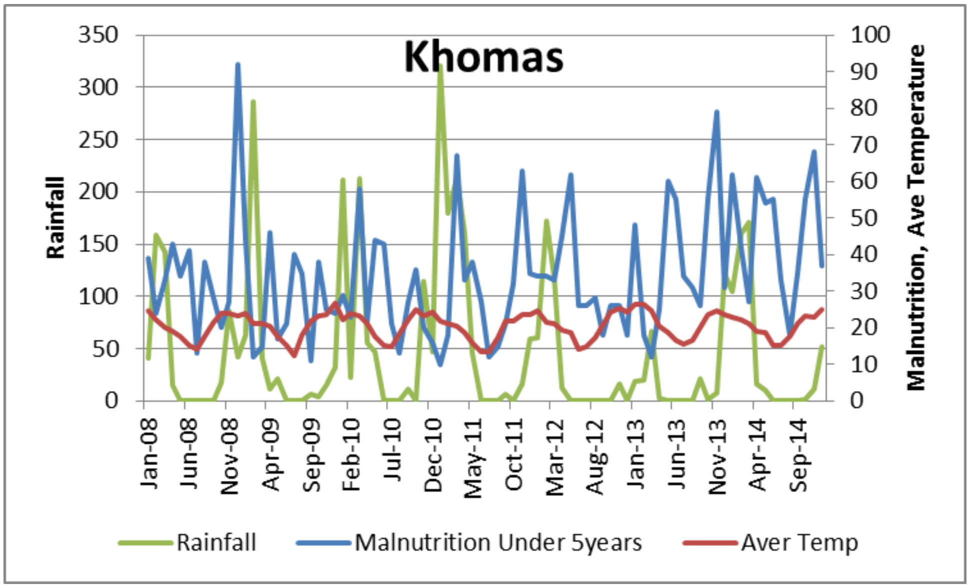
Figure 1-7. Relationship in malnutrition and climatic variables by regions

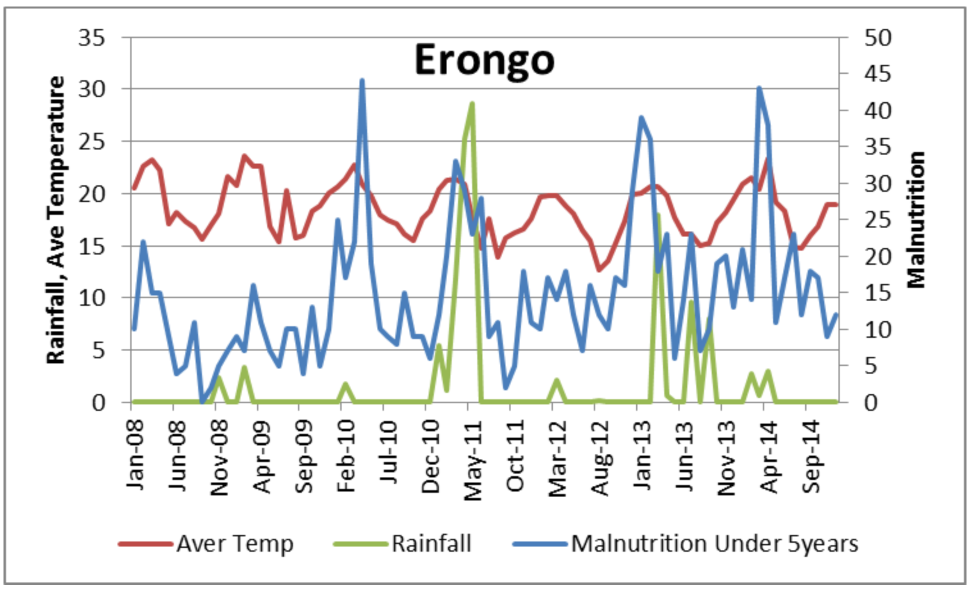





Karas
Rainfall
Malnutrition, Average Temperature
180
160
140
120
100
80
60
40
20
0
35
30
25
20
15
10
5
0
Jan-08
Jun-08
Nov-08
Apr-09
Sep-09
Feb-10
Jul-10
Dec-10
May-11
Oct-11
Mar-12
Aug-12
Jan-13
Jun-13
Nov-13
Apr-14
Sep-14
Rainfall
Malnutrition Under 5years
Aver Temp


Kavango
Rainfall, Malnutrition
Ave Temperature
400
350
300
250
200
150
100
50
0
35
30
25
20
15
10
5
0
Jan-08
Jun-08
Nov-08
Apr-09
Sep-09
Feb-10
Jul-10
Dec-10
May-11
Oct-11
Mar-12
Aug-12
Jan-13
Jun-13
Nov-13
Apr-14
Sep-14
Malnutrition Under 5years
Rainfall
Aver Temp


Khomas
Rainfall
Malnutrition, Ave Temperature
350
300
250
200
150
100
50
0
100
90
80
70
60
50
40
30
20
10
0
Jan-08
Jun-08
Nov-08
Apr-09
Sep-09
Feb-10
Jul-10
Dec-10
May-11
Oct-11
Mar-12
Aug-12
Jan-13
Jun-13
Nov-13
Apr-14
Sep-14
Rainfall
Malnutrition Under 5years
Aver Temp


Erongo
Rainfall, Ave Temperature
Malnutrition
35
30
25
20
15
10
5
0
50
45
40
35
30
25
20
15
10
5
0
Jan-08
Jun-08
Nov-08
Apr-09
Sep-09
Feb-10
Jul-10
Dec-10
May-11
Oct-11
Mar-12
Aug-12
Jan-13
Jun-13
Nov-13
Apr-14
Sep-14
Aver Temp
Rainfall
Malnutrition Under 5years

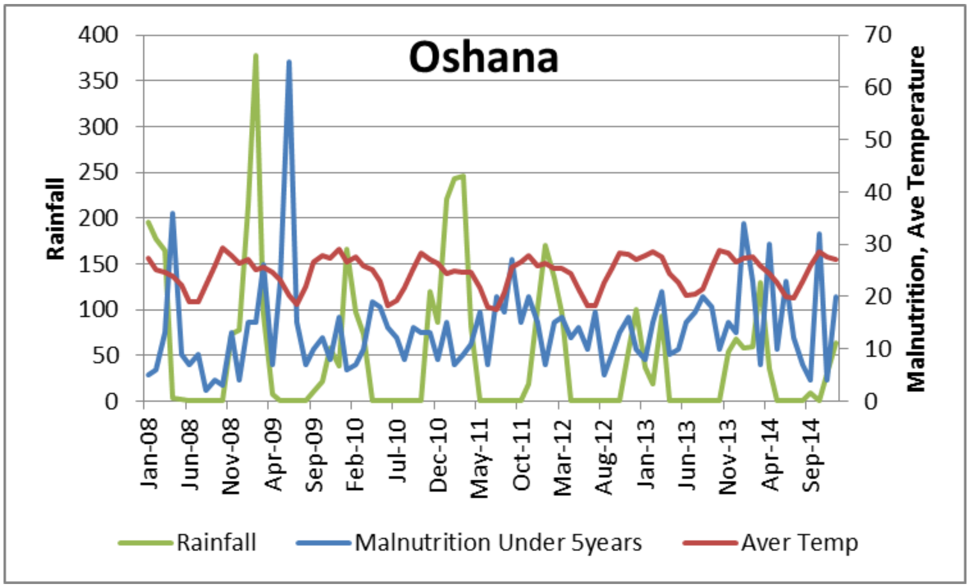


Table 2: Regression estimates from separate regional models of the relationship between malnutrition and climatic variables, controlled for year and month.

	Erongo Region			Karas Region			Kavango Region			Khomas Region			Otjozondjupa Region			Zambezi Region			Oshana Region		
Variable	RR	95% CI		RR	95% CI		RR	95% CI		RR	95% CI		RR	95% CI		RR	95% CI		RR	95% CI	
MaxT(Lag1)	0.92	0.86	0.97	1.05	0.95	1.17	0.97	0.93	1	0.88	0.83	0.94	1.02	0.96	1.08	1.01	0.94	1.09	0.96	0.91	1.02
MinT(Lag1)	1.31	1.2	1.42	0.98	0.88	1.09	1.01	0.97	1.04	1.03	0.96	1.1	0.93	0.89	0.96	1	0.96	1.05	1.03	0.97	1.11
Rain(Lag1)	1	0.99	1.01	1	1	1.01	1	1	1	1	1	1	1	1	1	1	1	1	1	0.99	1.02
MaxT(Lag2)	0.99	0.94	1.05	1.09	1	1.2	0.95	0.92	0.99	1	0.95	1.06	0.88	0.84	0.93	1.04	0.97	1.12	0.99	0.94	1.05
MinT(Lag2)	1.04	0.96	1.13	0.96	0.87	1.05	0.99	0.96	1.03	1.03	0.97	1.09	1.12	1.08	1.17	1.05	1	1.1	0.99	0.93	1.06
Rain(Lag2)	1.02	1.01	1.03	1.01	1	1.01	1	1	1	1	1	1	1	1	1	1	1	1	0.99	0.97	0.99
Year 2008	0.41	0.31	0.54	1.08	0.82	1.42	1.36	1.2	1.53	0.77	0.67	0.89	0.58	0.46	0.72	0.43	0.34	0.53	0.54	0.4	0.72
Year 2009	0.44	0.34	0.56	1.5	1.16	1.95	0.84	0.75	0.94	0.56	0.49	0.65	0.78	0.66	0.92	0.62	0.5	0.77	1.23	0.99	1.52
Year 2010	1.14	0.9	1.45	1.23	0.94	1.61	1.11	1	1.22	0.7	0.6	0.81	0.99	0.85	1.16	0.92	0.77	1.1	0.71	0.57	0.89
Year 2011	1.37	1	1.88	1.21	0.94	1.54	1.17	1.06	1.29	0.57	0.49	0.67	0.61	0.52	0.72	0.77	0.64	0.92	0.86	0.59	1.26
Year 2012	1.58	1.1	2.27	0.99	0.76	1.3	1.47	1.34	1.61	0.76	0.67	0.88	0.87	0.75	1.01	0.92	0.78	1.1	0.61	0.44	0.83
Year 2013	1.04	0.85	1.28	1.23	0.96	1.58	1.41	1.27	1.57	1.06	0.93	1.22	0.96	0.78	1.17	1.4	1.18	1.67	0.79	0.62	1.01
Year 2014	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.
January	0.82	0.58	1.15	0.8	0.53	1.2	0.85	0.73	0.98	0.89	0.73	1.09	0.9	0.69	1.16	1.46	0.98	2.18	1.69	1.07	2.68
February	0.47	0.28	0.79	0.6	0.37	0.99	0.62	0.5	0.76	0.51	0.4	0.64	0.63	0.46	0.85	1.42	0.79	2.56	1.78	1.02	3.12
March	0.58	0.31	1.07	0.99	0.59	1.64	0.81	0.66	1	0.53	0.41	0.68	0.82	0.59	1.12	1.59	0.91	2.78	2.58	1.44	4.64
April	0.86	0.48	1.55	1.04	0.63	1.73	0.69	0.56	0.85	0.5	0.38	0.65	0.75	0.53	1.06	2.15	1.25	3.69	1.89	1	3.56
May	0.69	0.41	1.18	1.08	0.62	1.9	0.65	0.51	0.84	0.47	0.36	0.63	0.58	0.39	0.86	1.91	1.09	3.36	1.31	0.55	3.12
June	1.17	0.77	1.79	1.19	0.59	2.38	0.59	0.41	0.85	0.52	0.36	0.76	0.51	0.31	0.84	2.03	0.96	4.27	1.15	0.3	4.37
July	2.11	1.42	3.15	1.57	0.6	4.07	0.61	0.36	1.05	0.32	0.19	0.53	0.46	0.24	0.9	3.08	1.13	8.42	0.45	0.08	2.54
August	1.82	1.17	2.83	2.37	0.83	6.71	0.81	0.43	1.55	0.33	0.19	0.6	0.45	0.21	0.98	4.13	1.3	13.2	0.09	0.01	0.63
September	1.69	1.03	2.78	1.76	0.69	4.48	0.8	0.46	1.41	0.44	0.26	0.74	0.82	0.42	1.6	2.67	0.98	7.28	0.11	0.12	0.68
October	1.82	1.15	2.86	1.81	0.93	3.53	1.1	0.78	1.57	0.97	0.69	1.38	1.1	0.73	1.68	2.53	1.35	4.74	0.3	0.09	1.06
November	1.22	0.87	1.72	1.92	1.27	2.89	1.19	0.99	1.43	1.28	1.04	1.56	1.49	1.14	1.96	1.35	0.95	1.94	0.72	0.37	1.39
December	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.

Note: RR=Relative risk; MinT=minimum temperature; MaxT=maximum temperature

In Zambezi region, all months of the year were associated with increased risk of malnutrition, with July and August at 3 times and 4 times, respectively, more likely to report malnutrition (RR=3.08, 95% CI: 1.13-8.43 in July and RR=4.13, 95% CI:1.30-13.15 in August). On the other hand, the risk of malnutrition has been present in Karas region from 2008 to 2013, relative to the year 2014. This is in contrast with Zambezi region, the only notable year with increased risk was 2013 (RR=1.40, 95% CI: 1.18-1.67).

In both Karas and Zambezi regions, rainfall at lag 1 and lag 2, were associated with increased risk of malnutrition. We also found that maximum temperature at both lags of 1 and 2, was likely to lead to malnutrition. The effect of minimum temperature was marginal, likely to reduce malnutrition in Karas region, but associated with high risk of malnutrition in Zambezi region.

Similar findings to those obtained in Erongo region, were observed in Kavango and Khomas regions. Minimum temperature and rainfall were associated with increased risk of malnutrition. Higher risk of the disease was observed to increase in the year 2010 in Kavango region, while in Khomas region, the highest risk was observed only in 2013. For both regions, the risk of malnutrition remained lower in most months, and only picked in October and November. This monthly effect is also observed in Otjozondjupa region, only peaking up starting from October. For this region, all years were associated with reduced risk of malnutrition, although climatic variables remained important factors driving the risk of malnutrition.

In Table 3, we consider a model that includes region as an explanatory variable, fitted as a categorical variable. For all the regions, pooled together, the risk of malnutrition was likely to be associated with rainfall at lag 1 (RR=1.051, 95% CI: 1.033-1.074) and lag 2 (RR=1.101, 95% CI: 1.002-1.201). The effects of temperature were marginal, of which they are likely to reduce the risk of the disease. In general, between 2008 and 2014, the risk of malnutrition only increased in 2013, relative to the year 2014 (RR=1.077, 95% CI: 1.016-1.141). Our findings also suggest, seasonal effects, with high risk observed in January, March and April, as well as in October and November, but lower in the other months. Among the 7 regions considered in this study, about three were associated with higher incidence of malnutrition. In Kavango region, the risk was almost 4 times higher than Zambezi region, while in Khomas region, the risk was estimated at RR=1.60 (95% CI: 1.48-1.172). For Otjozondjupa region, this was about 1.2 times higher than in Zambezi region (RR=1.206, 95% CI: 1.12-1.298).

Table 3: Results from an overall model including climatic, time and regional effects.

Variable	RR	95 % CI	
MaxT(Lag1)	1.005	0.991	1.019
MinT(Lag1)	0.989	0.974	1.004
Rain(Lag1)	1.051	1.033	1.074
MaxT(Lag2)	0.995	0.982	1.009
MinT(Lag2)	0.997	0.982	1.012
Rain(Lag2)	1.101	1.002	1.201
Year 2008	0.880	0.829	0.934
Year 2009	0.758	0.713	0.806
Year 2010	0.914	0.862	0.969
Year 2011	0.899	0.848	0.954
Year 2012	0.992	0.937	1.051
Year 2013	1.077	1.016	1.141
Year 2014	1.000	.	.
January	1.111	1.022	1.207
February	0.973	0.883	1.072
March	1.216	1.103	1.339
April	1.240	1.132	1.358
May	0.998	0.903	1.103
June	0.875	0.782	0.978
July	0.837	0.727	0.963
August	0.982	0.847	1.138

September	0.922	0.804	1.058
October	1.086	0.971	1.215
November	1.107	1.013	1.209
December	1.000	.	.
Erongo	0.690	0.614	0.774
Karas	0.538	0.495	0.586
Kavango	3.741	3.540	3.953
Khomas	1.600	1.488	1.721
Otjozondjupa	1.206	1.120	1.298
Zambezi	1.000	.	.

Conclusion:

In this study we focus on understanding the impact of climate variability on food security as using child malnutrition as a proxy on health and nutrition outcomes. Malnutrition is widely used to monitor development and food security, this study therefore provides evidence of the broader long-term implications of rising temperatures and changing rainfall patterns on health and nutrition outcomes.

Without considering the contextual variables associated with regions understudy, the results of our analyses suggest that there is an observed association between climatic variability and food security related outcomes. Malnutrition is sensitive to changes in temperature and rainfall. Although this paper has taken some initial steps, there is much more to do. Expand the analysis to include contextual variables that may improve understanding the impact of climate change on food security.

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