Supplementary Material

Supplementary information to Section 7.2

The burning embers diagrams (Figure 7.1, 7.2 and 7.3) outline risks associated with climate change as a function of global warming, socio-economic development and mitigation choices. Diagrams indicate transitions between undetectable, moderate, high, and very high risks to humans and ecosystems. The method is based on a literature review of estimated impacts at different global mean surface temperature levels (O'Neill et al. 2017) on different components of desertification, land degradation and food security, including emerging literature on Shared Socio-economic Pathways (SSPs) as well as literature from IPCC AR5 and SR15.

Most studies focus on changes in hazards as a function of climate change (e.g. as represented by RCP scenarios or other climate change scenarios) or climate change superimposed on present-day exposure. Only a limited number of studies focus on changes in risk as a function of both RCPs and SSPs (climate and socio-economic change and adaptation decisions). This was addressed by splitting the embers into different figures. Figure 7.1 focuses on the impact of climate change on risk, under present-day exposure and vulnerability. Figure 7.2 examines the relationship between climate change and risks under two SSPs (SSP1 and SSP3). Figure 7.3 depicts risks to humans and ecosystems as a function of the land area employed for mitigation through bioenergy plantations.

Further, a formal expert elicitation protocol, based on the modified-Delphi technique (Mukherjee et al. 2015) and the Sheffield Elicitation Framework (Oakley and O'Hagan 2016; Gosling 2018), was followed to develop threshold judgments on risk transitions. Specifically, experts participated in a multi-round elicitation process, with feedback of group opinion provided after each round: the first two rounds involved independent anonymous threshold judgment, and the final round involved a group consensus discussion (von der Gracht 2012). To strengthen the rigor of developing expert consensus on risk transitions (Hasson and Keeney 2011), the protocol pre-specified the following prior to beginning the elicitation exercise (Grant et al. 2018): the research question, eligibility criteria and strategy to recruit experts, research materials, data collection procedure, and analysis plan. This systematic process of developing expert consensus on threshold judgments for risk transitions can better inform subsequent analytical approaches—an approach that may be further developed for use in future IPCC cycles (Bojke et al. 2010; Sperber et al. 2013). References for the current and past assessments are listed at the end of this document and by the relevant tables.

Table SM7.1: literature considered in the expert judgement of risk transitions for figure 7.1

Reference	Risk	variable (unit)	Direction of impact	climate scenario	Time frame	D/A of current impact	Impact at 1 degree	Impact at 2 degree	Impact at 3 degree	Impact at 4 degree	Impact at 4.5 degree	Adaptation potential	Region (Including Regional Differences)
AVAILABILITY													
Rosenzweig, Cynthia, Joshua Elliott, Delphine Deryng, Alex C. Ruane, Christoph Müller, Almut	Availability Yield	yield	Strong negative effect on yields,	NA		-	See Figure 1. Maize mid to	Maize - 20 to +5 % yeild	Maize about - 20 to +5%	Maize - +15 to minus	Maize is now all	Between 3 and 4 degrees	Use RCPs so could examine yield

Arneth, Kenneth J. Boote, et al. 2014. “Assessing Agricultural Risks of Climate Change in the 21st Century in a Global Gridded Crop Model Intercomparison.” Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1222463110.			especially at higher levels of warming and at lower latitudes,				hight latitude is -10 to +15 % yield change	change	yield change in mid latitude and ALL negative in low latiude	20% yield change in mid latitude. Catastrophic in low latitude with - 10 to - 60 Percent change!	negative in mid latitude	seems to me catstrophic in low latitudes for maize, wheat also significant declines around 4 degrees and same for rice	according to different pathways.
Zscheischler, Jakob, Seth Westra, Bart J.J.M. Van Den Hurk, Sonia I. Seneviratne, Philip J. Ward, Andy Pitman, Amir Aghakouchak, et al. 2018. “Future Climate Risk from Compound Events.” Nature Climate Change. https://doi.org/10.1038/s41558-018-0156-3.	Availability (crop failure)	crop yield	" increases the likelihood of such events considerably, and may make events of the rarity of the Russian event foreseeable and to some extent predictable"	Review	2010	-	-	-	-	-	-	-	
IPCC Special Report on Global Warming of 1.5˚C, 2018	Availability (crop yields)	yield	Decrease to yields	NA		-	-	-	-	-	-	Limiting global warming to 1.5°C compared to 2°C would result in a lower global reduction in crop yields	
Medina, Angel, Asya Akbar, Alaa Baazeem, Alicia Rodriguez, and Naresh Magan. 2017. “Climate Change, Food Security and Mycotoxins: Do We Know Enough?” Fungal Biology Reviews. https://doi.org/10.1016/j.fbr.2017.04.002.	Availability (increased loss of crops and livestock; increased pest burden, increased disease burden; higher post-harvest losses due to mycotoxins)	infection of staple food commodities by fungal diseases pre-harvest and by spoilage fungi post-harvest	reduced availability of food	NA		-	-	-	-	-	-		low to moderate

Paterson, R. R.M., and N. Lima. 2011. "Further Mycotoxin Effects from Climate Change." Food Research International. https://doi.org/10.1016/j.foodres.2011.05.038.	Availability (increased loss of crops and livestock; increased pest burden, increased disease burden; higher post-harvest losses due to mycotoxins)	crops after harvest	reduced availability of food	NA	NA	-	-	-	-	-	-		unclear. "Crops introduced to exploit altered climate may be subject to fewer mycotoxin producing fungi (the "Parasites Lost" phenomenon). Increased mycotoxins and UV radiation may cause fungi to mutate on crops and produce different mycotoxins"
Magan, N., A. Medina, and D. Aldred. 2011. "Possible Climate-Change Effects on Mycotoxin Contamination of Food Crops Pre- and Postharvest." Plant Pathology. https://doi.org/10.1111/j.1365-3059.2010.02412.x.	Availability (increased loss of crops and livestock; increased pest burden, increased disease burden; higher post-harvest losses due to mycotoxins)	crops after harvest	reduced availability of food	NA	NA	-	-	-	-	-	-	from high risk to permanent between 3 and 5 degrees	low to moderate
Rivera-Ferre, M. G., M. Di Masso, I. Vara, M. Cuellar, A. Calle, M. Mailhos, F. López-i-Gelats, G. Bhatta, and D. Gallar. 2016. "Local Agriculture Traditional Knowledge to Ensure Food Availability in a Changing Climate: Revisiting Water Management Practices in the Indo-Gangetic Plains." Agroecology and Sustainable Food Systems. https://doi.org/10.1080/21683565.2016.1215368.	Availability (increased loss of crops and livestock; increased pest burden, increased disease burden; higher post-harvest losses due to mycotoxins)	crop yield	reduced availability of food	NA	NA	-	-	-	-	-	-	-	Local\ntraditional knowledge in agriculture (LTKA) is proposed in this article\nas valid knowledge to ensure food availability under climate change,\n given its long experience in dealing with climate variability

Zimmermann, Andrea, Heidi Webber, Gang Zhao, Frank Ewert, Johannes Kros, Joost Wolf, Wolfgang Britz, and Wim de Vries. 2017. “Climate Change Impacts on Crop Yields, Land Use and Environment in Response to Crop Sowing Dates and Thermal Time Requirements.” Agricultural Systems. https://doi.org/10.1016/j.agsy.2017.07.007.	Availability (increased yields if management assumptions hold, thermal management)	crop yields in Europe	increased yields	three SRES climate change scenarios to 2050	three SRES climate change scenarios to 2050	-	-	-	-	-	-		high
Faye, Babacar, Heidi Webber, Jesse B. Naab, Dilys S. MacCarthy, Myriam Adam, Frank Ewert, John P.A. Lamers, et al. 2018. “Impacts of 1.5 versus 2.0 °c on Cereal Yields in the West African Sudan Savanna.” Environmental Research Letters. https://doi.org/10.1088/1748-9326/aaab40.	Availability (modeled crop yield)	crop yield	negative	NA		-	-	-	-	-	-	between 1 and 2 with success of intensification the key factor making the difference between whether risk remains moderate or red to purple	low to moderate ("despite the larger losses, yields were always two to three times higher with intensification, irrespective of warming scenario")
Tesfaye, Kindie, P. H. Zaidi, Sika Gbegbelegbe, Christian Boeber, Dil Bahadur Rahut, Fite Getaneh, K. Seetharam, Olaf Erenstein, and Clare Stirling. 2017. “Climate Change Impacts and Potential Benefits of Heat-Tolerant Maize in South Asia.” Theoretical and Applied Climatology. https://doi.org/10.1007/s00704-016-1931-6.	Availability (modeled crop yield)	crop yield	negative	NA		-	-	"at regional scale, they found maize yields declines in 2050 of up to 12% to 14% in rainfed and irrigated maize"	-	-	-	between 1.0 and 1.5	low
Scheelbeek, Pauline F. D., Frances A. Bird, Hanna L. Tuomisto, Rosemary Green, Francesca B. Harris, Edward J. M. Joy, Zaid Chalabi, Elizabeth Allen, Andy Haines, and Alan D. Dangour. 2018. “Effect of Environmental Changes on Vegetable and Legume Yields and Nutritional Quality.” Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1800442115.	Availability (modeled crop yield)	crop yield	negative	NA		-	-	-	-	mean yield declines of fruits -31.5%	-		
Rippke, Ulrike, Julian Ramirez-Villegas, Andy	Availability	crop yield	negative	NA	to end	-	-	"30-60% of	-	-	-	between 2.6	low

Jarvis, Sonja J. Vermeulen, Louis Parker, Flora Mer, Bernd Diekkrüger, Andrew J. Challinor, and Mark Howden. 2016. “Timescales of Transformational Climate Change Adaptation in Sub-Saharan African Agriculture.” Nature Climate Change. https://doi.org/10.1038/nclimate2947.	(modeled crop yield)				of 21st century			common bean growing area and 20-40% of banana growing areas in Afria will lose viability in 2078-2098 with a global temperature increase of 2.6 and 4.0"				and 4.0 (""30-60% of common bean growing area and 20-40% of banana growing areas in Afria will lose viability in 2078-2098 with a global temperature increase of 2.6 and 4.0")	
Bisbis, M. B., N. Gruda, and M. Blanke, 2018: Potential impacts of climate change on vegetable production and product quality - A review. J. Clean. Prod., 170, 1602–1620, doi:10.1016/j.jclepro.2017.09.224.	Availability (modeled fruit crop yield), and utilization (reduced quality, more spoilage, reduced nutrition)	crop yield	negative	NA		-	-	-	-	-	-	between 1.0 and 1.5	medium
Tebaldi, Claudia, and David Lobell. 2018. “Estimated Impacts of Emission Reductions on Wheat and Maize Crops.” Climatic Change. https://doi.org/10.1007/s10584-015-1537-5.	Availability (models relation between climate variables, CO2 concentrations, and yields)	crop yield	negative	RCP4.5 and RCP8.5	short (2021–2040), medium (2041–2060) and long (2061–2080) time horizons	-	-	"critical or “lethal” heat extreme	-	-	-	modeling results in RCP8.5 (tripling of lethal heat extremes), modeling results in RCP4.5 (doubling of lethal heat extremes) towards end of 21st century	low
Schleussner, Carl Friedrich, Delphine Deryng, Christoph Müller, Joshua Elliott, Fahad Saeed, Christian Folberth, Wenfeng Liu, et al. 2018. “Crop Productivity Changes in 1.5 °c and 2 °c Worlds under Climate Sensitivity Uncertainty.”	Availability (reduced yields and soil fertility and increased land degradation for	yield	negative for half a degree additional warming (1.5 to 2)	HAPPI		-	-	"half a degree warming will also lead to more extreme low yields, in	-	-	-		

Environmental Research Letters. https://doi.org/10.1088/1748-9326/aab63b.	some regions and crops)							particular over tropical regions "					
Ovalle-Rivera, Oriana, Peter Läderach, Christian Bunn, Michael Obersteiner, and Götz Schroth. 2015. “Projected Shifts in Coffea Arabica Suitability among Major Global Producing Regions Due to Climate Change.” PLoS ONE. https://doi.org/10.1371/journal.pone.0124155.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	yield	Decrease in coffee yields	NA		-	-	-	-	-	-		
Bunn, Christian, Peter Läderach, Oriana Ovalle Rivera, and Dieter Kirschke. 2015. “A Bitter Cup: Climate Change Profile of Global Production of Arabica and Robusta Coffee.” Climatic Change. https://doi.org/10.1007/s10584-014-1306-x.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	yield	Decrease in coffee yields by 50%	NA		-	-	-	-	-	-		
Roberts, Michael J., and Wolfram Schlenker. 2013. “Identifying Supply and Demand Elasticities of Agricultural Commodities: Implications for the US Ethanol Mandate.” American Economic Review. https://doi.org/10.1257/aer.103.6.2265. 2009	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	yield	productivity of major crops will decline as a result of climate change, particularly from increasing warming	NA		-	-	-	-	-	-		
Peng, S., J. Huang, J. E. Sheehy, R. C. Laza, R. M. Visperas, X. Zhong, G. S. Centeno, G. S. Khush, and K. G. Cassman. 2004. “Rice Yields Decline with Higher Night Temperature from Global Warming.” Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.0403720101.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	grain yields	Grain yield of rice declined 10% for each 1°C increase in night-time temperature during the dry season	NA		-	-10%	-20%	-30%	-40%	-50%		
Asseng, S., F. Ewert, P. Martre, R. P. Rötter, D. B. Lobell, D. Cammarano, B. A. Kimball, et al. 2015. “Rising Temperatures Reduce Global Wheat Production.” Nature Climate Change. https://doi.org/10.1038/nclimate2470. et al., 2015	Availability (reduced yields and soil fertility and increased land degradation for some	soy bean & maize yields	while maize and soy bean yields are expected to decline by 6% for each day	NA		-	-6%/day above 30°C	-12%/day above 30°C	-18%/day above 30°C	-24%/day above 30°C	-30%/day above 30°C		

	regions and crops)		above 30°C.										
Asseng, Senthold, Davide Cammarano, Bruno Basso, Uran Chung, Phillip D. Alderman, Kai Sonder, Matthew Reynolds, and David B. Lobell. 2017. “Hot Spots of Wheat Yield Decline with Rising Temperatures.” Global Change Biology. https://doi.org/10.1111/gcb.13530.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	wheat yields	wheat yields are expected to decline by 6% for each 1°C increase;	NA		warming is already slowing yield gains at a majority of wheat-growing locations.	-0.06	-0.12	-0.18	-0.24	-0.3	tiping point above 28 degrees C, no yield	medium
Porter, John R., Liyong Xie, Andrew J Challinor, Kevern Cochrane, S. Mark Howden, Muhammad Mohsin Iqbal, David B. Lobell, and Maria Isabel Travasso. 2014. “Food Security and Food Production Systems.” In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 485–533. https://doi.org/10.1111/j.1728-4457.2009.00312.x.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	crop yields all crops	If global temperature increases beyond 3°C it will have negative yield impacts on all crops	NA		-	-	-	negative yield impact	-	-		
Schleussner, Carl Friedrich, Tabea K. Lissner, Erich M. Fischer, Jan Wohland, Mahé Perrette, Antonius Golly, Joeri Rogelj, et al. 2016. “Differential Climate Impacts for Policy-Relevant Limits to Global Warming: The Case of 1.5 °c and 2 °c.” Earth System Dynamics. https://doi.org/10.5194/esd-7-327-2016.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	competition for land	increasing competition for land from the expansion of bioenergy	NA		-	-	-	-	-	-		
Fischer, Günther, Mahendra Shah, Francesco N. Tubiello, and Harrij Van Velhuizen. 2005. “Socio-Economic and Climate Change Impacts on Agriculture: An Integrated Assessment, 1990-2080.” In Philosophical Transactions of the Royal Society B: Biological Sciences. https://doi.org/10.1098/rstb.2005.1744.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)		Decrease in yields	NA		-	10%	10-20%	10-20%	10-20%	-		on-farm and via market mechanisms
Smith, Pete, R. Stuart Haszeldine, and Stephen M. Smith. 2016. “Preliminary Assessment of the Potential for, and Limitations to, Terrestrial Negative	Availability (reduced yields and soil fertility and	soil	reduced yields	NA	NA	-	-	-	-	-	-	-	moderate

Emission Technologies in the UK." Environmental Science: Processes and Impacts. https://doi.org/10.1039/c6em00386a.	increased land degradation for some regions and crops)												
Challinor, A. J., J. Watson, D. B. Lobell, S. M. Howden, D. R. Smith, and N. Chhetri. 2014. "A Meta-Analysis of Crop Yield under Climate Change and Adaptation." Nature Climate Change. https://doi.org/10.1038/nclimate2153.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	crop yield	reduced yields	NA	2050 to end of century	-	-	-	-	-	-	likely between 1.5 and 2.0	low to moderate
FAO 2018a	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)	crop yield	reduced yields	NA		-	-	-	-	-	-	likely between 1.0 and 1.5	low to moderate
Roberts, Michael J., and Wolfram Schlenker. 2013. "Identifying Supply and Demand Elasticities of Agricultural Commodities: Implications for the US Ethanol Mandate." American Economic Review. https://doi.org/10.1257/aer.103.6.2265. 2009	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)(3 crops)		Decrease in yields	NA		-	30-46%	30-46%	63-80%	63-80%	-		
Richard A Betts, Lorenzo Alfieri, John Caesar, Luc Feyen, Laila Gohar, Aristeidis Koutroulis, et al. 2018. "Subject Areas : Author for Correspondence : Changes in Climate Extremes , Fresh Water Availability and Vulnerability to Food Insecurity Projected at 1 . 5 ° C and 2 ° C Global Warming with a Higher-Resolution Global Climate Model." et al, 2018	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)(food crops)	yield	decreae	NA		-	-	-	-	-	-		
Tigchelaar, M, D Battisti, R.L Naylor, and D.K Ray. 2018. "Probability of Globally Synchronized Maize Production Shocks." Proceedings of the National Academy of	Availability (reduced yields and soil fertility and increase		Decrease in yields	NA		-	-	7-10%	-	87%	-		

Sciences 115 (26): 6644–49.	d land degradation for some regions and crops)(Maize)												
Leng, Guoyong, and Jim Hall. 2019. “Crop Yield Sensitivity of Global Major Agricultural Countries to Droughts and the Projected Changes in the Future.” Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2018.10.434.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)(six crops)		Declining yield (but varies between crops and regions)	NA		-	-	-	-	-	-		Study doesn't consider adaptations
Bocchiola, D., L. Brunetti, A. Soncini, F. Polinelli, and M. Gianinetto. 2019. “Impact of Climate Change on Agricultural Productivity and Food Security in the Himalayas: A Case Study in Nepal.” Agricultural Systems. https://doi.org/10.1016/j.agsy.2019.01.008.	Availability (reduced yields and soil fertility and increased land degradation for some regions and crops)(wheat, rice, maize)		Declining	NA		-	-	-	-	-	-		Increasing altitude - increases yield for maize and rice slightly
Rozenzweig et al. 2017	Availability (simulated wheat and maize yield changes)	crop yield	negative	AgMIP coordinated global and regional assessment (CGRA)		-	-	-	-	-	-	between 1.5 and 2.0	low
Parkes et al. 2017	Availability (simulated wheat and maize yield changes)	crop yield	negative	NA		-	-	-	-	-	-	between 1.0 and 1.5	low
Lombardozzi, Danica L., Nicholas G. Smith, Susan J. Cheng, Jeffrey S. Dukes, Thomas D. Sharkey, Alistair Rogers, Rosie Fisher, and Gordon B. Bonan. 2018. “Triose Phosphate Limitation in Photosynthesis Models Reduces Leaf Photosynthesis and Global Terrestrial Carbon Storage.” Environmental Research Letters. https://doi.org/10.1088/1748-9326/aacf68.	Availability (Yield)	yield	positive effect of CO2 on future crop yields muted by negative impacts of climate	CESM/CLM4.5 under RCP8.5	2006-2100	-	-	-	-	Corn: -10 to +20% Wheat +40 to +100 %; Soy -10 to +5 %; Rice +10 to +50%	-		
Chen, Y. et al. (2018) ESD Impacts of climate change and climate	Availability (Yield)	yield	decrease in organic	NA		-	-	-	-	-	-		

extremes on major crops productivity in China at a global warming of 1.5 and 2.0C			matter in soil, soil erosion										
Leng, G. (2018) SOTE Keeping global warming within 1.5C reduces future risk of yield loss in the United States: A probabilistic modeling approach	Availability (Yield)	yield		NA		-	-	-	-	-	-		
Byers, Edward, Matthew Gidden, David Leclère, Juraj Balkovic, Peter Burek, Kristie Ebi, Peter Greve, et al. 2018. “Global Exposure and Vulnerability to Multi-Sector Development and Climate Change Hotspots.” Environmental Research Letters 13 (5): 055012. https://doi.org/10.1088/1748-9326/aabf45.	Availability (Yield)	yield		NA		-	-	-	-	-	-		
Xie, Wei, Wei Xiong, Jie Pan, Tariq Ali, Qi Cui, Dabo Guan, Jing Meng, Nathaniel D. Mueller, Erda Lin, and Steven J. Davis. 2018. “Decreases in Global Beer Supply Due to Extreme Drought and Heat.” Nature Plants. https://doi.org/10.1038/s41477-018-0263-1.	Availability barley yields (beer)	yield	Decrease in barley yield, consumption (and hence global beer supply)	NA		-	-	-3%	-10%	-17%	-		
Leng, Guoyong, and Jim Hall. 2019. “Crop Yield Sensitivity of Global Major Agricultural Countries to Droughts and the Projected Changes in the Future.” Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2018.10.434.	Availability Corn Yields	yield	Decrease to yields.	NA		2.5% decrease of corn yield for the historical period, which is reduced to 1.8% if accounting for the effects of corn growing pattern changes	Negative corn yield response to warmer growing season, largest yield reduction up to 20% by 1° increase of temperature	majority of impacts will be driven by trends in temperature rather than precipitation	-	-	-	Negative corn yield response to warmer growing season	Corn yield is predicted to decrease by 20~40% by 2050s
Leng, Guoyong. 2018. “Keeping Global Warming within 1.5 °C Reduces Future Risk of Yield Loss in the United States: A Probabilistic Modeling Approach.” Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2018.06.344.	Availability crop yields	yield	Decrease in yields	NA		-	-	-	-	-	-		
Su, B. et al. (2018) Drought losses in China might double between the 1.5C and 2.0C warming, PNAS	Availability crop yields	yield	Decrease in yields	NA		-	-	-	-	-	-		
Zhao, Chuang, Bing Liu, Shilong Piao, Xuhui Wang, David B. Lobell, Yao Huang, Mengtian	Availability maize yields	yield, production/ per hectare	Decrease in yield	NA		-	-	-	-	-	-		

Huang, et al. 2017. “Temperature Increase Reduces Global Yields of Major Crops in Four Independent Estimates.” Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1701762114.													
Brisson, Nadine, Philippe Gate, David Gouache, Gilles Charmet, François Xavier Oury, and Frédéric Huard. 2010. “Why Are Wheat Yields Stagnating in Europe? A Comprehensive Data Analysis for France.” Field Crops Research. https://doi.org/10.1016/j.fcr.2010.07.012.	Availability Yield	yield	yield losses/plateauing	NA		-	-	-	-	-	-		
Lin, M., and P. Huybers. 2012. “Reckoning Wheat Yield Trends.” Environmental Research Letters. https://doi.org/10.1088/1748-9326/7/2/024016.	Availability Yield	yield	yield losses/plateauing	NA		-	-	-	-	-	-		
Grassini, Patricio, Kent M. Eskridge, and Kenneth G. Cassman. 2013. “Distinguishing between Yield Advances and Yield Plateaus in Historical Crop Production Trends.” Nature Communications. https://doi.org/10.1038/ncomms3918.	Availability Yield	yield	yield losses/plateauing	NA		-	-	-	-	-	-		
Myers, S.S.; M. R. Smith, S. Guth, C. D. Golden, B. Vaitla, N. D. Mueller, A. D. Dangour, and P. Huybers, 2017: Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition. Annu. Rev. Public Health, 38, 259–277, doi:10.1146/annurev-publhealth-031816-044356. http://www.annualreviews.org/doi/10.1146/annurev-publhealth-031816-044356.	Availability yield declines	yield		NA		-	-	-	-	-	-		adaptation could lead to crop yields that are 7-15% higher. Gains will be highest in temperate areas but will be unlikely to help tropical maize and wheat production
Hasegawa, Tomoko, Shinichiro Fujimori, Petr Havlík, Hugo Valin, Benjamin Leon Bodirsky, Jonathan C. Doelman, Thomas Fellmann, et al. 2018. “Risk of Increased Food Insecurity under Stringent Global Climate Change Mitigation Policy.” Nature Climate Change 8 (8): 699–703. https://doi.org/10.1038/s41558-018-0230-x.	Mitigation policy combined with climate effect on yields	available land		NA		-	-	-	-	-	-		
ACCESS													
Schmidhuber, J., and F. N. Tubiello. 2007.	Access Price	Price	increase in price	NA		-	-	-	80%	170%	-	current period	

"Global Food Security under Climate Change." Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.0701976104., 2007	(cereal)											(timewise)	
IPCC AR4 (Easterling et al, 2007)	Access Price (cereal)	price	increase in price	NA		-	10-30%	10-30%	10-40%	10-40%	10-40%		
Parry, M. L., C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fischer. 2004. "Effects of Climate Change on Global Food Production under SRES Emissions and Socio-Economic Scenarios." Global Environmental Change. https://doi.org/10.1016/j.gloenvcha.2003.10.008.	Access Price (food crops)	Price	increase in price	NA		-	-	5-35%	-	-	-		Increase fertiliser and pesticide application, irrigation
Fujimori, Shinichiro, Tomoko Hasegawa, Joeri Rogelj, Xuanming Su, Petr Havlik, Volker Krey, Kiyoshi Takahashi, and Keywan Riahi. 2018. "Inclusive Climate Change Mitigation and Food Security Policy under 1.5 °C Climate Goal." Environmental Research Letters 13 (7): 074033. https://doi.org/10.1088/1748-9326/aad0f7.	Access Price (food crops)	price	increase in price	NA		-	-	-	-	-	-		food policy scenarios (international aid, domestic reallocation, bioenergy tax)
Hertel, Thomas W., Marshall B. Burke, and David B. Lobell. 2010. "The Poverty Implications of Climate-Induced Crop Yield Changes by 2030." Global Environmental Change. https://doi.org/10.1016/j.gloenvcha.2010.07.001.	Access Price (major staples)	Price	increase in price	NA		3.60%	10-15%	-	-	-	-		new crop varieties, significant expansion of irrigation Infrastructure
UNCCD 2017	Access (disproportionate impact on low-income consumers, in particular women and girls, due to lack of resources to purchase food)	soil health	negative	NA		-	-	-	-	-	-		low (soil health provides key adaptation option, without which lit reviewed by UNCCD points towards low adaptation potential)
Vermeulen, Sonja J., Bruce Campbell, and John S. Ingram. 2012. "Climate Change and Food Systems." SSRN. https://doi.org/10.1146/annurev-environ-020411-130608.	Access (inability to invest in adaptation and diversification measures to endure price rises)	agricultural yields and earnings, food prices, reliability of delivery, food quality, and, notably,	reduced access to food	NA		-	-	-	-	-	-		low

		food safety											
Morris, George Paterson, Stefan Reis, Sheila Anne Beck, Lora Elderkin Fleming, William Neil Adger, Timothy Guy Benton, and Michael Harold Depledge. 2017. “Scoping the Proximal and Distal Dimensions of Climate Change on Health and Wellbeing.” Environmental Health: A Global Access Science Source. https://doi.org/10.1186/s12940-017-0329-y.	Access (indirect impacts due to spatial dislocation of consuption from production for many societies)	crop yield	reduced access to food	GGCMs		-	-	-	-	-	-	strong negative effects of climate change, especially at higher levels of warming and at low latitudes	
FAO 2016a	Access (loss of agricultural income due to reduced yields and higher costs of production inputs, such as water, limits ability to buy food)	crop yield	negative	NA		-	-	-	-	-	-	likely 1.0 and 1.5	low to moderate
Abid, Muhammad, Uwe A. Schneider, and Jürgen Scheffran. 2016. “Adaptation to Climate Change and Its Impacts on Food Productivity and Crop Income: Perspectives of Farmers in Rural Pakistan.” Journal of Rural Studies. https://doi.org/10.1016/j.jrurstud.2016.08.005.	Access (loss of agricultural income due to reduced yields and higher costs of production inputs, such as water, limits ability to buy food)	farm income	negative	NA		-	-	-	-	-	-	likely 1.0 and 1.5	low
Harvey, Celia A., Zo Lalaina Rakotobe, Nalini S. Rao, Radhika Dave, Hery Razafimahatratra, Rivo Hasinandrianina Rabarijohn, Haingo Rajaofara, and James L. MacKinnon. 2014. “Extreme Vulnerability of Smallholder Farmers to Agricultural Risks and Climate Change in Madagascar.” Philosophical Transactions of the Royal Society B: Biological Sciences. https://doi.org/10.1098/rstb.2013.0089.	Access (loss of agricultural income due to reduced yields and higher costs of production inputs, such as water, limits ability to buy food)	farm income	negative	NA		-	-	-	-	-	-	likely 1.0 and 1.5	low

Calvin, Katherine, Marshall Wise, Page Kyle, Pralit Patel, Leon Clarke, and Jae Edmonds. 2014. “Trade-Offs of Different Land and Bioenergy Policies on the Path to Achieving Climate Targets.” Climatic Change 123 (3–4): 691–704. https://doi.org/10.1007/s10584-013-0897-y.	Access (Price)	Price	increase in price	NA		-	-	-	-	320%	-		
Kreidenweis, Ulrich, Florian Humpenöder, Miodrag Stevanović, Benjamin Leon Bodirsky, Elmar Kriegler, Hermann Lotze-Campen, and Alexander Popp. 2016. “Afforestation to Mitigate Climate Change: Impacts on Food Prices under Consideration of Albedo Effects.” Environmental Research Letters 11 (8): 085001. https://doi.org/10.1088/1748-9326/11/8/085001.	Access (Price)	Price	increase in price	NA		-	-	60-80%	-	-	-		Increase investment in R&D, etc
Tilman, David, and Michael Clark. 2014. “Global Diets Link Environmental Sustainability and Human Health.” Nature. https://doi.org/10.1038/nature13959.	Access demand	demand	doubling of demands by 2050	NA		-	-	-	-	-	-		
Chatzopoulos, Thomas, Ignacio Pérez Domínguez, Matteo Zampieri, and Andrea Toreti. 2019. “Climate Extremes and Agricultural Commodity Markets: A Global Economic Analysis of Regionally Simulated Events.” Weather and Climate Extremes. https://doi.org/10.1016/j.wace.2019.100193. et al., 2019	Access	Economic impacts				negative. Large-scale events will ‘very likely’ occur more frequently, more intensely, and last longer	key wheat-growing regions display yield reductions from −28% (Australia) to −6% (US and Ukraine). ...consumer prices increase by up to one third, most notably in Asian countries	"Besides Australia, three more regions exceed a reduction of -20%: Canada, Russia, and Kazakhstan."	"persistent large-scale harvest failures may deplete grain stocks and thus render future prices even more responsive."	-	-	unspecified in the modeling approach based on extreme events, implied 1.5GMST	governments trapped in risk-averse or risk-taking behavior, difficult to achieve and sustain crop stocks to buffer
UTILIZATION													
Müller, Christoph, Joshua Elliott, and Anders Levermann. 2014. “Food Security: Fertilizing Hidden Hunger.” Nature Climate Change. https://doi.org/10.1038/nclimate2290.	Utilization (decline in nutritional quality resulting from increasing	human migration	negative (heat stress induced long-term migration of people)	NA		-	-	-	-	-	-	likely between 1.0 and 1.5 due to heat stress peaks	low (unless long term migration is considered an acceptable form of migration)

	atmospheric CO2)												
Myers, Samuel S., Antonella Zanobetti, Itai Kloog, Peter Huybers, Andrew D.B. Leakey, Arnold J. Bloom, Eli Carlisle, et al. 2014. “Increasing CO2 Threatens Human Nutrition.” Nature. https://doi.org/10.1038/nature13179.	Utilization (decline in nutritional quality resulting from increasing atmospheric CO2)	zinc and iron	reduced nutrition	NA	2050 or 550ppm	-	-	-	-	-	-	550ppm	Low/Moderate. Differences between cultivars of a single crop suggest that breeding for decreased sensitivity to atmospheric CO2 concentration could partly address these new challenges to global health.
Smith, M. R., C. D. Golden, and S. S. Myers. 2017. “Potential Rise in Iron Deficiency Due to Future Anthropogenic Carbon Dioxide Emissions.” GeoHealth. https://doi.org/10.1002/2016gh000018.	Utilization (decline in nutritional quality resulting from increasing atmospheric CO2)	iron	negative (iron deficiency)	NA		-	-	550 ppm	-	-	-	likely between 1.0 and 1.5 due to heat stress peaks	low to moderate
Myers, Samuel S., K. Ryan Wessells, Itai Kloog, Antonella Zanobetti, and Joel Schwartz. 2015. “Effect of Increased Concentrations of Atmospheric Carbon Dioxide on the Global Threat of Zinc Deficiency: A Modelling Study.” The Lancet Global Health. https://doi.org/10.1016/S2214-109X(15)00093-5.	Utilization (decline in nutritional quality resulting from increasing atmospheric CO2)	zinc deficiency under different CO2 concentrations	negative (zinc deficiency)	NA	2050	-	-	The total number of people estimated to be placed at new risk of zinc deficiency by 2050 was 138 million (95% CI 120-156).	-	-	-		moderate
Moretti, Antonio, Michelangelo Pascale, and Antonio F. Logrieco. 2019. “Mycotoxin Risks under a Climate Change Scenario in Europe.” Trends in Food Science and Technology. https://doi.org/10.1016/j.tifs.2018.03.008.	Utilization (higher post-harvest losses due to mycotoxins)	crops after harvest	reduced availability of food	NA	current to 2050	-	-	-	-	-	-	possibly between 1.0 and 1.5	low to moderate
Fels-Klerx, H.J. Van der, C. Liu, and P. Battilani. 2016. “Modelling Climate Change Impacts on Mycotoxin	Utilization (negative impact on food	crops after harvest	reduced utilization of food	NA		-	-	-	-	-	-	likely between 1.0 and 1.5	not yet clear

Contamination.” World Mycotoxin Journal. https://doi.org/10.3920/wmj2016.2066.	safety due to effect of increased temperatures on microorganisms, including increased mycotoxins in food and feed)												
Tirado, Maria Cristina, and Janice Meerman. 2012. “Climate Change and Food and Nutrition Security.” In The Impact of Climate Change and Bioenergy on Nutrition. https://doi.org/10.1007/978-94-007-0110-6-4.	Utilization (negative impact on food safety due to effect of increased temperatures on microorganisms, including increased mycotoxins in food and feed)		reduced utilization of food	NA	to midcentury	-	-	-	-	-	-		moderate
Aberman, Noora Lisa, and Cristina Tirado. 2014. “Impacts of Climate Change on Food Utilization.” In Global Environmental Change. https://doi.org/10.1007/978-94-007-5784-4_124.	Utilization (negative impact on nutrition resulting from reduced water quantity and quality used to prepare food)	food availability, utilization, access	negative	NA	2020-end of century	-	-	-	-	-	-	likely between 1.0 and 1.5	low (water availability)
Thompson, Brian, and Marc J. Cohen. 2012. The Impact of Climate Change and Bioenergy on Nutrition. The Impact of Climate Change and Bioenergy on Nutrition. https://doi.org/10.1007/978-94-007-0110-6.	Utilization (negative impact on nutrition resulting from reduced water quantity and quality used to prepare food)	nutrition, distribution of food	negative	NA		-	-	-	-	-	-		low
Special Report on Global Warming of 1.5˚C Summary for Policymakers, 2018	Utilization (nutrition)	nutrients	Decrease in nutritional content	NA		at 0.87, yellow - associated impacts are both detecta	associated impacts are both detectable and attributable to	indicates closer to severe and widespread	-	-	-	Limiting global warming to 1.5°C compared to 2°C	

						ble and attributable to climate change with at least medium confidence.	climate change with at least medium confidence.	impacts.				would result in a lower global reduction on innutritional quality	
Bahrami, Helale, Luit J. De Kok, Roger Armstrong, Glenn J. Fitzgerald, Maryse Bourgault, Samuel Henty, Michael Tausz, and Sabine Tausz-Posch. 2017. "The Proportion of Nitrate in Leaf Nitrogen, but Not Changes in Root Growth, Are Associated with Decreased Grain Protein in Wheat under Elevated [CO2]." Journal of Plant Physiology. https://doi.org/10.1016/j.jplph.2017.05.011.	Utilization Nutrients	nutrients	above ground biomass production and yield will typically increase by 17–20% while concentrations of nutrients such as N will decrease by 9–15% in plant tissues. Here they found - The 12% loss in grain protein under e[CO2]	NA		-	-	-	-	-	-		Grain yield per plant was greater under e[CO2]. Irrigation treatment significantly enhanced grain yield by 128%. Grain protein concentration (%) decreased by 12% in e[CO2] grown wheat compared to a[CO2]. Grain protein concentration (%) was 15% higher in rain-fed than well-watered treatments but did not differ between the two wheat cultivars. Continuing favourable water supply conditions for photosynthesis during grain filling can prolong carbohydrate delivery to grains and thereby increase yield but depress grain protein, which is consistent with greater

													grain yield and lower grain protein concentrations in wellwateredcompared to rain-fed crops in our study
Medek, Danielle E., Joel Schwartz, and Samuel S. Myers. 2017. “Estimated Effects of Future Atmospheric Co$_2$concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region.” Environmental Health Perspectives. https://doi.org/10.1289/EHP41.	Utilization nutrition	protein content	Decrease Under eCO_2, rice, wheat ,barley, and potato protein contents decreased by 7.6% ,7.8%, 14.1% ,and 6.4%,respectively.	NA		-	-	-	-	-	-		
Smith, M. R., C. D. Golden, and S. S. Myers. 2017. “Potential Rise in Iron Deficiency Due to Future Anthropogenic Carbon Dioxide Emissions.” GeoHealth. https://doi.org/10.1002/2016gh000018.	Utilization nutrition	nutrients	CO_2concentrations of 550 ppm can lead to 3–11% decreases of zinc and iron concentrations in cereal grains and legumes and 5–10% reductions in the concentration of phosphorus, potassium, calcium, sulfur, magnesium, iron, zinc, copper, and manganese across a wide range of crops under more extreme conditions of 690 ppmCO_2	NA		-	-	-	-	-	-		
Puma, Michael J., Satyajit Bose, So Young Chon, and Benjamin I. Cook. 2015. “Assessing the Evolving Fragility of	Utlilization (disruptions to food	crops after harvest	reduced utilization of food	NA	1992-2009	moderate risk at present	increased connectivity and flows	-	-	-	-		low

the Global Food System." Environmental Research Letters. https://doi.org/10.1088/1748-9326/10/2/024007.	storage and transportation networks)						within global trade networks suggest that the global food system is vulnerable to systemic disruptions, especially considering tendency for exporting countries to switch to non-exporting states during times of food scarcity in the global markets.						
Wellesley, Laura, Felix Preston, Johanna Lehne, and Rob Bailey. 2017. "Chokepoints in Global Food Trade: Assessing the Risk." Research in Transportation Business and Management. https://doi.org/10.1016/j.rtbm.2017.07.007.	Utlilization (disruptions to food storage and transportation networks)	food prices	reduced utilization of food	NA		-	-	-	-	-	-	likely 1.0 and 1.5	moderate
STABILITY													
Schmidhuber, J., and F. N. Tubiello. 2007. "Global Food Security under Climate Change." Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.0701976104., 2007	Stability		High Fluctuation (price, supply, yields)	NA		negative. increased fluctuations in crop yields and local food supplies and higher risks of landslides and erosion damage, they can adversely affect the stability of food supplies and thus	In semiarid areas, droughts can dramatically reduce crop yields and livestock numbers and productivity (most in sub-Saharan Africa and parts of South Asia) poorest regions with the highest level of	-	-	-	-		Food import, freer trade, investment (storage, irrigation, transport, communication)

						food security.	chronic undernourishment will also be exposed to the highest degree of instability in food production						
Zheng, Jingyun, Lingbo Xiao, Xiuqi Fang, Zhixin Hao, Quansheng Ge, and Beibei Li. 2014. "How Climate Change Impacted the Collapse of the Ming Dynasty." Climatic Change. https://doi.org/10.1007/s10584-014-1244-7.	Stability (civil disturbance, social tension)	social tension	disruption food supply	NA		-	1. Extreme events will severely disrupt the food supply 2. Extreme events will escalate popular unrest, rebellions and wars 2. Extreme events will increase expenditure to 60 -70%	-	-	-	-		
Diffenbaugh, Noah S., Thomas W. Hertel, Martin Scherer, and Monika Verma. 2012. "Response of Corn Markets to Climate Volatility under Alternative Energy Futures." Nature Climate Change. https://doi.org/10.1038/nclimate1491.	Stability (impacts on world market export prices that carry through to domestic consumer prices due to climate shocks)	price of corn	negative	NA		-	-	-	-	-	-		low
Verma, Monika, Thomas Hertel, and Noah Diffenbaugh. 2014. "Market-Oriented Ethanol and Corn-Trade Policies Can Reduce Climate-Induced US Corn Price Volatility." Environmental Research Letters. https://doi.org/10.1088/1748-9326/9/6/064028.	Stability (impacts on world market export prices that carry through to domestic consumer prices due to climate shocks)	price of corn	likely negative	NA		-	-	-	-	-	-		low
Willenbockel, Dirk. 2012. Extreme Weather Events and Crop Price Spikes in a Changing	Stability (impacts on world market	food price	negative (potential food price	NA	2030	-	1. Extreme events, such as	-	-	-	-		moderate

Climate. Illustrative Global Simulation Scenarios. Oxfam Research Reports.	export prices that carry through to domestic consumer prices due to climate shocks)		impacts of a number of extreme weather event scenarios in 2030 for each of the main exporting regions for rice, maize and wheat)				flooding, can wipe out economic infrastructure; 2. Agricultural infrastructure will be affected 3. weather-related yield shocks occurred will occur 4. Global crop production will drop						
Salmon, J.Meghan, Mark A. Friedl, Steve Frolking, Dominik Wisser, and Ellen M. Douglas. 2015. “Global Rain-Fed, Irrigated, and Paddy Croplands: A New High Resolution Map Derived from Remote Sensing, Crop Inventories and Climate Data.” International Journal of Applied Earth Observation and Geoinformation. https://doi.org/10.1016/j.jag.2015.01.014.	stability (political and economic)	rainfall, temperature	disruption food supply, price fluctuation, decrease in production	NA		-	-	-	-	-	-		agricultural intensification, ghanges in land use practices
Medina-Elizalde, Martín, and Eelco J. Rohling. 2012. “Collapse of Classic Maya Civilization Related to Modest Reduction in Precipitation.” Science. https://doi.org/10.1126/science.1216629.	stability (political and economic)	rainfall	Low yields	NA		-	-	-	-	-	-		
Challinor, Andy J., W. Neil Adger, Tim G. Benton, Declan Conway, Manoj Joshi, and Dave Frame. 2018. “Transmission of Climate Risks across Sectors and Borders.” Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. https://doi.org/10.1098/rsta.2017.0301.	Stability (widespread crop failure contributing to migration and conflict)	crop failure	negative	NA		-	-	-	-	-	-		moderate
Hendrix, Cullen S. 2018. “Searching for Climate–conflict Links.” Nature Climate Change. https://doi.org/10.1038/s41558-018-0083-3.	Stability (widespread crop failure contributing to migration and conflict)	crop failure	negative	NA	current	-	-	-	-	-	-		moderate
Kelley, Colin, Shahrzad Mohtadi, Mark Cane,	Stability (widespr	crop failure	negative	NA	current	negative.severe	"Multiyear	-	-	-	-		low to medium.

Richard Seager, and Yochanan Kushnir. 2017. “Commentary on the Syria Case: Climate as a Contributing Factor.” Political Geography. https://doi.org/10.1016/j.polgeo.2017.06.013.	ead crop failure contributing to migration and conflict)					drought 2006/2007 caused northeastern “breadbasket” region to collapse (zero or near-zero production, livestock herds lost).	drought episodes in the late 1950s, 1980s, and 1990s, the total population of Syria (Fig. 1D) grew from 4 million in the 1950s to 22 million in recent years; (ii) decline ground water supply (iii) drought occurred shortly after the 1990s drought						
Kelley, Colin P., Shahrzad Mohtadi, Mark A. Cane, Richard Seager, and Yochanan Kushnir. 2015. “Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought.” Proceedings of the National Academy of Sciences 112 (11): 3241–46. https://doi.org/10.1073/pnas.1421533112.	Stability (widespread crop failure contributing to migration and conflict)	crop failure	negative, low yields and price increase	NA	current	-	1.Extreme events will lead to unprecedented rise in food prices 2. Extreme events will obiltrate livestock	-	-	-	-		low
Schmidhuber, J., and F. N. Tubiello. 2007. “Global Food Security under Climate Change.” Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.0701976104.	Stability (production, supply chain, extreme events)	extreme events	Fluctuation (yield and supply), Reduction (labour, productivity), Increase (disease burden)	NA		-	1. droughts can dramatically reduce crop yields and livestock productivity 2. exposed to the highest degree of instability in food production	-	-	-	-		Food imports, Freer trade, Investment (storage, irrigation, transport, communication
Chatzopoulos, Thomas, Ignacio Pérez Domínguez, Matteo Zampieri, and Andrea Toreti. 2019. “Climate Extremes and	stability(variability in supply, price)	yield, market, price	Fluctuation (yield, market and price)	NA		negative. climate extremes collide	key wheat-growing regions display yield	Besides Australia, three more	The transmission of domestic		-	unspecified in the modeling approac	buffer stock schemes for stabilizing supply

Agricultural Commodity Markets: A Global Economic Analysis of Regionally Simulated Events." Weather and Climate Extremes. https://doi.org/10.1016/j.wace.2019.100193. et al., 2019						with major drivers (population growth, dietary shifts, environmental degradation, andtrade interdependence.	reductions −28% (Australia) to −6% (US and Ukraine).	regions exceed a reduction of -20%: Canada, Russia, and Kazakhstan. The highest absolute drops, corresponding to −0.9 t/ha and −0.7 t/ha, were found in Canada and Russia.	prices to global markets is visible in most scenarios with large shocks in key exporters and importers being responsible for the most pronounced effects.			h based on extreme events, implied 1.5GMST. "Economic simulation models typically operate under the assumption of 'normal' growing conditions, contain no explicit parameterization of climatic anomalies on the supply side, and confound multifarious sources of yield fluctuation in harvest-failure scenarios"	and prices of major staple commodities in food-insecure regions may mitigate some of the induced price volatility but are generally difficult to achieve and sustain in practice
Bellemare, Marc F. "Rising Food Prices, Food Price Volatility, and Social Unrest." American Journal of Agricultural Economics, 2015, doi:10.1093/ajae/aau038.	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is reduced does not distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices	NA	2007-2010	negative.	990-2011 food price increases led to increases in social unrest, food price volatility has not been associated with increases in social unrest	-	-	-	-		medium in SSP1-like world

			spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)										
Zampieri, M., A. Ceglar, F. Dentener, and A. Toreti. 2017. “Wheat Yield Loss Attributable to Heat Waves, Drought and Water Excess at the Global, National and Subnational Scales.” Environmental Research Letters. https://doi.org/10.1088/1748-9326/aa723b.	stability(variability in supply, price)	yield, market, price	Fluctuation (yield, market and price)	NA		negative.	-	-	-	-	-		
Donati, Michele, et al. “The Impact of Investors in Agricultural Commodity Derivative Markets.” Outlook on Agriculture, 2016, doi:10.5367/oa.2016.0233.	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is reduced does not distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)		2007-2010	negative.	open trade helps improve access to food at lower prices, combined with observations in other articles about impact of market speculation (US) combined with export restraints (Russia, Ukraine, India, Vietnam) in 2007-2011 drought periods.	-	-	-	-		
Gilbert, C. L., and C. W. Morgan. “Food Price Volatility.” Philosophical Transactions of the Royal Society B: Biological Sciences, 2010,	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is		2007-2010	negative. not yet clear if trend in food price volatilit	"World dollar prices of major agricultural food commod	-	-	-	-	moderate	global

doi:10.1098/rstb.2010.0139.			reduced does not distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)			y is permanent	ities rose dramatically from late 2006 through to mid-2008. Prices collapsed dramatically in the second half of 2008 with the onset of the financial crisis. periods of high volatility have been relatively short and interspaced with longer periods of market tranquillity. It would therefore be wrong simply to extrapolate recent and current high volatility levels into the future. However, it remains valid to ask whether part of the volatility rise may be permanent."						
Gilbert, Christopher L. "How to Understand High Food Prices." Journal of Agricultural Economics, 2010, doi:10.1111/j.1477-9552.2010.00248.x.	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is reduced does not		2007-2010	negative. not yet clear if trend in food price volatility is perman	index-based investment in agricultural futures markets is seen as the	-	-	-	-		moderate depending on exposure to market speculation

			distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)			ent	major channel through which macroeconomic and monetary factors generated the 2007–2008 food price rise						
Headey, Derek. “Rethinking the Global Food Crisis: The Role of Trade Shocks.” Food Policy, 2011, doi:10.1016/j.foodpol.2010.10.003.	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is reduced does not distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)			negative.	when food prices peaked in June of 2008, they soared well above the new equilibrium price. observations that international rice prices surged in response to export restrictions by India and Vietnam suggested that trade-related factors could be an important basis for overshooting, especially given the very tangible	"In all cases except soybeans, we find that large surges in export volumes preceded the price surges. The presence of these large demand surges, together with back-of-the-envelope estimates of their price impacts, suggests that trade events played a much larger and	-	-	-		monthly data from Thailand (the largest exporter of rice), and the United States (the largest exporter of wheat and maize and the third largest exporter of soybeans).

							link between export volumes and export prices	more pervasive role than previously thought."					
Marchand, Philippe, et al. “Reserves and Trade Jointly Determine Exposure to Food Supply Shocks.” Environmental Research Letters, 2016, doi:10.1088/1748-9326/11/9/095009.	Stability (trade)	trade, supply, price	negative, trade in situations where global grain production is reduced does not distribute world food stocks / inadequate and counter to modeling results (in reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)		2007-2010	negative. without coordinated and effective international and domestic risk management of food stocks.	supply shocks driven not only by the intensification of trade, but as importantly by changes in the distribution of reserves. trade dependency may accentuate the risk of food shortages from foreign production shocks	increased number and volume of trade links (relative to production), decrease and a more even distribution of global reserves (still relative to production). -->distribution of reserves matters more than their aggregate quantity in terms of conferring resilience to shocks.	Possibility of multiple supply side shocks across different regions of the world (multi-breadbasket failure)	Compounded risk: Tra greater reliance on imports increases the risk of critical food supply losses following a foreign shock, notably in the case of several Central American and Caribbean countries that import grains from the United States"	-		Medium. Trade dependency has substantially increased in the last few decades and more than doubled since the mid-1980s (Porkka et al 2013, D’Odorico et al 2014) likely as a result of liberalization and the associated removal of subsidies and trade protections in developing countries (e.g., Shafaeddin 2005)."
Sternberg, Troy. “Chinese Drought, Bread and the Arab Spring.” Applied Geography, 2012, doi:10.1016/j.apgeog.2012.02.004.	Stability (trade, political)	trade, supply, price	negative, trade in situations where global grain production is reduced does not distribute world food stocks / inadequate and counter to modeling results (in		2007-2010	"Chinese drought contributed to a doubling of global wheat prices. The drought affected the price of bread in Egypt which influenced	-	-	-	-	-	-	Depends on food reserves, trade policy (risk management) and if multi-breadbasket failure is present

			reality producing countries protect domestic grain reserves; prices spike upwards in times of reduced yields but do not fall as much in times of normal or increased yields)			political protest. The process exemplifies the potential global consequences of climate hazards today.″							
Permafrost degradation													
Chadburn, S. E. et al., 2017 NCC	permafrost degradation	Permafrost area change (million km^2)	increased loss of permafrost, leading to radical changes in high-latitude hydrology and biogeochemical cycling. Estimated sensitivity of permafrost area loss to global mean warming at stabilization of 4.0 +/- 1.1 million km^2 °C^-1.	CMIP5, multiple RCPs	1850-2300	Indirectly	13	9	6	4	2	-	Global
Burke, E. J. et al., 2018 ERL	permafrost degradation	Increased land carbon emissions at stabilization Gt C /yr	Additional emissions between 225 and 345 GtC (10th to 90th percentile) from permafrost thaw under 2 °C stabilised warming. 60–100 GtC less in a 1.5	JULES-IMOGEN intermediate complexity climate model	1.5° and 2°C stabilization	-	1.5: 0.08 to 0.16 Gt C yr−1 (10th to 90th percentile)	0.09 to 0.19 GtC yr−1 (10th to 90th percentile)	-	-	-	-	Global

			°C world.										
Jorgenson & Osterkamp 2005	permafrost degradation	Water erosion	Increased water erosion	Review	-	-	-	-	-	-	-	-	Global
Gauthier et al., 2015	permafrost degradation	Tree mortality	Permafrost thawing in dry continental Siberia may trigger widespread drought-induced mortality in dark coniferous forests and larch forests that cover 20% of the global boreal forest	Review	-	-	-	-	-	-	-	-	Fennoscandia, Siberia and the northern reaches of North America
FAO 2012	permafrost degradation	Damage to forest hydrological regimes	Permafrost thawing will reinforce the greenhouse effect and induce irreversible damage to forest hydrological regimes, especially across regions receiving litle rainfall.	Review	2012-2030	-	-	-	-	Carbon release by 2100 could be several times that of current tropical deforestation	-	-	Siberia
Price et al., 2013	permafrost degradation	Permafrost thaw	Increases in nearsurface permafrost temperatures during 2007–2009 are up to 2 °C warmer compared to 2-3 decades, and there is a concurrent trend in its degradati	Review	1995-2100	-	Permafrost is now warming at almost all sites across the North American permafrost zones, except for site where the permafrost is already close to	-	Rapid degradation and disappearance over extensive areas within next 50–100 years (Camill 2005; Smith et al. 2005). Accelerated degrad	16%–35% of Canadian permafrost area in 2000 may be lost by 2100 (Zhang et al., 2008a; 2008b)	-	-	Canada

			on and disappearance. Overall transient responses of permafrost to warming are likely to be nonlinear.				0 °C and vertical ground temperature profiles are isothermal, indicating ongoing phase changes (Smith et al. 2010)		ation by 2050 likely in several regions.				
Hjort et al., 2018 NatComm	permafrost degradation	Proportion of all residential, transportation, and industrial infrastructure in areas of nearsurface permafrost thaw (a) and high hazard (b) in the pan-Arctic permafrost area (%)	Arctic infrastructure at risk from degrading permafrost by mid-century	Infrastructure hazard computations	2041 – 2060	-	-	4 million people, 70% of current infrastructure	-	-	-	-	Global
Fire													
Bajocco et al., 2010	fire	Area burned	Multidirectional relationships between climate, land degradation and fire may be amplified under future land use change and climate scenarios (Bajocco et al. 2010).	-	1990-2000	-	-	-	-	-	-	-	Mediterranean
Marlon et al., 2016	fire	Biomass burning	Increase in charcoal influx (i.e. biomass burning) during the undustrial period (probably not related to climate	Paleoclimate reconstruction	22ka-2000	-	-	-	-	-	-	-	Global

			but human activities)										
Giglio et al., 2016	fire	Area burned	Trends in land area burnt have varied regionally	Recent observations	1995-2011	Regionally varying trends	-	-	-	-	-	-	Northern Hemisphere Africa has experienced a fire decrease of 1.7 Mha yr-1 (–1.4% yr-1) since 2000, while Southern Hemisphere Africa saw an increase of 2.3 Mha yr-1 (+1.8% yr-1) during the same period. Southeast Asia witnessed a small increase of 0.2 Mha yr-1 (+2.5% yr-1) since 1997, while Australia experienced a sharp decrease of about 5.5 Mha yr-1 (-10.7% yr-1) during 2001-11, followed by an upsurge in 2011 that exceeded the annual area burned in the previous 14 years
Andela et al., 2017 Science	fire	Area burned	A recent analysis using the Global Fire Emissions Database v.4 that includes small fires concluded that the net reduction in land	Remote sensing	1998-2015	Global decline	-	-	-	-	-	high in the tropics	Global

			area burnt globally during 1998–2015 was -24.3± 8.8% (-1.35 ± 0.49% yr–1) . However, from the point of fire emissions it is important to consider the land cover types which have experienced changes in area burned; in this instance, most of the declines have come from grasslands, savannas and other non-forest land cover types (Andela et al. 2017).										
Abatzoglou and Williams, 2016	fire	Forest area burned	Significant recent increases in forest area burned (with higher fuel consumption per unit area) recorded in western and boreal North America.	Detection/ attribution	1979-2015	plus100 % cumulative forest fire area, CC acounted for 55% of incease in fuel arididty	-	-	-	-	-	moderate (rise in forest fires despite increasing adaptation measures)	western and boreal north America
Ansmann et al., 2018	fire	Forest area burned	Clear link between the western Canadian fires and	Aerosoles, case study	2017-2017	-	-	-	-	-	-	-	western and boreal north America

			aerosol loading over Europe.									
Pechony and Shindell 2010	fire	Fire activity (% rel to pre-industrial)	Temperature increase and precipitation decline may become the major driver of fire regimes under future climates as evapotranspiration increases and soil moisture decreases.	Driving forces, A2, A1B, B1; singe GCM, AR4-era	800-2100	-	plus0-10%	plus0-10%	plus5-10%	plus10-35%	plus15%	low under high warming levels	"Although temperatures rise throughout the country, it becomes more humid and rainy in the East and drier in theWest (Fig. 4B). Consequently, in the eastern United States fire activity declines, while rising considerably in the western United States (Fig. 4A). In both cases increasing population densities and land-cover changes (Fig. 4C) generally reduce fire activity."
Aldersley et al., 2011	fire	Fire regimes	Temperature increase and precipitation decline may become the major driver of fire regimes under future climates as evapotranspiration increases and soil moisture decreases.	Random forest on data sets	2000-2000	-	-	-	-	-	-	-	Global
Fernandes et al., 2017	fire	Fire regimes	Temperature increase and precipita	Logistic regression	1995-2015	Yes, for Indonesia during moderat	-	-	-	-	-	-	Indonesia

			tion decline may become the major driver of fire regimes under future climates as evapotranspiration increases and soil moisture decreases.			e to wet years							
Liu et al., 2010	fire	Probability of fire	The risk of wildfires in future could be expected to change, increasing significantly in North America, South America, central Asia, southern Europe, southern Africa, and Australia	KBDI on GCM data	2070-2100	-	-	-	-	-	-	-	North America, South America, central Asia, southern Europe, southern Africa, and Australia
Jolly et al., 2015	fire	Fire weather season length	Fire weather season has already increased by 18.7% globally between 1979 and 2013, with statistically significant increases across 25.3% but decreases only across 10.7% of Earth's land surface covered with vegetation; even sharper changes have	Weather analysis	1979-2013	Yes, global	plus18.7%	-	-	-	-	-	Global

			been observed during the second half of this period.										
Jolly et al., 2015	fire	Area experiencing long weather fire season	Global area experiencing long weather fire season has increased by 3.1% per annum or 108.1% during 1979–2013.	Weather analysis	1979-2013	Yes, global	plus108.1%	-	-	-	-	-	Global
Huang et al., 2014	fire	Fire frequencies	Fire frequencies by 2050 are projected to increase by ~27% globally, relative to the 2000 levels, with changes in future fire meteorology playing the most important role in enhancing the future global wildfires, followed by land cover changes, lightning activities and land use, while changes in population density exhibits the opposite effects.	A1B	2000-2050	-	-	-	19%	-	-	-	Global
Knorr et al., 2016a NCC	fire	Area burned	Climate is only one driver of a complex set of	SIMFIRE +LPJGUESS RCP4.5/8.5	1971-2100	-	no change	no change	no change	plus5%	plus10%	-	Global

			environmental, ecological and human factors in influencing fire (Bowman et al. 2011). Interplay leads to complex projections of future burnt area and fire emissions (Knorr et al. 2016b,a), yet human exposure to wildland fires is projected to increase because of population expansion into areas already under high risk of fires.										
Knorr et al., 2016a NCC	fire	Axposure (#people)	Climate is only one driver of a complex set of environmental, ecological and human factors in influencing fire (Bowman et al. 2011). Interplay leads to complex projections of future burnt area and fire emissions (Knorr et al. 2016b,a), yet human exposure	SIMFIRE +LPJGUESS RCP4.5/8.5	1971-2100	-	413	-	497-646	-	527-716	-	Global

			to wildland fires is projected to increase because of population expansion into areas already under high risk of fires.										
Knorr et al., 2016b BG	fire	Greenhouse gas emissions from fire	Climate is only one driver of a complex set of environmental, ecological and human factors in influencing fire (Bowman et al. 2011). Interplay leads to complex projections of future burnt area and fire emissions (Knorr et al. 2016b,a), yet human exposure to wildland fires is projected to increase because of population expansion into areas already under high risk of fires.	SIMFIRE +LPJGUESS RCP4.5/8.5	1971-2100	-	-15%	-	-	-	-	-	Global
Flannigan et al., 2009	fire	Area burned, fire season length	General increase in area burned and fire occurrence but a lot of spatial variability, with	Review	pres-2100	-	-	-	-	-	-	-	Review of regional studies

			some areas of no change or even decreases in area burned and occurrence. Fire seasons are lengthening for temperate and boreal regions and trend will continue in a warmer world. Future trends of fire severity and intensity are difficult to determine owing to the complex and non-linear interactions between weather, vegetation and people.										
Abatzoglou et al., 2019	fire	Multimodel median proportion of burnable terrestrial surfaces for which emergence occurs (%)	Anthropogenic increases in extreme Fire Weather Index days emerge for an increasingly large fraction of burnable land area under higher global temperatures.	Fire Weather Index on 17 CMIP5 climate models	1861-2099	Yes, on 22% of burnable land	0-3%	15-30%	30-50%	-	-	-	Global (pronounced effects in Mediterranean and Amazon)
Westerling et al., 2006 Science	fire	Wildfire frequency and duration	Higher large-wildfire frequency, longer wildfire durations, and longer wildfire	Fire reports	1970-2003	Yes, for Western US	-	-	-	-	-	-	Western US

			seasons.										
Yang et al., 2014 JGR	fire	Area burned	Global decline in recent burned area (1.28 × 104km2 yr1), driven signficant decline in tropics and extratropics causd by human factors. warming and droughts are expected to increase wildfire activity towards the future.	DLEM-Fire	1901-2007	-	-	-	-	-	-	-	Global
Turco, M. et al., 2018	fire	Area burned	Increase in burned area scales with warming levels. Substantial benefits from limiting warming to well below 2 °C.	SM and NSM under RCP2.6 and RCP8.5	1981-2100	-	-	plus50-75%	plus75-175%	-	-	-	Mediterranean
Flannigan et al., 2005	fire	Area burned	Increase burned area under enhanced CO2 scenarios	2xCo2, 3xCO2 (cfr SRES A2)	1975-1995; 2050; 2100	-	-	-	plus78%	-	plus143%	-	Canada
Coastal degradation													
Mentaschi et al., 2018	coastal degradation	Coastal erosion area (km2)	Substantial global-scale increases in coastal erosion in recent decades.	Remote sensing	1984 – 2015	No	28,000 km2 eroded globally	-	-	-	-	-	Global
Neumann, B., et al., 2015 Plos One	coastal degradation	Number of people exposed to a 1-in-100 year flood event incoastal regions (million)	Increased population exposure to 1-in-100 year storm surge. Strongest chages	Population projections	2000-2060	No	625	879-949	1053-1388	-	-	-	Coastal regions are also characterised by high population density, particularly in Asia (Banglade

			in exposure in Egypt and sub-Saharan countries in Western and Eastern Africa.										sh, China, India, Indonesia, Vietnam) whereas the highest population increase of coastal regions is projected in Africa (East Africa, Egypt, and West Africa)
Nicholls et al. 2011	coastal degradation	Number of people displaced (million)	Increases in coastal erosion.	DIVA model framework	2000-2100	No	-	-	-	-	72-187 (0.9-2.4%)	high: most of the threatened population could be protected.	Global
Cazenave and Cozannet 2014	coastal degradation	-	Increases in coastal erosion.	Review, mostly qualitatively	2000-2100	No	-	-	-	-	-	-	Global (with Southeast Asia concentrating many locations highly vulnerable to relative sea level rise)
Rahmstorf 2010	coastal degradation	-	Increases in coastal erosion.	Commentary	2000-2100	Yes	-	-	-	-	-	-	Global
Meeder and Parkinson 2018	coastal degradation	Coastal erosion	Increases in coastal erosion.	Sedimentary record	1900-2000	-	-	-	-	-	-	-	Everglades, USA
Shearman et al. 2013	coastal degradation	Coastal erosion	Net contraction in mangrove area	Land cover classification	1980s-2000s	Indirectly	-0.28%	-	-	-	-	-	Asia-Pacific Region
McInnes et al. 2011	coastal degradation	Coastal erosion	CMIP3 wind speed exhibit low skill over land areas.	CMIP3 evaluation wind speed, SRES	1981-2100	-	-	-	-	-	-	-	Global
Mori et al. 2010	coastal degradation	Coastal erosion	Wave heights increase in future climates across mid-latitudes and the Antarctic Ocean.	GCM combined with a wave model under SRES	1979-2099	-	-	-	-	-	-	-	Global (rise in wave height in midlatitudes and southern ocean, decrease in tropics)
Savard et al., 2009	coastal degradation	Coastal erosion	Increases in coastal erosion	Stakeholder discussions	2005-2007	-	-	-	-	-	-	-	Canada
Tamarin-Brodsky and Kaspi 2017	coastal degradat	Tropical cyclones	Poleward shift in	Storm tracking	1980-2099	-	-	-	-	-	-	-	Midlatitudes

	ion		the genesis latitude and increased latitudinal displacement of tropical cyclones under global warming.	algorithm to CMIP5									
Ruggiero 2013	coastal degradation	Total water level	Increases in wave height (and period), increasing the probability of coastal flooding/ erosion more than sea level rise alone.	Simple total water level model	1965-2010	-	-	-	-	-	-	-	U.S. Pacific Northwest
Elliott et al., 2014	coastal degradation	Nexus	Nexus of climate change and increasing concentration of people .	Review, mostly qualitatively	-	-	-	-	-	-	-	-	Global
Knutson et al., 2010	coastal degradation	Tropical cyclone intensity	Increased intensity and frequency of high-intensity hurricanes with higher warming levels.	Review	1950-2100	Yes globally, regionally difficult	-	-	-	-	-	-	Tropical cyclone regions
Bender et al., 2010	coastal degradation	Atlantic hurricane category 4 frequency	Increased intensity and frequency of high-intensity hurricanes with higher warming levels.	CMIP3 downscaling with hurricane model; SRES A1B	2001-2020; 2081-2100	-	-	-	plus75-81%	-	-	-	Atlantic (with the largest increase projected over the Western Atlantic, north of 20°N)
Vecchi et al., 2008	coastal degradation	Hurrican Power Dissipation Index Anomaly (10^11 m^3 s^-2)	Increased intensity and frequency of high-intensity hurricanes with higher warming	Statistical regression SST PDI applied to CMIP	1950-2100	-	plus1	-1 to +4	-1 to +6	-	-	-	Atlantic

			levels.										
Bhatia et al., 2018	coastal degradation	Tropical cyclone category 4 frequency (# TCs)	Frequency, intensity, and intensification distribution of TCs all shift to higher values during the twenty-first century.	RCP4.5, single GCM	2016-2035; 2081-2100	-	plus26-67%	plus27-133%		-	-	-	Tropical cyclone regions
Bhatia et al., 2018	coastal degradation	Tropical cyclone category 5 frequency (# TCs)	Frequency, intensity, and intensification distribution of TCs all shift to higher values during the twenty-first century.	RCP4.5, single GCM	2016-2035; 2081-2100	-	plus46-50%	plus85-200%		-	-	-	Tropical cyclone regions
Tu et al., 2018	coastal degradation	Tropical cyclones	Regime shift in the destructive potential of tropical cyclones around 1998, with regional regulation by the ElNiño/Southern Oscillation and the Pacific Decadal Oscillation.	PDI on observations	1979-2016	No	-	-	-	-	-	-	Western North Pacific
Sharmila and Walsh 2018	coastal degradation	Tropical cyclones paths	Tropical cyclones paths shift poleward	Reanalysis	1980-2014	Indirectly: hadley cell expansion has been linked to climate change	-	-	-	-	-	-	Tropical cyclone regions
Kossin 2018	coastal degradation	Tropical cyclones translation speed	Over the last seven decades, the speed at which tropical	Best-track data from IBTrACS	1949-2016	Indirectly: trend analysis	-	-	-	-	-	-	Tropical cyclone regions

			cyclones move has decreased significantly as expected from theory, exacerbating the damage on local communities from increasing rainfall amounts										
Luke et al., 2016	coastal degradation	Forest composition	The heterogeneity of land degradation at coasts that are affected by tropical cyclones can be further enhanced by the interaction of its components (for example, rainfall, wind speed, and direction) with topographic and biological factors (for example, species susceptibility	Case studies of TC impacts on vegetation	2004-2007	-	-	-	-	-	-	-	West Indies
Emmanuel 2005 Nature	coastal degradation	Tropical cyclone Power Dissipation Index	Potential destructiveness of hurricanes has increased markedly since the mid-1970s due to both longer storm lifetimes and greater storm intensities.	‘best track’ tropical data sets	1930-2010	Indirectly: consistency with increase in SST	-	-	-	-	-	-	Global
Emmanuel 2017 PNAS	coastal degradat	Tropical cyclone	Increase in	downscaling of large	1981-2000;	-	x6 increase	-	x18 increas	-	-	-	Texas

	ion	precipitation	inetnse precipitation associated with tropical cyclones	numbers of tropical cyclones from three climate reanalyses and six climate models	2081-2100		in probability since late 20th century		e in probability since late 20th century				
Wehner, M. F. et al., 2018 ESD	coastal degradation	Tropical cyclone counts of category 4/5	Increase in frequency and intensity of most intense tropiccal cyclolnes under 1.5°C and 2°C warming levels.	single GCM, HAPPI protocol	HAPPI	-	at 1.5°C: plus2.1/plus1.2	plus1.4/plus1.2	-	-	-	-	Tropical cyclone regions
Hanson et al., 2011 CC	coastal degradation	People exposed to 1-in-100-year coastal floodig (# people)	Enhanced exposure to extreme coastal flooding, with total population exposure possibly increasing threefold by 2070.	Global rise of 0.5 m above current levels by 2070, +10% increase in extreme water levels	2005; 2070s	-	38.5 M people (0.6%)	150 M people	-	-	-	high! "This research shows the high potential benefits from risk-reduction planning and policies at the city scale to address the issues raised by the possible growth in exposure." (paper)	Global
Hanson et al., 2011 CC	coastal degradation	Assets exposed to 1-in-100-year coastal floodig (%global GDP of that period)	Enhanced exposure to extreme coastal flooding, with total population exposure possibly increasing threefold by 2070.	Global rise of 0.5 m above current levels by 2070, +10% increase in extreme water levels	2005; 2070s	-	5%	9%	-	-	-	high! "This research shows the high potential benefits from risk-reduction planning and policies at the city scale to address the issues raised by the possible	Global

												growth in exposure." (paper)	
Vousdoukas et al., 2016 CDD	coastal degradation	Extreme storm surge levels	The anticipated increase in relative sea level rise can be further enforced by an increase in extreme storm surge levels.	RCP4.5 + 8.5, 8 CMIP5 models	1970-2100	-	-	-	-	-	-	present and needed	Europe
Vousdoukas et al., 2017 EF	coastal degradation	Extreme sea level change compared to present-day	100-year extreme sea level along Europe's coastlines is on average projected to increase by 57/81 cm for RCP4.5/8.5.	RCP4.5 + 8.5, 6 CMIP5 models	1980-2014; 2100	-	-	plus57 cm	-	plus81cm	-	-	Europe
Vousdoukas et al., 2017 EF	coastal degradation	Extreme sea level return period affecting 5 Million Europeans	100-year extreme sea level along Europe's coastlines is on average projected to increase by 57(81) cm for RCP4.5(8.5).	RCP4.5 + 8.5, 6 CMIP5 models	1980-2014; 2100	-	100year	3 year	-	1 year	-	-	Europe
Vousdoukas et al., 2018 NComm	coastal degradation	Extreme sea level chang compared to present-day	By 2050, extreme sea level rise would annually expose a large part of the tropics to the present-day 100-year event. Unprecedented flood risk levels by the end of the century unless	RCP4.5 + 8.5, 6 CMIP5 models	1980-2014; 2100	-	-	plus34–76 cm	-	plus58-172cm	-	-	Global

			timely adaptation measures are taken.										
Rasmussen, D. J. et al., 2018	coastal degradation	Human population exposure under 2150 local SLR projections (millions)	Increased permafrost melt, increased coastal erosion	1.5K, 2.0K, 2.5K stabilisation scenarios	2010; 2150	-	1.5: 56.05 (32.54–112.97)	61.84 (32.89–138.63)	2.5: 62.27 (34.08–126.95)	-	-	-	Global
Moftakhari et al., 2017 PNAS	coastal degradation	Coastal flooding	Compound flooding from river flow and coastal water level enhances risk derived from univariate assessments.	RCP4.5 + 8.5	2030; 2050	-	-	-	-	-	-	-	Global
van den Hurk et al., 2015 ERL	coastal degradation	Coastal flooding	Compound flooding from river flow and coastal water level enhances risk derived from univariate assessments.	800 sim years with an RCM	2012-2012	-	-	-	-	-	-	-	The Netherlands
Zscheischler et al., 2018 NCC	coastal degradation	Coastal flooding	Interaction between multiple climate drivers and/or hazards play a major role in coastal extremes.	Review	-	-	-	-	-	-	-	-	USA
Jevrejeva, S. et al., 2018 ERL	coastal degradation	Coastal flooding	Rising global annual flood costs with future warming.	1.5K, 2.0K, stabilisation scenarios + RCP8.5 in CMIP5	2100	-	1.5°C: 1	1.2	-	14-27	-	"Adaptation could potentially reduce sea level induced flood costs by a factor of 10" (paper)	Global, "Upper middle income countries are projected to experience the largest increase in annual flood

													costs (up to 8% GDP) with a large proportion attributed to China. High income countries have lower projected flood costs, in part due to their high present-day protection standards." (paper)
Brown, S. et al., 2018 REC	coastal degradation	Decadal average of land inundatd by flooding (km2)	Increased soil erosion, increased soil salinity, subsiding land with future warming.	1.5, 2.0 and 3.0 stabilisation scenarios from SRES A1B, with Delta Dynamic Integrated Emulator Model	1986-2005; 2050; 2100	-	1.5°C: 1000-1500	1500-1700	2000-2500	-	-	"With slow rates of sea-level rise, adaptation remains possible, but further support is required" (paper)	Ganges-Brahmaputra-Meghna and other vulnerable deltas
Nicholls, R. J. et al., 2018	coastal degradation	Expected people flooded (millions yr–1)	Increase in coastal inundation and number of people exposed under future warming levels.	1.5K, 2.0K, stabilisation scenarios + RCP8.5 in CMIP5; Warming Acidification and Sea Level Projector Earth systems model , large ensembles	1986-2300	-	1.5°C: 150 (100-230)	170 (120-270)	-	-	400 (220-700)	"adaptation remains essential in densely populated and economically important coastal areas under climate stabilization. Given the multiple adaptation steps that this will require, an adaptation pathways approach has merits for coastal areas."	Global

												(paper)	
Mentaschi et al., 2017 GRL	coastal degradation	Extreme wave energy flux in 100yr return level	More extreme wave activity in the southern hemisphere towards the end of the century.	Spectral wave model Wavewatch III forced by 6 CMIP5 models under RCP8.5	1980-2010; 2070-2100	-	-	-	-	up to plus30%	-	-	Southern hemisphere
Villarini et al., 2014 BAMS	coastal degradation	Coastal flooding	Flooding from tropical cyclones affects large areas of the United States.	Discharge measurements	1981-2011	-	-	-	-	-	-	-	Eastern US
Woodruff et al., 2013 Nature	coastal degradation	Coastal flooding	Increase in future extreme flood elevations.	Review of global and regional studies	1981-2100	-	-	-	-	-	-	-	Global
Brecht et al., 2012 JED	coastal degradation	Coastal flooding	Strong inequalities in the risk from future disasters.	Implications of tropical storm intensification for 31 developing countries and 393 of their coastal cities with populations greater than 100,000	2000-2100	-	-	-	-	-	-	-	Selected cities across the world
Hallegatte et al 2013	coastal degradation	Flood losses (Billion US$ yr-1)	Increasing global flood future warming.	Quantification of present and future flood losses in the 136 largest coastal cities.	2005; 2050 (20 and 40 cm sea level rise; assume 2°C but no info in paper)	-	6	1000 without adaptation, 60-63 with adaptation keeping constant flood probability	-	-	-	huge challenge: "To maintain present flood risk, adaptation will need to reduce flood probabilities below present values" (paper)	Global
Jongman et al., 2012 GEC	coastal degradation	People and value of assets in flood-prone regions (Trillion US$ in 1/00 coastal flood hazard areas)	Increased people and asset exposure in 1-in-100-year coastal flood hazard areas.	Population density and GDP per capita estimate; land-use estimate	2010; 2050	-	27-46	80-158	-	-	-	-	Global (largest population exposure increase in Asia (absolute) and Sub-Sahran+North Africa (relative))

Muis et al., 2018 EF	coastal degradation	Coastal flooding	Significant correlations across the Pacific between ENSO and extreme sea levels.	Tides and storm surge reanalysis	1979-2014	No	-	-	-	-	-	-	Global
Reed et al., PNAS	coastal degradation	Return period of 1/500yr pre-industrial flood height (yr)	Mean flood heights increased by ~1.24 m from ~A.D.850 to present.	Proxy sea level records and downscaled CMIP5	850-1800; 1970-2005	Yes	24 year	-	-	-	-	-	New York
Wahl et al., NCC	coastal degradation	Return period of 1/100yr pre-industrial flood height (yr)	Increase in the number of coastal compound events over the past century .	Statistical analyses	1900-2012	Yes	42 year	-	-	-	-	-	USA & New York
Vegetation degradaton													
Allen et al., 2010	vegtation changes	Tree mortality	Increases in tree mortality	Global assessment of recent tree mortality attributed to drought and heat stress. "Although episodic mortality occurs in the absence of climate change, studies compiled here suggest that at least some of the world's forested ecosystems already may be responding to climate change and raise concern that forests may become increasingly vulnerable to higher background tree mortality	1970-2008	Yes but not formally	-	-	-	-	-	-	quasi-Global

				rates and die-off in response to future warming and drought, even in environments that are not normally considered water-limited" (paper)									
Trumbore et al.,2015	vegtation changes	Forest health	Intensification of stresses on forests	Review	-	-	-	-	-	-	-	-	-
Hember et al., 2017	vegtation changes	Net ecosystem biomass production (NEBP)	A 90% increase in NEBP driven by environmental changes.	Observations at 10,307 plots across southern ecozones of Canada	1501-2012	Yes but not formally	rise in wet climates, decline in dry climates	-	-	-	-	-	Canada
Midgley and Bond 2015	vegtation changes	Vegetation structure	Climate, atmospheric CO2 and disturbance changes are able to shift vegetation between states.	Review	-	-	-	-	-	-	-	-	Africa
Norby et al., 2010	vegtation changes	Net Primary Productivity (NPP, kg dry matter m-2 yr-1)	Increasing N limitation, expected from stand development and exacerbated by elevated CO2.	FACE: CO2 vs N	1998-2008	-	reduction in NPP difference between abient and elevated CO2 experiments	-	-	-	-	-	High latitudes
Gauthier et al., 2015	vegtation changes	Boreal forest shift to woodland/shrubland biome	Increase in drought-induced mortality, changes in climate and related disturbances may overwhelm the resilience of species and ecosystems, possibly leading to importan	Review	-	-	climate zones shift faster than adaptation capacity	-	-	-	-	-	Fennoscandia, Siberia and the northern reaches of North America

			t biome-level changes.										
FAO 2012	vegtation changes	Boreal forest productivity	Enhanced dieback and timber quality decrease despite increase in forest productivity.	Review	2012-2030	-	"Higher forest mortality is already being observed in practically all areas of the boreal belt."	-	-	-	mass destruction of forest stands.	"The state of knowledge regarding adaptive potential and the regional vulnerability of forests to climate change is insufficient" (paper)	Siberia (highest risks for Southern regions and forest steppe)
Price et al., 2013	vegtation changes	Boreal forest productivity	Where precipitation is generally nonlimiting, warming coupled with increasing atmospheric carbon dioxide may stimulate higher forest productivity. Increase in large wildfires. Risk of endemic forest insect pests population outbreaks in response to relatively small temperature increases.	Review	1995-2100	-	-	-	-	-	-	-	Canada
Girardin et al., 2016	vegtation changes	Boreal forest productivity	Tree growth dependence on soil moisture in boreal Canada since the mid-20th century. Projections of	Dendrochronology	1950-2015	drought and heat control boreal tree growth	no change	-	-	-	-	-	North America

			future drying pose risk to forests especially in moisture-limited regimes.										
Beck et al., 2011	vegtation changes	Boreal forest productivity	Growth increases at the boreal–tundra ecotones in contrast with drought-induced productivity declines throughout interior Alaska. Initiating biome shift.	Dendrochronology and remote sensing	1982-2010	drought-induced productivity declines	-	-	-	-	-	-	North America
Lewis et al., 2004	vegtation changes	Tropical forest health	Widespread changes observed in mature tropical forests.	Review	1900-2001	-	-	-	-	-	-	-	Global
Bonan et al., 2008	vegtation changes	Forest health	Forests under large pressure from global change.	Review	-	-	-	-	-	-	-	-	Global
Miles et al., 2004	vegtation changes	Species becoming non-viable (%)	Little change in the realized distributions of most species due to delays in population responses.	HADCM2 GSa1 1%CO2 (old ref)	1990-2095	-	-	-	-	-	43% by 2095	-	Amazonia (highest risks over lowland and montane forests of Western Amazonia)
Anderegg et al., 2012	vegtation changes	Tree mortality	Increased tree mortality	Review	-	-	-	-	-	-	-	-	Global
Sturrock et al., 2011	vegtation changes	Tree mortality	Increased tree mortality	Review "We Review knowledge of relationships between climate variables and several forest diseases, as well as current evidence	-	-	-	-	-	-	-	"Regardless of these uncertainties, impacts of climate change on forest health must be mitigated. This will require	Global

				of how climate, host and pathogen interactions are responding or might respond to climate change." (paper)								proactive thinking and a modified suite of forest management approaches, because status quo management strategies will not protect forest values in a changing climate. Climate change is already disrupting practices and policies for managing commercial and non-commercial forests, such as forest classification systems, projections of growth and yield and subsequent models of supply for timber and other forest products, plans and projections for managing habitat for differen	

												t species of animals, and cycling of carbon, nutrients and water (Graham et al., 1990)." (paper)	
Bentz et al., 2010	vegtation changes	Tree mortality	Increased tree mortality	Population models forced with CRCM climate projections under A2	1961-2100	-	-	-	e.g. Spruce beetle: "In the period 2001–2030 and again from 2071 to 2100, we would expect substantial increases in spruce forest area with high probability of spruce beetle offspring produced annually rather than semiannually (figure 1b, 1c, 1e, 1f). By the end of the century, the change in temperatures across the boreal forests of central Canada may cause markedly	-	-	-	North America

									higher probability of spruce beetle outbreak potential, based on developmental timing alone. A model for predicting the cold tolerance of this insect is not available" (paper)				
McDowell et al., 2011	vegtation changes	Tree mortality	Increased tree mortality	Synthetic theory	1850-2100	-	-	-	-	-	-	-	Global
Lindner et al., 2010	vegtation changes	Tree mortality	positive effects on forest growth and wood production from increasing atmospheric CO_2 content and warmer temperatures especially in northern and western Europe. Increasing drought and disturbance (e.g. fire) risks will cause adverse effects, outweighing positive trends in southern and eastern Europe.	Review	2000-2100	Some changes already detected (e.g. in Pyrenees)	-	-	-	-	-	-	Europe
Mokria et al. 2015	vegtation changes	Tree mortality	Decreasing trend in tree	Dendrochronology	2006-2013	-	-	-	-	-	-	-	Northern Ethiopia, dry

			mortality with increasing elevation.										afromontane forest
Shanahan et al., 2016	vegtation changes	Abrupt woodland - grassland shifts	Interactions between climate, CO2 and fire can make tropical ecosystems more resilient to change, but systems are dynamically unstable and potentially susceptible to abrupt shifts between woodland and grassland dominated states in the future.	28,000-year integrated record of vegetation, climate and fire from West Africa	15-28Ka	-	-	-	-	-	-	-	West Africa
Ferry Slik et al., 2002	vegtation changes	Tree mortality	Reduction in number of trees and tree species per surface area directly after disturbance (fire).	Forest plot monitoring	1970-2002	-	-	-	-	-	-	-	Indonesia
Dale et al., 2001	vegtation changes	Tree mortality	Altered frequency, intensity, duration and timing of fires, droughts, introduced species and other disturbances can affect forests.	Review	-	-	-	-	-	-	-	-	Global
Schlesinger and Jasechko 2014	vegtation changes	ratio of transpiration over evapotranspiration (%)	Changes in transpiration due to rising CO2	Review	-	-	-	-	-	-	-	-	Global

			concentrations, land use changes, shifting ecozones and climate warming.										
Loucks et al., 2010 CC	coastal degradation	Number of breeding tiger species	Tiger habitat loss under future climate change. High agreement that the joint effect of climate change and land degradation will be very negative for the area.	Sea level rise scenarios of 0, 12, 28cm (assumed 1,2,3K)	2000-2090	-	115	105	5	-	-	-	Sundarban, Bangladesh
Payo et al., 2016 CC	coastal degradation	Mangrove area loss (km2)	Increasing mangrove area losses by 2100 relative to 2000 due to sea level rise.	Sea level rise scenarios of 0.46, 0.75 and 1.48m	2000; 2100	-	-	-	81-1391km^2 lost	-	-	-	Sundarban, Bangladesh
Song et al., 2018	vegtation changes	Land change	60% of all recent land changes are associated with direct human activities whereas 40% with indirect drivers such as climate change.	Remote Sensing	1982-2016	-	40% of land change from indirect drivers such as climate change	-	-	-	-	-	Global
Mc Kee et al. 2004 GEB	vegtation changes	Salt marsh dieback (ha)	Vegetation dieback and soil degradation.	Areal and ground surveys	2000-2001	-	More than 100,000 ha affected, with 43,000 ha everely damaged	-	-	-	-	-	USA
soil erosion													
Li and Fang, 2016	soil erosion	Soil erosion rates (t ha^-1 yr^-1)	more often than not studies project an	Review	1990-2100	Indirectly: close links demonstrated	0-73.04	-	-	-	-	-	Global

			increase in erosion rates (+1.2 to + 1600%, 49 out of 205 studies project more than 50% increase).			regionally, no formal D&A							
Serpa et al., 2015	soil erosion	Sediment export change in humid/dry catchment (%)	Decrease in streamflow (2071-2100)	SWAT + ECHAM SRES A1B and B1	1971-2000; 2071-2100	-	-	-22/+5%	-29/+222%	-	-	-	Mediterranean
Neupane and Kumar, 2015	soil erosion	Change in river flow	Dominant effect of LULCC	SWAT under SRES B1, A1B, A2	1987-2001; 2091-2100	-	-	-	-	-	-	-	Big Sioux River
Mullan et al., 2012	soil erosion	Change in soil erosion	Erosion rates without land management changes would decrease by 2020s, 2050s and 2100s, dominant effect of land management	WEPP under SRES	2020s; 2050s; 2080s	-	-	-	-	-	-	-	Northern Ireland
Bond-Lamberty et al., 2018	soil erosion	Soil organic matter (SOM)	Soil carbon decline	Global soil respiration data base	1990-2014	-	-	-	-	-	-	-	Global
Bellmay et al., 2005 Nature	soil erosion	Soil property changes	Soil carbon decline	National soil inventory of England and Wales	1978-2003	Indirectly: relation between rate of carbon loss and carbon content irrespective of land use, suggesting a link to climate change.	-0.6%/yr	-	-	-	-	-	UK
Ramankutty et al., 2002	soil erosion	Suitability for agriculture (%)	Increased suitability for agriculture in northern high latitutdes ,	IS92a ‘business as usual’ "calibrating the satellite-based IGBP-DIS 1-km land-cover	1992; 2070-2099	-	-	-	-	plus16%	-	-	Global

			decrease in tropics	classification dataset (Loveland et al., 2000) against a worldwide collection of agricultural census data." (paper)									
Zabel et al., 2014	soil erosion	Suitability for agriculture (million km²)	Increased suitability for agriculture in northern high latitutdes, decrease in tropics	ECHAM5 SRES A1B	1980-2010; 2071-2100	-	-	-	-	plus 5.6	-	-	Global
Burt et al., 2016b	soil erosion	Extreme precipitation indices	Soil erosion may increase in a warmer, wetter world, yet land management is first-order control.	Commentary	1900-2016	-	-	-	-	-	-	-	India
Capolongo et al., 2008	soil erosion	Climate erosivity	Influence on soil erosion in Mediterranean	Simplified rainfall erosivity model	1951-2000	-	-	-	-	-	-	-	Mediterranean
Barring et al. 2003 Catena	soil erosion	Wind erosion	No clear trend in wind erosion.	Review	1901-2000	-	-	-	-	-	-	-	Sweden
Munson et al., 2011 PNAS	soil erosion	Wind erosion	Enhanced wind erosion.	Wind erosion model	1989-2008	-	-	-	-	-	-	-	USA
Allen & Breshears 1998 - PNAS	soil erosion	Water erosion	Increased water erosion.	Observations	1950-1990	-	-	-	-	-	-	-	USA
Shakesby 2011 Earth Science Reviews	soil erosion	Water erosion	Water erosion after wildfire not notably distinct in Mediterranean, likely due to land use effects	Review	-	-	-	-	-	-	-	-	Mediterranean
Pruski and Nearing 2002	soil erosion	Water erosion	Complex interactions betweeen several factors that affect erosion.	HadCM3	1990-2099	-	-	-	-	-	-	-	USA

Knorr et al., 2005 Nature	soil erosion	Soil Organic Carbon (SOC) turnover time	Soil carbon decline	Three-pool model, theoretical study	-	-	-	-	-	-	-	-	Global
Bond-Lamberty & Thompson 2010 Nature	soil erosion	Soil respiration change (PgC yr^-1)	Enhanced soil respiration.	Database of worldwide soil respiration observations	1961-2008	-	plus0.1 Pg C/yr	-	-	-	-	-	Global
Jiang et al., 2014	soil erosion	Soil erosion rates (t ha^-1 yr^-1)	No significnat change in soil erosion during one decade	Revised Universal Soil Loss Equation (RUSLE)	2000; 2006; 2012	-	-	-	-	-	-	-	Mount Elgon
Vanmaercke et al. 2011 (Science of the Total Environment)	soil erosion	Sediment yield	High sediment yield indicates desertification.	Review	-	-	-	-	-	-	-	-	Europe
Vanmaercke et al. 2016 (Earth-Science Reviews)	soil erosion	Volumetric gully headcut retreat rate change (%)	Increase in headcut retreat rates	Gully headcut retreat sensitivity to climate	-	-	gully erosion already forms an important problem in many regions	-	plus27-300%	-	-	-	Global
de Vente et al. 2013 ESR	soil erosion	Soil erosion and sediment yield	Importance of spatial and temporal scales when considering erosion processes.	Review	-	-	-	-	-	-	-	-	Global
Broeckx et al., 2018 ESR	soil erosion	Landslide susceptibility	precipitation not a significant driver of landslide susceptibility, but is significant in non-arid climates	Review	-	-	-	-	-	-	-	-	Africa
Gariano and Guzetti 2016 ESR	soil erosion	Landslide susceptibility	Increase in the number of people exposed to landslide risk in regions with future enhanced frequenc	Review	-	-	-	-	-	-	-	-	Global

			y and intensity of severe rainfall events.										
Water scarcity in drylands													
IPCC AR5	water scarcity	drought		observations	historical	high confidence in observed trends in some regions of the world, including drought increases in the Mediterranean and West Africa and drought decreases in central North America and northwest Australia							
Hoegh-Guldberg et al., 2018	water scarcity	drought		observations	historical	medium confidence that greenhouse forcing has contributed to increased drying in the Mediterranean region (including southern Europe, northern Africa and the Near East)							
Greve et al., GRL, 2015	water scarcity	P-ET (mm)	generally a decrease in P-ET in dryland regions but not statistically significant	RCP8.5	2080 – 2099 compared to 1980 – 1999	-	-	-	-	-	-	-	global
Byers et al., ERL, 2018	water scarcity	water stress	increased water	time sampling	2050	-	-	391 (11%)	418 (12%)	-	-	-	Drylands particularl

		index (population exposed and vulnerable in drylands, in millions and in percentage of drylands population)	stress with temperature	approach using a combination of RCPs									y impacted, including southwestern North America, southeastern Brazil, northern Africa, the Mediterranean, the Middle East, and western, southern and eastern Asia
Hanasaki, N., et al, 2013, Hydrol. Earth Syst. Sci., 17, 2393–2413, doi:10.5194/hess-17-2393-2013.	water scarcity	percentage of population under severely water-stressed conditions based on Cumulative Abstraction to Demand ratio CAD≤0.5	increase with time and RCP	RCP2.6, 4.5, 8.5	(2071 – 2100 compared to 1971 – 2000	-		3.6% - 12%	6.2% - 16%	-	12.3% - 22.4%	-	global
Huang, J. et al. 2017 (NCC) Drylands face potential threat under 2C global warming target (CarbonBrief)	impact of temperature increase	temperature	higher temperature increase in drylands compared to rest of the world			-	-	44% more warming over drylands than humid lands	-	-	-	-	drylands/global
Zeng and Yoon, GRL, 2009	increase desert area	expansion of desert area (i.e. LAI less than 1)	increase in desert area	A1B	2099 compared to 1901	-	-	-	-	-	2.5 million km2 (10% increase)/ with vegetation - albedo feedback: +8.5 million km2 (34% increase)	-	drylands/global
Liu, W. et al. 2018 (ESD) Global drought and severe drought-Affected populations in 1.5 and 2C warmer worlds	water scarcity	increase in population exposed to severe drought	increase in exposed population globally	time sampling approach at 1.5 and 2 degree		-	-	194.5± 276.5 M	-	-	-	-	global
Naumann, G. et al. (2018) Global Changes in Drought Conditions	water scarcity	drought magnitude	increase in drought	time sampling approach		-	-	Doubling of drough	-	-	-	-	global

Under Different Levels of Warming			magnitude	at 1.5 and 2 degree				t magnitude for 30% of global landmass					
Schewe et al., 2014 PNAS	water scarcity	river runoff as a proxi for water resources	increase in population confronted to water scarcity	RCP8.5		-	-	severe reduction in water resources for about 8% of the global population	severe reduction in water resources for about 14% of the global population	-	-	-	global
Haddeland et al., 2014 PNAS	Irrigation water scarcity	percentage of population under worsened water-stressed conditions based on Cumulative Abstraction to Demand ratio	irrigation water scarcity increases with temperature in most regions			-	-	-	-	-	-	-	global

Table SM7.2: literature considered in the expert judgement of risk transitions for figure 7.2

Reference	Risk	variable (unit)	climate scenario	timeframe	GMST level	Direction of impact	SSP 1	SSP2	SSP3	SSP 4	SSP5	Region (Including Regional Differences)
Food security												
(Palazzo et al. 2017)	food availability	percent deviaiton from 2010 Kilocalorie	RCP 8.5	2050		increase	up to 30%		only up to 10%			West Africa
(Hasegawa et al. 2018)	change in crop yield combined with exposure and vulnerability based on prevalence of the undernourishment (PoU) concept	population at risk of hunger (million)	RCP2.6	2050		increasing population at risk of hunger	approx 2M	approx 5M	approx 24M	-	-	sub-Saharan Africa and South Asia have highest impacts
(Hasegawa et al. 2018)	change in crop yield combined with exposure and vulnerability based on prevalence of the undernourishment (PoU) concept	population at risk of hunger (million)	RCP6.0	2050		increasing population at risk of hunger	approx 5M (0-30M) (RCP to GMT conversion based on SM SR15 ch3)	24M (2-56M) (RCP to GMT conversion based on SM SR15 ch3)	approx 80M (2-190M)	-	-	sub-Saharan Africa and South Asia have highest impacts

(Byers et al. 2018)	crop yield change	crop yield change (Number of exposed and vulnerable people)	time sampling approach using a combination of RCPs	2050	1.5		2	8	20	-	-	
(Byers et al. 2018)	crop yield change	crop yield change (Number of exposed and vulnerable people)	time sampling approach using a combination of RCPs	2050	2		24	81	178	-	-	
(Byers et al. 2018)	crop yield change	crop yield change (Number of exposed and vulnerable people)	time sampling approach using a combination of RCPs	2050	3		118	406	854	-	-	
(Wiebe et al. 2015)	Economic access	% change in price	RCP4.5	2050		Increase in price	~3% to ~17% (interquartile range)					
(Wiebe et al. 2015)	Economic access	% change in price	RCP6.0	2050		Increase in price	-	0 to ~12% increase (interquartile range)	-	-	-	
(Wiebe et al. 2015)	Economic access	% change in price	RCP8.5	2050		Increase in price			~5% to 30% (interquartile range), median by crop varies from 10% to 30%; restricting trade increases effects			
(van Meijl et al. 2018)	Crop production	% change in production	RCP6.0	2050		Decrease in production	2-3% decline		1-4% decline			
(van Meijl et al. 2018)	Economic access	% change in price	RCP6.0	2050		Increase in price	up to 5%		up to 20%			
(Ishida et al. 2014)	undernourishment	DALYs attributable to childhood underweight (DAtU)	Used RCP 4.5 for BAU	2050 compared to 2005		generally decrease in undernourishment	Health burden decreases by 36.4 million DALYS by 2030 and to 11.6 DALYS by 2050	decrease by 30.4 DALYS by 2030 and 17.0 DAYS by 2050	decrease by 16.2 DALYS by 2030 but increase to 43.7 by 2050	-	-	These are global statistics but there are regional differences. E.g. sub-Saharan Africa has higher DALYS
(Ishida et al. 2014)	undernourishment	DALYs attributable to childhood underweight (DAtU)	Used RCP 2.6	2050 compared to 2005		generally decrease in undernoursihment, although there are some climate impacts	Difference in health burden of 0.2% compared to BAU	Difference of 0.5% in 2050 compared to BAU	Difference of 2.0% compared to BAU	-	-	These are global statistics but there are regional differences. E.g. sub-Saharan Africa has higher DALYS
(Fujimori et al. 2018)	Economic access	GDP loss	RCP8.5	2100		Decline in GDP	0%	0.04%	0.57% decrease			

									in "GDP change rate"			
(Springmann et al. 2016)	Deaths due to changes in dietary and weight-related risk facors	Climate-related deaths	RCP2.6 to RCP8.5	2050			more avoided deaths compared to SSP2 and 3	intermediate	fewer avoided deaths			
Land degradation												
(Byers et al. 2018)	habitat degradation	population (Million) exposed and vulnerable in relation to share of land area within a pixel being converted from natural land to agricultural land	time sampling approach using a combination of RCPs	2050	1.5		88	88	107	-	-	non-drylands only; data provided by authors
(Byers et al. 2018)	habitat degradation	population (Million) exposed and vulnerable in relation to share of land area within a pixel being converted from natural land to agricultural land	time sampling approach using a combination of RCPs	2050	2		257	551	564	-	-	non-drylands only; data provided by authors
(Byers et al. 2018)	habitat degradation	population (Million) exposed and vulnerable in relation to share of land area within a pixel being converted from natural land to agricultural land	time sampling approach using a combination of RCPs	2050	3		652	1068	1156	-	-	non-drylands only; data provided by authors
(Hinkel et al. 2014)	flooding and sea level rise, Coastal erosion	number of people exposed to annual flooding		2100			Lowest number of people flooded	-	highest number of people flooded	-	-	
(Hinkel et al. 2014)	Flood costs, Coastal erosion	cost of flooding (% GDP)		2100		The global costs of protecting the coast with dikes are	-	-	lowest costs under contstant protection	-	highest costs under constant protecti	

						significant with annual investment and maintenance costs of US$ 12–71 billion in 2100, but much smaller than the global cost of avoided damages even without accounting for indirect costs of damage to regional production supply.			but highest under enhanced protection !		on	
(Zhang et al. 2018)	Extreme preciptation	population exposed to precipitation extremes (RX5day events exceeding 20-year return values)	time sampling approach on RCP8.5 and RCP4.5	2100	2	exposed population steadily increases with temperature, with only marginal differences between SSPs						
(Knorr et al. 2016a)	fire	exposure (#people)	RCP4.5 transient	2071-2100 vs 1971-2000	2		-	560	646	-	508	globally
(Knorr et al. 2016a)	fire	exposure (#people)	RCP8.5 transient	2071-2100 vs 1971-2000	4		-	610	716	-	527	globally
(Knorr et al. 2016b)	fire	emissions (Pg C yr^-1)	RCP4.5 transient	2071-2100 vs 1971-2000	2		-	1.22	1.11	-	1.31	globally
(Knorr et al. 2016b)	fire	emissions (Pg C yr^-1)	RCP8.5 transient	2071-2100 vs 1971-2000	4		-	1.33	1.22	-	1.43	globally
Desertification												
(Zhang et al. 2018)	Extreme preciptation	population exposed to precipitation extremes (RX5day events exceeding 20-year return values)	time sampling approach on RCP8.5 and RCP4.5	2100	2	exposed population steadily increases with temperature, with only marginal differences between SSPs						
(Byers et al. 2018)	water scarcity	water stress index (2050); population exposed and vulnerable in drylands (Units: Million and percentage of drylands population)	time sampling approach using a combination of RCPs	2050	1.5		76 (2%)	349 (10%)	783 (20%)	-	-	Dryland only: data provided by authors

(Byers et al. 2018)	water scarcity	water stress index (2050); population exposed and vulnerable in drylands (Units: Million and percentage of drylands population)	time sampling approach using a combination of RCPs	2050	2		82 (3%)	391 (11%)	864 (22%)	-	-	Dryland only: data provided by authors
(Byers et al. 2018)	water scarcity	water stress index (2050); population exposed and vulnerable in drylands (Units: Million and percentage of drylands population)	time sampling approach using a combination of RCPs	2050	3		91 (3%)	418 (12%)	919 (24%)	-	-	Dryland only: data provided by authors
(Arnell and Lloyd-Hughes 2014)	water scarcity	Numbers of people (millions) exposed to increased water resources stress	RCP2.6	2050			379–2997	473–3434	626–4088	508–3481	418–3033	
(Arnell and Lloyd-Hughes 2014)	water scarcity	Numbers of people (millions) exposed to increased water resources stress	RCP4.5	2050			810–2845	881–3239	1037–3975	884–3444	854–2879	
(Arnell and Lloyd-Hughes 2014)	water scarcity	Numbers of people (millions) exposed to increased water resources stress	RCP6	2050			759–2668	807–3054	924–3564	809–3227	803–2682	
(Arnell and Lloyd-Hughes 2014)	water scarcity	Numbers of people (millions) exposed to increased water resources stress	RCP8.5	2050			802–2947	(919–3416	1006–4201	950–3519	854–2981	
(Hanasaki et al. 2013)	water scarcity	Population living in grid cells with CAD < 0.5	RCP8.5	2041-2070			-	-	4188 - 4434 (baseline is ~2000; all regions increase)	-	-	Global. Paper includes maps and graphs with regional

												information.
(Hanasaki et al. 2013)	water scarcity	Population living in grid cells with CAD < 0.5 (millions)	RCP6.0	2041-2070			2853 - 3043 (baseline is ~2000; all regions increase)					Global. Paper includes maps and graphs with regional information.
UNCCD, 2017	mean species abundance, aridity; biodiversity, land degradation, water scarcity	population living in drylands					-	43% increase	-	-	-	

Table SM7.3: literature considered in the expert judgement of risk transitions for figure 7.3

Reference	Risk	Variable	Climate scenario	SSP	Timeframe	Non-climatic hazard	Bioenergy area	Impacts	Notes
(Humpenöder et al. 2017)	trade-offs with SDGs	sustainability indicators: SDG 2; 7; 13; 14; 15	no climate change (consistent with strong mitigation)	SSP1	2100 compared to baseline without bioenergy	bioenergy deployment	636 Mha	only slight impact on sustainability indicators (i.e. no trade-offs due to lower food demand in SSP1) compared to baseline	
(Humpenöder et al. 2017)	trade-offs with SDGs	sustainability indicators: SDG 2; 7; 13; 14; 15	no climate change (consistent with strong mitigation)	SSP2	2100 compared to baseline without bioenergy	bioenergy deployment	636 Mha	pronounced decrease in all sustainability indicators (i.e. increase in adverse side-effects) compared to case without bioenergy	
(Humpenöder et al. 2017)	trade-offs with SDGs	sustainability indicators: SDG 2; 7; 13; 14; 15	no climate change (consistent with strong mitigation)	SSP5	2100 compared to baseline without bioenergy	bioenergy deployment	636 Mha	pronounced decrease in all sustainability indicators (i.e. increase in adverse side-effects) even more severe than in SSP2	
(Heck et al. 2018)	planetary boundaries transgression	Planetary Boundaries (PBs): biosphere integrity; land-system change; biogeochemical flows; freshwater use	RCP2.6	SSP1	2050 compared to baseline without bioenergy	bioenergy deployment	870Mha	upper limit of most PBs is transgressed implying high risk of irreversible shifts	
(Heck et al. 2018)	planetary boundaries transgression	Planetary Boundaries (PBs): biosphere integrity; land-system change; biogeochemical flows; freshwater use	RCP2.6	SSP2	2050 compared to baseline without bioenergy	bioenergy deployment	778Mha	upper limit of most PBs is transgressed implying high risk of irreversible shifts	
(Boysen et al. 2017)	food production	kcal cap−1 day−1 production loss (%); N application (Mt yr^-1)	4.5°C trajectory	NA	2100	bioenergy deployment	1078Mha	-43%; 96 Mt yr^-1	
(Boysen et al. 2017)	food production	kcal cap−1 day−1 production loss	4.5°C trajectory	NA	2100	bioenergy deployment	2176Mha	-73%; 151 Mt yr^-1	

		(%); N application (Mt yr^-1)							
(Boysen et al. 2017)	food production	kcal cap−1 day−1 production loss (%); N application (Mt yr^-1)	4.5°C trajectory	NA	2100	bioenergy deployment	4267Mha	-100%; 196 Mt yr^-1	
(Hasegawa et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP1	2050 compared to baseline	mitigation policies (including bioenergy)	262Mha (106-490) (provided by authors)	approx +25M	
(Hasegawa et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP2	2050 compared to baseline?	mitigation policies (including bioenergy)	752Mha (175-1904) (provided by authors)	approx +78M (0-170)	
(Hasegawa et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP3	2050 compared to baseline?	mitigation policies (including bioenergy)	813Mha (171-1983) (provided by authors)	approx +120M	
(Fujimori et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP1	2050 compared to baseline	mitigation policies (including bioenergy)	90Mha	approx +20M	
(Fujimori et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP2	2050 compared to baseline	mitigation policies (including bioenergy)	170Mha	approx +100M	
(Fujimori et al. 2018)	population at risk of hunger	population at risk of hunger (million)	RCP2.6	SSP3	2050 compared to baseline	mitigation policies (including bioenergy)	220Mha	approx +260M	
(Obersteiner et al. 2016)	agricultural water use	km3		SSP1	2030	bioenergy	210Mha	approx + 13 km3	
(Obersteiner et al. 2016)	agricultural water use	km3		SSP2	2030	bioenergy	210Mha	approx +12km3	
(Obersteiner et al. 2016)	agricultural water use	km3		SSP3	2030	bioenergy	210Mha	approx +11km3	
(Hejazi et al. 2014)	bioenergy water withdrawal	km3		SSP3	2050	bioenergy	150 Mha	approx +300km3	Paper uses a pre-cursor to the SSP3, with a similar population and storyline.
(Hasegawa et al. 2015)	population at risk of hunger	population	RCP2.6	SSP2	2050	bioenergy	280Mha	approx +2M	
Fujimori et al., NSust, accepted	population at risk of hunger	population	No climate; but assessed in SM as small effect	SSP2	2050	bioenergy	38 - 395 Mha	approx 25 - 160 M	Difference between 1.5C scenario and Baseline for both bioenergy and impact. Total population at risk of hunger is ~300 to >500 million; total increase in population at risk of hunger is 50 to 320 M. Authors state that roughly half is attributed to bioenergy; those numbers are included here.
Fujimori et al., NSust, accepted	population at risk of hunger	population	No climate; but assessed in SM as small effect	SSP2	2050	bioenergy	43 - 225 Mha	approx 20 - 145 M	Difference between 2C scenario and Baseline for both bioenergy and impact. Total population at risk of hunger is ~290 to ~500 million; total increase in

									population at risk of hunger is 40 to 290 M. Authors state that roughly half is attributed to bioenergy; those numbers are included here.

Table SM7.4. Risks thresholds for different components of desertification, land degradation and food security as a function of global mean surface temperature change relative to pre-industrial times. The confidence levels are defined according to the IPCC guidance note on consistent treatment of uncertainties (Mastrandrea et al., 2010). These data are used in Figure 7.1

Component	**Risk Transition**	**Global mean surface temperature change above pre-industrial levels °C**		**Confidence**
Low Latitude Crop Yield	Undetectable to Moderate	Min	0.5	high
		Max	0.7	
	Moderate to High	Min	1.2	medium
		Max	2.2	
	High to Very High	Min	3.0	medium
		Max	4.0	
Food Supply Stability	Undetectable to Moderate	Min	0.75	high
		Max	0.85	
	Moderate to High	Min	0.9	medium
		Max	1.4	
	High to Very High	Min	1.5	medium
		Max	2.5	
Permafrost Degradation	Undetectable to Moderate	Min	0.3	high
		Max	0.7	
	Moderate to High	Min	1.1	high
		Max	1.5	
	High to Very High	Min	1.8	medium
		Max	2.3	
Vegetation Loss	Undetectable to Moderate	Min	0.7	high
		Max	1.0	
	Moderate to High	Min	1.6	medium
		Max	2.6	
	High to Very High	Min	2.6	medium
		Max	4.0	
Coastal Degradation	Undetectable to Moderate	Min	0.8	high
		Max	1.05	
	Moderate to High	Min	1.1	high
		Max	1.6	
	High to Very High	Min	1.8	high

		Max	2.7	
Soil Erosion	Undetectable to Moderate	Min	0.8	medium
		Max	1.2	
	Moderate to High	Min	2.0	low
		Max	3.5	
	High to Very High	Min	4.0	low
		Max	6.0	
Fire	Undetectable to Moderate	Min	0.7	high
		Max	1.0	
	Moderate to High	Min	1.3	medium
		Max	1.7	
	High to Very High	Min	2.5	medium
		Max	3.0	
Water Scarcity in Drylands	Undetectable to Moderate	Min	0.7	high
		Max	1.0	
	Moderate to High	Min	1.5	medium
		Max	2.5	
	High to Very High	Min	2.5	medium
		Max	3.5	
Food Access	Undetectable to Moderate	Min	0.8	medium
		Max	1.1	
	Moderate to High	Min	1.4	low
		Max	2.4	
	High to Very High	Min	2.4	low
		Max	3.4	
Food Nutrition	Undetectable to Moderate	Min	1.1	low
		Max	1.7	
	Moderate to High	Min	1.9	low
		Max	2.2	
	High to Very High	Min	2.3	low
		Max	3.3	

7. SM. 1. Additional embers

Details of two embers (nutrition and coastal degradation) where not included in Chapter 7 due to space limitations. Changes in atmospheric CO2, will result in reduced nutritional value of crops (iron, protein, zinc, other micronutrients, and increases in mycotoxins), impacting food utilization, with potential risks to health of vulnerable groups such as children and pregnant women (*high confidence, high agreement*). This may create nutrition-related health risks for 600 million people (Zhou et al. 2018). Further details are provided in Chapter 5 of this Report.

Coastal flooding and degradation bring risk of damage to infrastructure and livelihoods. There are very few global studies investigating past changes in coastal degradation (erosion and flooding) and associated risk (Muis et al. 2018; Mentaschi et al. 2018), yet strong evidence exists that anthropogenic climate change is already affecting the main drivers of coastal degradation, including: mean and extreme sea level (IPCC, 2013), storm surges (Wahl et al. 2015) and tropical cyclones (Kossin 2018). It is also clear that land-based processes, such as groundwater extraction and land subsidence, may impact coastal degradation {See Chapter 4, including 4.8.5}.

At 1.5°C there is a high risk of destruction of coastal infrastructure and livelihoods (Hoegh-Guldberg et al. 2018) (*high confidence*). There is an associated strong increase in people and assets exposed to mean and extreme sea level rise and to coastal flooding above 1.5°C. Very high risks start to occur above 1.8 °C (*high confidence*) (Hanson et al. 2011; Vousdoukas et al. 2017; Jevrejeva et al. 2018; Hallegatte et al. 2013). Impacts of climate change on coasts is further explored in the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

7. SM 2 SSP and Mitigation Burning Embers

Table SM7.5 Risks thresholds associated to desertification, land degradation and food security as a function of Global mean surface temperature change relative to pre-industrial levels and socio-economic development. Risks associated to desertification include, population exposed and vulnerable to water scarcity and changes in irrigation supply and demand. Risks related to land degradation include vegetation loss, population exposed to fire and floods, costs of floods, extent of deforestation, and ecosystem services including the ability of land to sequester carbon. Risks to food security include population at risk of hunger, food price increases, disability adjusted life years. The risks are assessed for two contrasted socio-economic futures (SSP1 and SSP3) under unmitigated climate change up to 3°C. These data are used in Figure 7.2.

Component	**Risk Transition**	**Global mean surface temperature change above pre-industrial levels °C**		**Confidence**
Land Degradation (SSP1)	Undetectable to Moderate	Min	0.7	High
		Max	1.0	
	Moderate to High	Min	1.8	low
		Max	2.8	
	High to Very High	Min		does not reach this threshold
		Max		
Land Degradation (SSP3)	Undetectable to Moderate	Min	0.7	High
		Max	1.0	
	Moderate to High	Min	1.4	Medium
		Max	2.0	
	High to Very High	Min	2.2	Medium
		Max	2.8	
Food Security (SSP1)	Undetectable to Moderate	Min	0.5	Medium
		Max	1.0	
	Moderate to High	Min	2.5	Medium
		Max	3.5	
	High to Very High	Min		does not reach this threshold
		Max		

Food Security (SSP3)	Undetectable to Moderate	Min	0.5	Medium
		Max	1.0	
	Moderate to High	Min	1.3	Medium
		Max	1.7	
	High to Very High	Min	2	Medium
		Max	2.7	
Desertification (SSP1)	Undetectable to Moderate	Min	0.7	High
		Max	1.0	
	Moderate to High	Min		Does not reach this threshold
		Max		
	High to Very High	Min		Does not reach this threshold
		Max		
Desertification (SSP3)	Undetectable to Moderate	Min	0.7	High
		Max	1.0	
	Moderate to High	Min	1.2	Medium
		Max	1.5	
	High to Very High	Min	1.5	Medium
		Max	2.8	

Table SM7.6 Risk thresholds associated with 2nd generation bioenergy crop deployment (in 2050) as a land-based mitigation strategy under two SSPs (SSP1 and SSP3). The assessment is based on literature investigating the consequences of bioenergy expansion for food security, ecosystem loss and water scarcity, these indicators being aggregated as a single risk metric. These data are used in Figure 7.3.

Component	**Risk Transition**	**Land area used for bioenergy crop (Mkm2)**		**Confidence**
Risk due to bioenergy deployment (SSP1)	Undetectable to Moderate	Min	1	Medium
		Max	4	
	Moderate to High	Min	6	Low
		Max	8.7	
	High to Very High	Min	8.8	Medium
		Max	20	
Risk due to bioenergy deployment (SSP3)	Undetectable to Moderate	Min	0.5	Medium
		Max	1.5	
	Moderate to High	Min	1.5	Low
		Max	3	
	High to Very High	Min	4	Medium
		Max	8	

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