UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

The future(s) of food

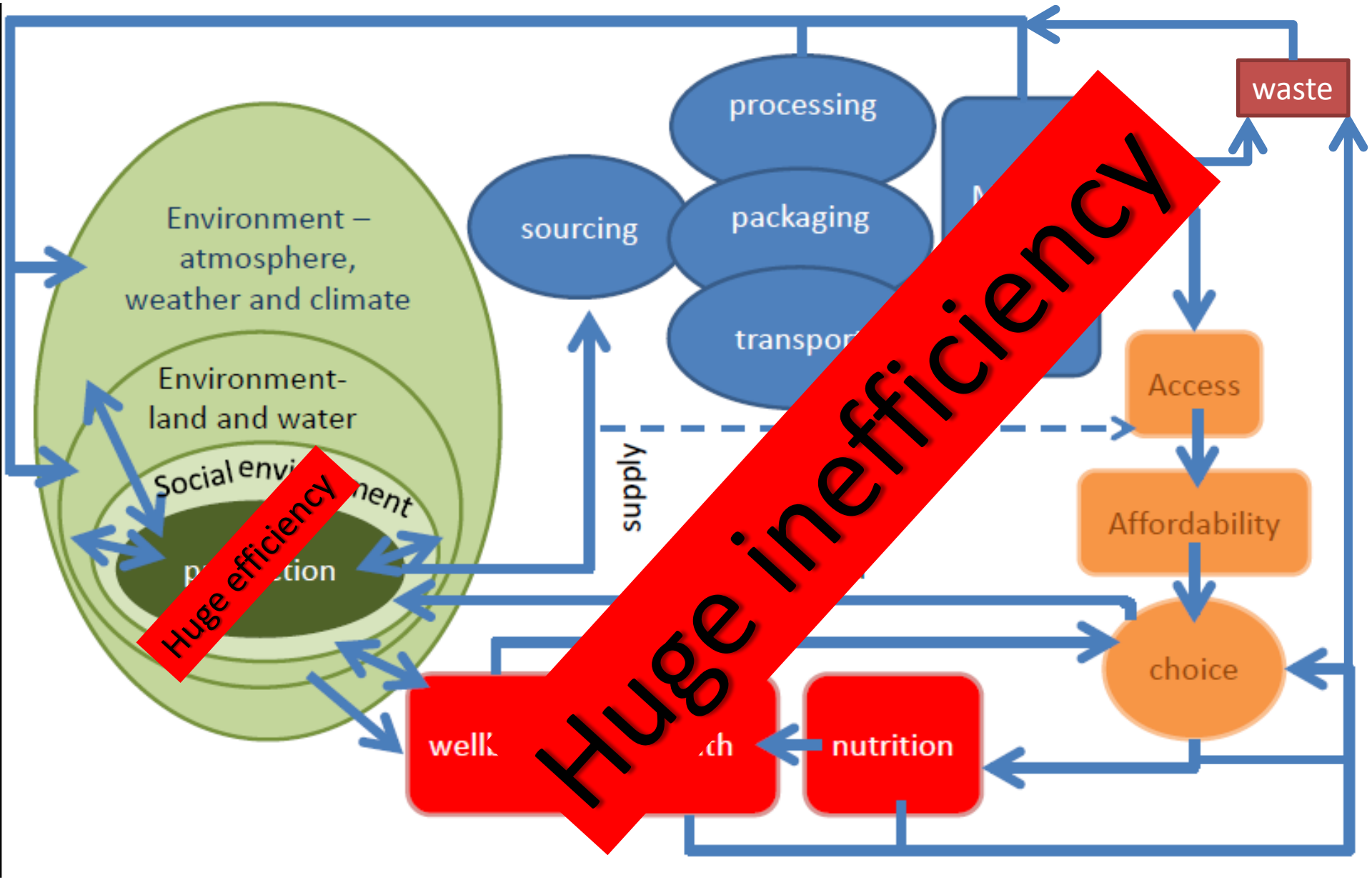
Tim Benton

University of Leeds and Royal Institute of International Affairs, Chatham House

t.g.benton@leeds.ac.uk
tbenton@chathamhouse.org

@timgbenton

What is a food system?



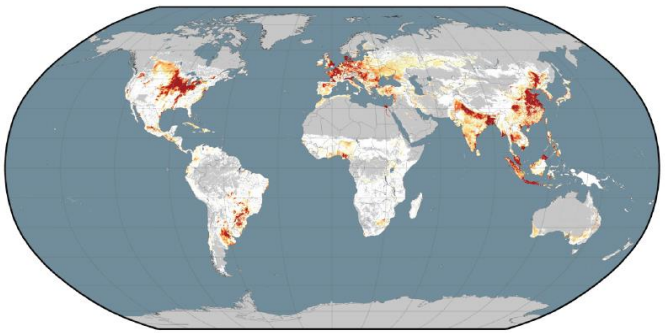
Food systems are spatial: the UK imports from 168 countries around the world

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

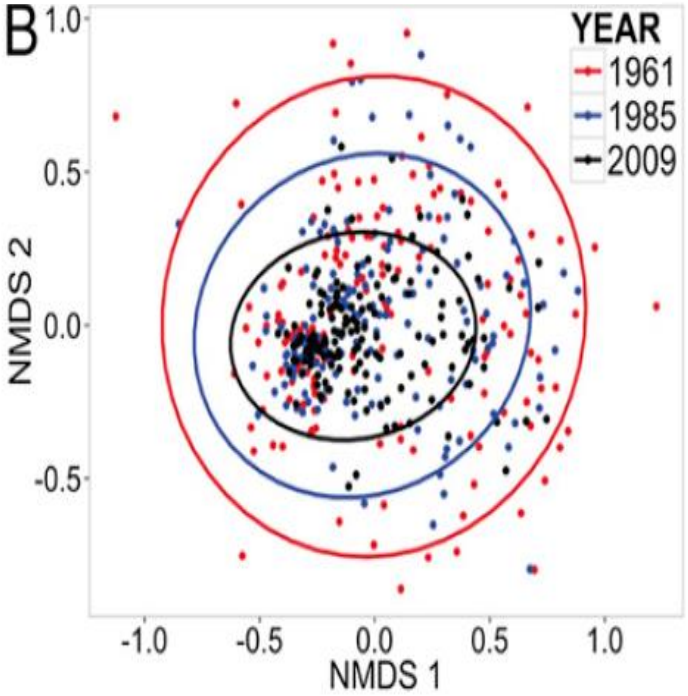
WHY OUR FOOD SYSTEM MUST CHANGE (1): HEALTH COSTS

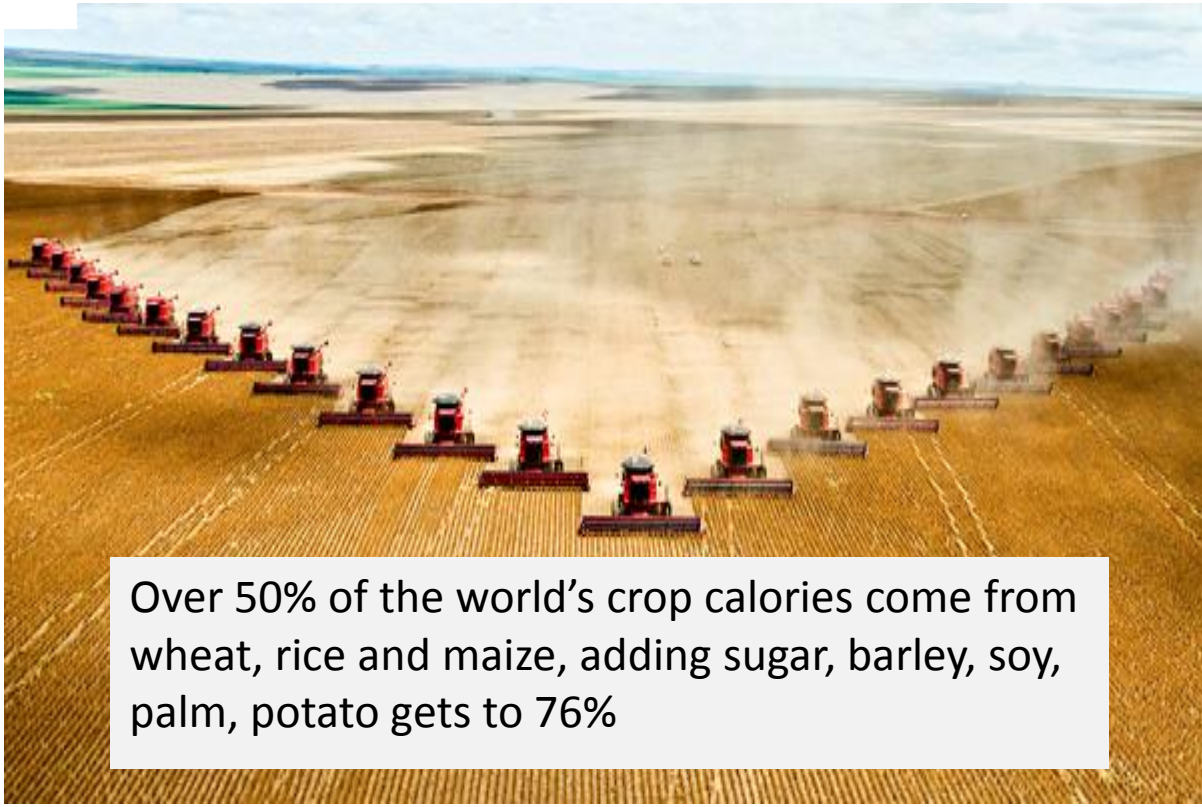
Theory of comparative advantage leads to global homogenisation



Foley et al 2011

Statistical “map” of global diets





Over 50% of the world’s crop calories come from wheat, rice and maize, adding sugar, barley, soy, palm, potato gets to 76%

Increasing homogeneity in global food supplies and the implications for food security

Colin K. Khoury[a,b,1], Anne D. Bjorkman[c,d], Hannes Dempewolf[d,e,f], Julian Ramirez-Villegas[a,g,h], Luigi Guarino[f], Andy Jarvis[a,g], Loren H. Rieseberg[d,e,i], and Paul C. Struik[b]

Associations of fats and carbohydrate intake with cardiovascular disease and mortality in 18 countries from five continents (PURE): a prospective cohort study

Mahshid Dehghan, Andrew Mente, Xiaohe Zhang, Sumathi Swaminathan, Wei Li, Viswanathan Mohan, Romaina Iqbal, Rajesh Kumar, Edelweiss Wentzel-Viljoen, Annika Rosengren, Leela Itty Amma, Alvaro Avezum, Jephat Chifamba, Rafael Diaz, Rasha Khatib, Scott Lear, Patricio Lopez-Jaramillo, Xiaoyun Liu, Rajeev Gupta, Noushin Mohammadifard, Nan Gao, Aytekin Oguz, Anis Safura Ramli, Pamela Seron, Yi Sun, Andrzej Szuba, Lungiswa Tsolekile, Andreas Wielgosz, Rita Yusuf, Afzal Hussein Yusufali, Koon K Teo, Sumathy Rangarajan, Gilles Dagenais, Shrikant I Bangdiwala, Shofiqul Islam, Sonia S Anand, Salim Yusuf, on behalf of the Prospective Urban Rural Epidemiology (PURE) study investigators*

Summary

Background The relationship between macronutrients and cardiovascular disease and mortality is controversial. Most available data are from European and North American populations where nutrition excess is more likely, so their applicability to other populations is unclear.

Methods The Prospective Urban Rural Epidemiology (PURE) study is a large, epidemiological cohort study of individuals aged 35–70 years (enrolled between Jan 1, 2003, and March 31, 2013) in 18 countries with a median follow-up of 7·4 years (IQR 5·3–9·3). Dietary intake of 135 335 individuals was recorded using validated food frequency questionnaires. The primary outcomes were total mortality and major cardiovascular events (fatal cardiovascular disease, non-fatal myocardial infarction, stroke, and heart failure). Secondary outcomes were all myocardial infarctions, stroke, cardiovascular disease mortality, and non-cardiovascular disease mortality. Participants were categorised into quintiles of nutrient intake (carbohydrate, fats, and protein) based on percentage of energy provided by nutrients. We assessed the associations between consumption of carbohydrate, total fat, and each type of fat with cardiovascular disease and total mortality. We calculated hazard ratios (HRs) using a multivariable Cox frailty model with random intercepts to account for centre clustering.

Findings During follow-up, we documented 5796 deaths and 4784 major cardiovascular disease events. Higher carbohydrate intake was associated with an increased risk of total mortality (highest [quintile 5] *vs* lowest quintile [quintile 1] category, HR 1·28 [95% CI 1·12–1·46], p_{trend}=0·0001) but not with the risk of cardiovascular disease or cardiovascular disease mortality. Intake of total fat and each type of fat was associated with lower risk of total mortality (quintile 5 *vs* quintile 1, total fat: HR 0·77 [95% CI 0·67–0·87], p_{trend}<0·0001; saturated fat, HR 0·86 [0·76–0·99], p_{trend}=0·0088; monounsaturated fat: HR 0·81 [0·71–0·92], p_{trend}<0·0001; and polyunsaturated fat: HR 0·80 [0·71–0·89], p_{trend}<0·0001). Higher saturated fat intake was associated with lower risk of stroke (quintile 5 *vs* quintile 1, HR 0·79 [95% CI 0·64–0·98], p_{trend}=0·0498). Total fat and saturated and unsaturated fats were not significantly associated with risk of myocardial infarction or cardiovascular disease mortality.

Interpretation High carbohydrate intake was associated with higher risk of total mortality, whereas total fat and individual types of fat were related to lower total mortality. Total fat and types of fat were not associated with cardiovascular disease, myocardial infarction, or cardiovascular disease mortality, whereas saturated fat had an inverse association with stroke. Global dietary guidelines should be reconsidered in light of these findings.

Published Online August 29, 2017 http://dx.doi.org/10.1016/S0140-6736(17)32252-3

See Online/Comment http://dx.doi.org/10.1016/S0140-6736(17)32241-9

*Investigators listed in the appendix

Population Health Research Institute, McMaster University, Hamilton, ON, Canada (M Dehghan PhD, A Mente PhD, X Zhang MSc, Prof K K Teo MD, S Rangarajan MSc, S I Bangdiwala PhD, S Islam MSc, Prof S Yusuf DPhil); **Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, ON, Canada** (A Mente); **St John's Research Institute, St John's National Academy of Health Sciences, Sarjapur Road, Koramangala, Bangalore, Karnataka, India** (S Swaminathan PhD); **State Key Laboratory of Cardiovascular Disease, Fuwai Hospital, National Center for Cardiovascular Disease, Peking Union Medical College & Chinese Academy of Medical Sciences, Beijing, China** (Prof W Li PhD, X Liu PhD)

Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): a prospective cohort study

Victoria Miller, Andrew Mente, Mahshid Dehghan, Sumathy Rangarajan, Xiaohe Zhang, Sumathi Swaminathan, Gilles Dagenais, Rajeev Gupta, Viswanathan Mohan, Scott Lear, Shrikant I Bangdiwala, Aletta E Schutte, Edelweiss Wentzel-Viljoen, Alvaro Avezum, Yuksel Altuntas, Khalid Yusoff, Noorhassim Ismail, Nasheeta Peer, Jephat Chifamba, Rafael Diaz, Omar Rahman, Noushin Mohammadifard, Fernando Lana, Katarzyna Zatonska, Andreas Wielgosz, Afzalhussein Yusufali, Romaina Iqbal, Patricio Lopez-Jaramillo, Rasha Khatib, Annika Rosengren, V Raman Kutty, Wei Li, Jiankang Liu, Xiaoyun Liu, Lu Yin, Koon Tea, Sonia Anand, Salim Yusuf, on behalf of the Prospective Urban Rural Epidemiology (PURE) study investigators*

Summary

Background The association between intake of fruits, vegetables, and legumes with cardiovascular disease and deaths has been investigated extensively in Europe, the USA, Japan, and China, but little or no data are available from the Middle East, South America, Africa, or south Asia.

Methods We did a prospective cohort study (Prospective Urban Rural Epidemiology [PURE] in 135 335 individuals aged 35 to 70 years without cardiovascular disease from 613 communities in 18 low-income, middle-income, and high-income countries in seven geographical regions: North America and Europe, South America, the Middle East, south Asia, China, southeast Asia, and Africa. We documented their diet using country-specific food frequency questionnaires at baseline. Standardised questionnaires were used to collect information about demographic factors, socioeconomic status (education, income, and employment), lifestyle (smoking, physical activity, and alcohol intake), health history and medication use, and family history of cardiovascular disease. The follow-up period varied based on the date when recruitment began at each site or country. The main clinical outcomes were major cardiovascular disease (defined as death from cardiovascular causes and non-fatal myocardial infarction, stroke, and heart failure), fatal and non-fatal myocardial infarction, fatal and non-fatal strokes, cardiovascular mortality, non-cardiovascular mortality, and total mortality. Cox frailty models with random effects were used to assess associations between fruit, vegetable, and legume consumption with risk of cardiovascular disease events and mortality.

Findings Participants were enrolled into the study between Jan 1, 2003, and March 31, 2013. For the current analysis, we included all unrefuted outcome events in the PURE study database through March 31, 2017. Overall, combined mean fruit, vegetable and legume intake was 3·91 (SD 2·77) servings per day. During a median 7·4 years (5·5–9·3) of follow-up, 4784 major cardiovascular disease events, 1649 cardiovascular deaths, and 5796 total deaths were documented. Higher total fruit, vegetable, and legume intake was inversely associated with major cardiovascular disease, myocardial infarction, cardiovascular mortality, non-cardiovascular mortality, and total mortality in the models adjusted for age, sex, and centre (random effect). The estimates were substantially attenuated in the multivariable adjusted models for major cardiovascular disease (hazard ratio [HR] 0·90, 95% CI 0·74–1·10, p_{trend}=0·1301), myocardial infarction (0·99, 0·74–1·31; p_{trend}=0·2033), stroke (0·92, 0·67–1·25; p_{trend}=0·7092), cardiovascular mortality (0·73, 0·53–1·02; p_{trend}=0·0568), non-cardiovascular mortality (0·84, 0·68–1·04; p_{trend}=0·0038), and total mortality (0·81, 0·68–0·96; p_{trend}<0·0001). The HR for total mortality was lowest for three to four servings per day (0·78, 95% CI 0·69–0·88) compared with the reference group, with no further apparent decrease in HR with higher consumption. When examined separately, fruit intake was associated with lower risk of cardiovascular, non-cardiovascular, and total mortality, while legume intake was inversely associated with non-cardiovascular death and total mortality (in fully adjusted models). For vegetables, raw vegetable intake was strongly associated with a lower risk of total mortality, whereas cooked vegetable intake showed a modest benefit against mortality.

Interpretation Higher fruit, vegetable, and legume consumption was associated with a lower risk of non-cardiovascular, and total mortality. Benefits appear to be maximum for both non-cardiovascular mortality and total mortality at three to four servings per day (equivalent to 375–500 g/day).

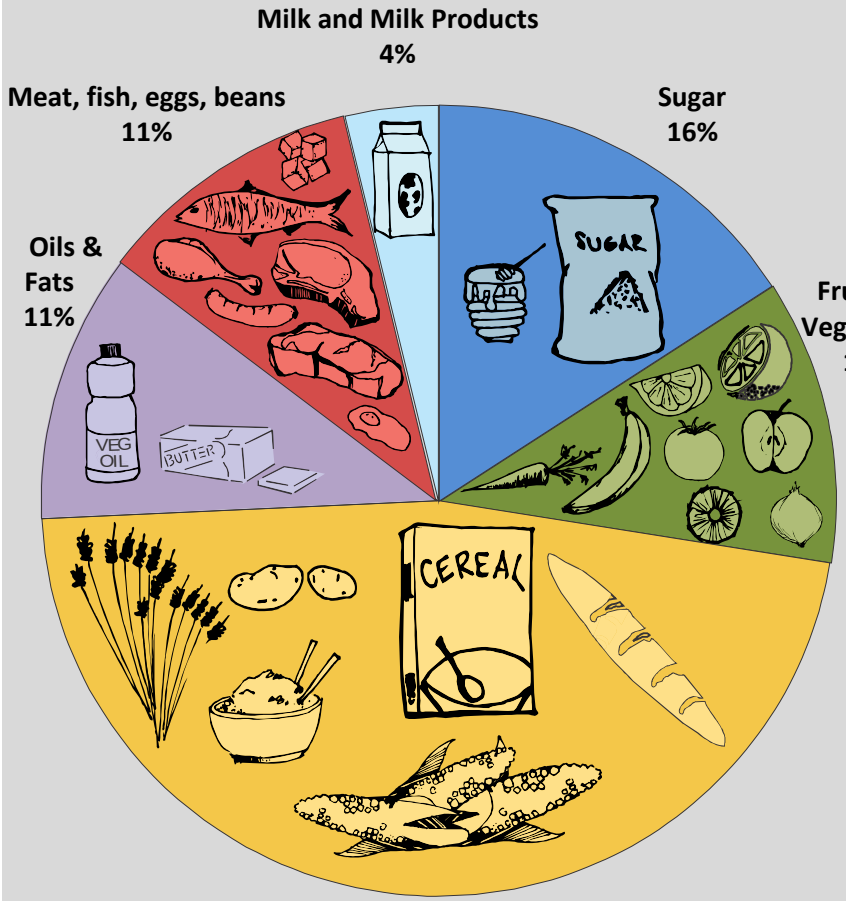
Published Online August 29, 2017 http://dx.doi.org/10.1016/S0140-6736(17)32253-5

See Online/Comment http://dx.doi.org/10.1016/S0140-6736(17)32251-1

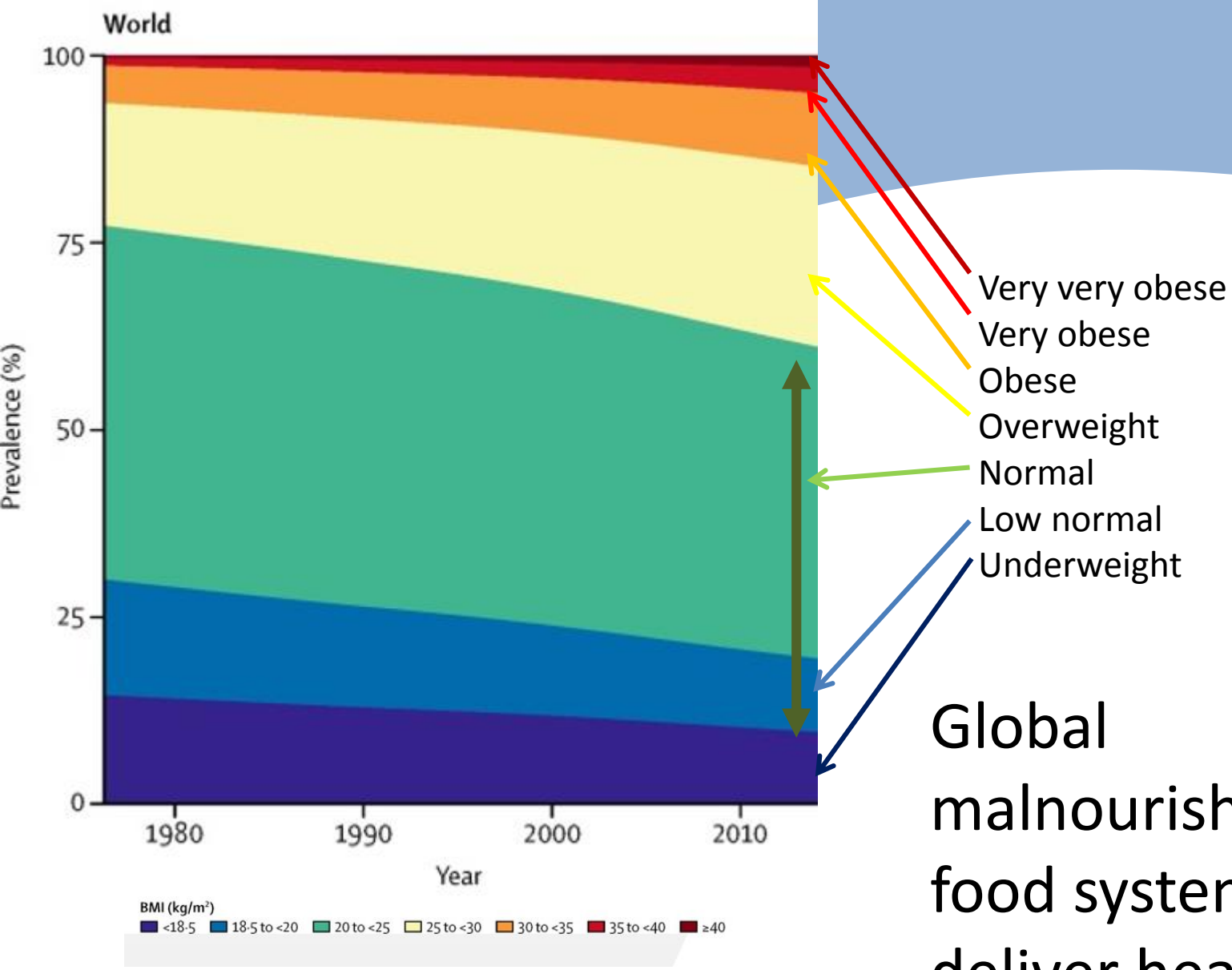
*Investigators listed in the appendix

Population Health Research Institute, McMaster University, Hamilton, ON, Canada (V Miller BSc, A Mente PhD, M Dehghan PhD, S Rangarajan MSc, X Zhang MSc, S I Bangdiwala PhD, Prof K Teo MD, Prof S A Anand MD, Prof S Yusuf DPhil); **St John's Research Institute, Bangalore, India** (S Swaminathan PhD); **Institut universitaire de cardiologie et pneumologie de Quebec, Université Laval, QC, Canada** (G Dagenais MD); **Eternal Heart Care Centre and Research Institute, Jaipur, India** (Prof R Gupta PhD); **Madras Diabetes Research Foundation, Dr Mohan's Diabetes Specialities Centre, Chennai, India** (Prof V Mohan MD); **Faculty of Health Sciences, Simon Fraser University, Vancouver, BC, Canada** (Prof S Lear PhD); **South African Medical Research Council/North-West University, Potchefstroom, South Africa** (A E Schutte PhD, E Wentzel-Viljoen PhD); **Dante Pazzanese Institute of Cardiology, University Santo Amaro, São Paulo, Brazil** (Prof A Avezum MD); **Istanbul Sisli Hamidiye Etfal Health Training and Research Center, Istanbul, Turkey**

What we are actually producing (According to 2011 FAO)



Evan Fraser, Guelph, FBS analysis, 2015



Trends in age-standardised prevalence of BMI categories in women, global

The Lancet Volume 387, Issue 10026, Pages 1377-1396 (April 2016)

Global malnourishment: the food system doesn't deliver health through diets

Global costs of Type 2 diabetes

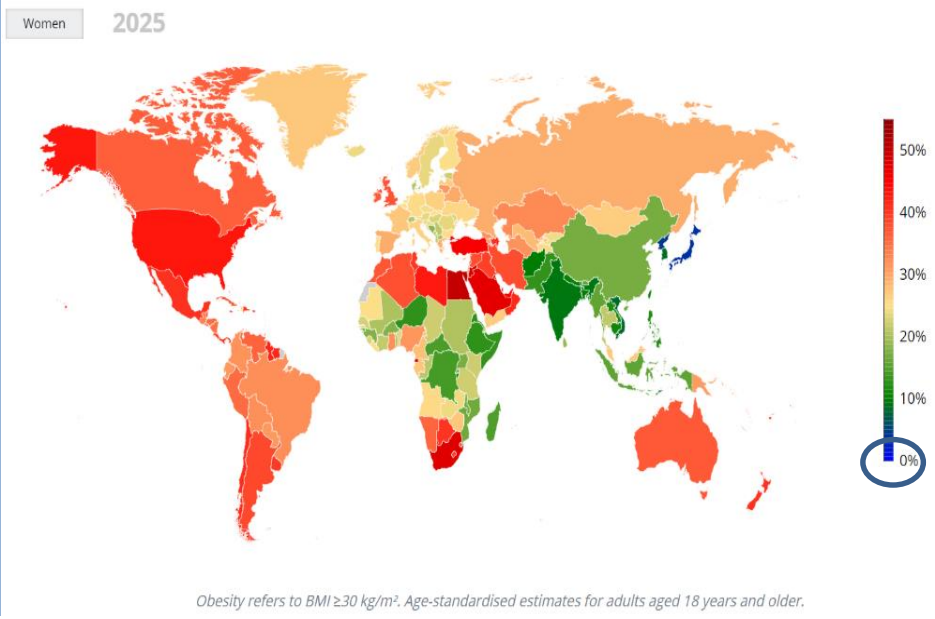


Fig 3.2. Predicted prevalence of obesity in adult women in 2025, from NCD-Risk Collaboration http://ncdrisc.org/obesity-prevalence-projection-map.ht

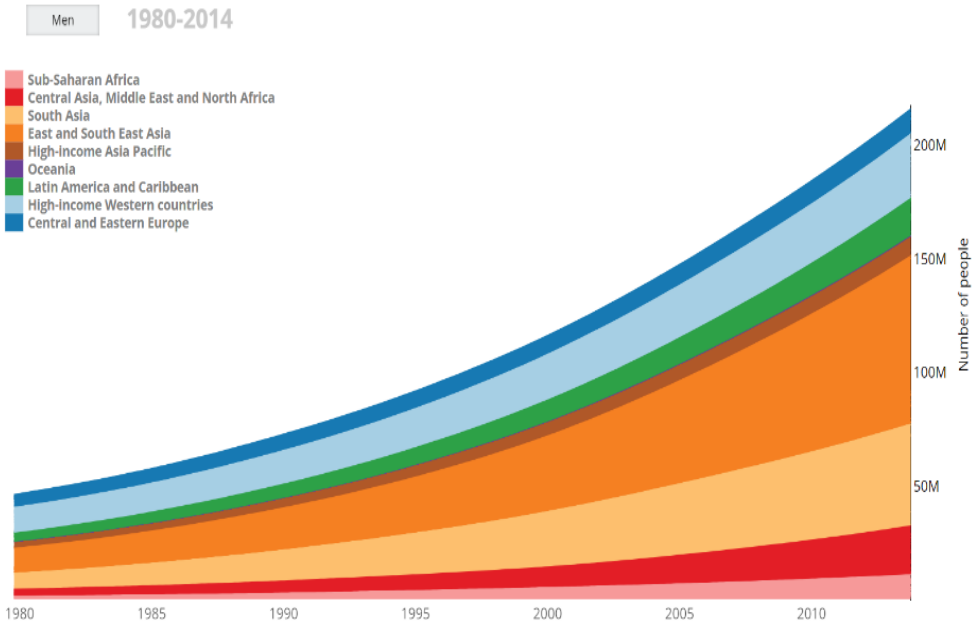


Fig 3.3. Number of adult men, by region, estimated to have diabetes. Data from NC Risk Collaboration http://ncdrisc.org/diabetes-population-stacked.html

- By 2025, over 700m people will have diabetes.
- UK health costs for 3.5m people are £13.75 bn, ~£4000 per cap per ann
- 700m at UK health costs=£2.75tn=$3.58 tn
- Global GDP (2014) was $76tn
- Diabetes costs ~4-5% GDP

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

WHY OUR FOOD SYSTEM MUST CHANGE (2): ENVIRONMENTAL COSTS

UNIVERSITY OF LEEDS

CHATHAM HOUSE

Per capita footprint of intensification

- 0.7-0.85 ha land
- 776 m^3 water
- 15.3 kg N
- 299 kg CO_2eq

Global Environmental Change, **39,** 125-132

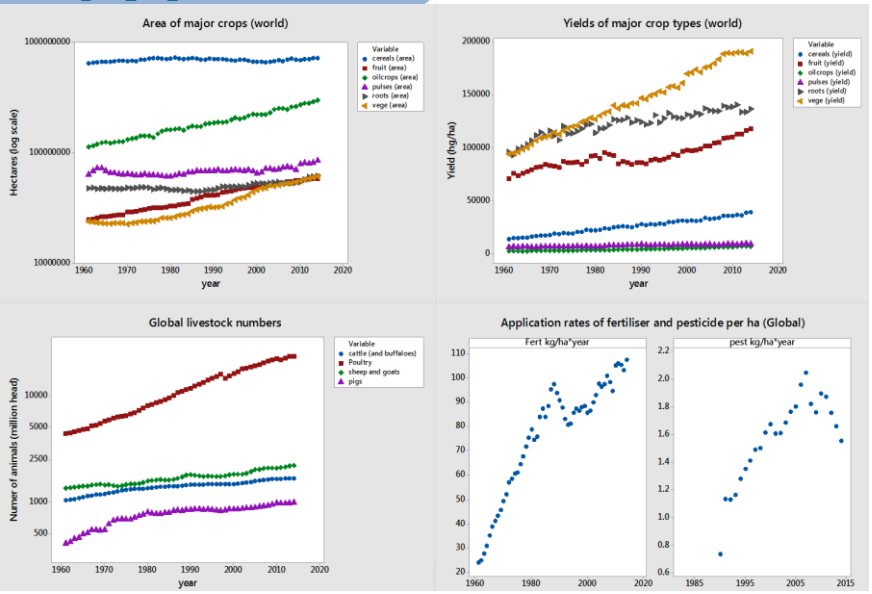
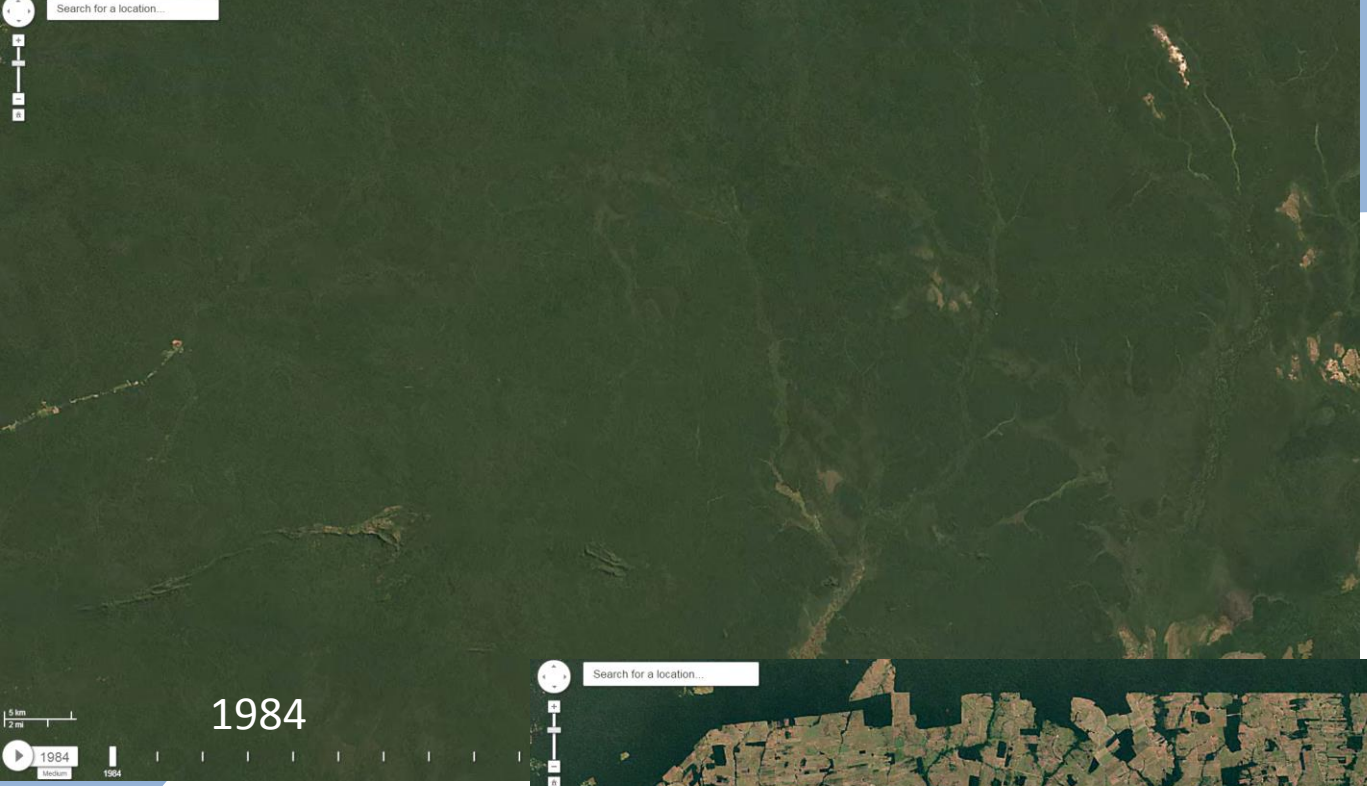
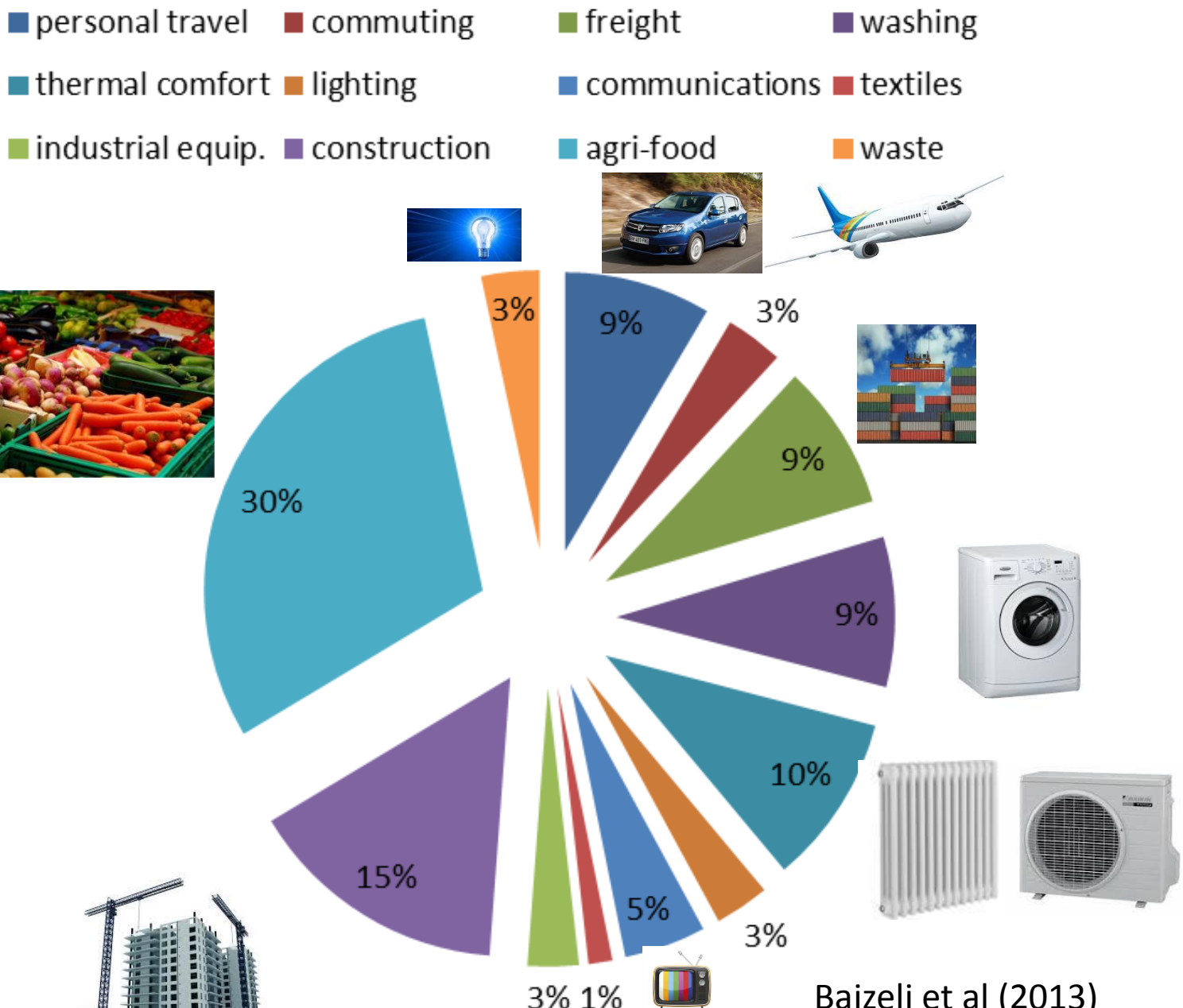


Fig 2.9. Some trends in world agriculture: (a) the cultivation area of major crops (Ha), (b) the yields of major crop types (Hg/Ha), (c) livestock numbers (in millions) and (d) kg of fertiliser per ha and kg of pesticide active ingredient per ha. Data from FAOSTAT, 2017: http://www.fao.org/faostat/en/#data/OA

Forest loss, Rondonia, Amazonia 1984-2006



GHG emissions by service (50.6 Gt CO2e total)



Baizeli et al (2013)

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

WHY OUR FOOD SYSTEM MUST CHANGE (3): SYSTEMIC RISKS

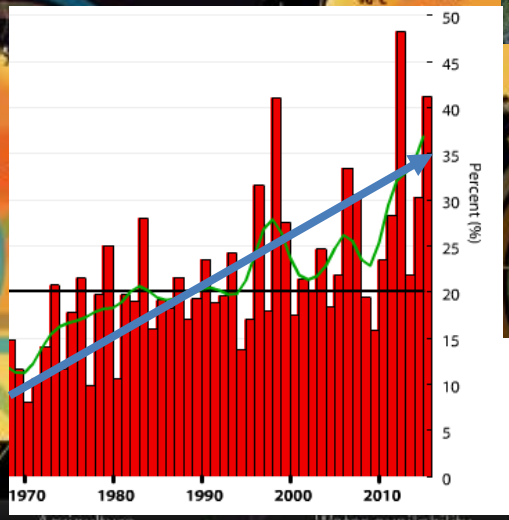
Supply chain logistics

courtesy of http://rsif.royalsocietypublishing.org/content/early/2010/01/19/rsif.2009.0495.full

Met Office

The impact of a global temperature rise of 4°C (7 °F)

HM Government



Climate Extremes Index

Contiguous U.S. CEI (All Steps Combined)
Annual (January-December) 1910-2015

9-Point Binomial Filter
Mean
Actual Percent

The Amazon Forest | Agriculture | Water availability | Sea-level rise | Carbon cycle | Temperature rises

Crops | Water Availability | Sea Level Rise | Marine | Drought | Permafrost | Tropical Cyclones | Extreme Temp | Health

+ °Celsius

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	4	5	7	9	11	13	14	16	18	20	22	23	25	27	29

+ °Fahrenheit

City populations
5-10 Million
10-20 Million

Source: UN Statistics Division Demographic Yearbook 2007

Credits

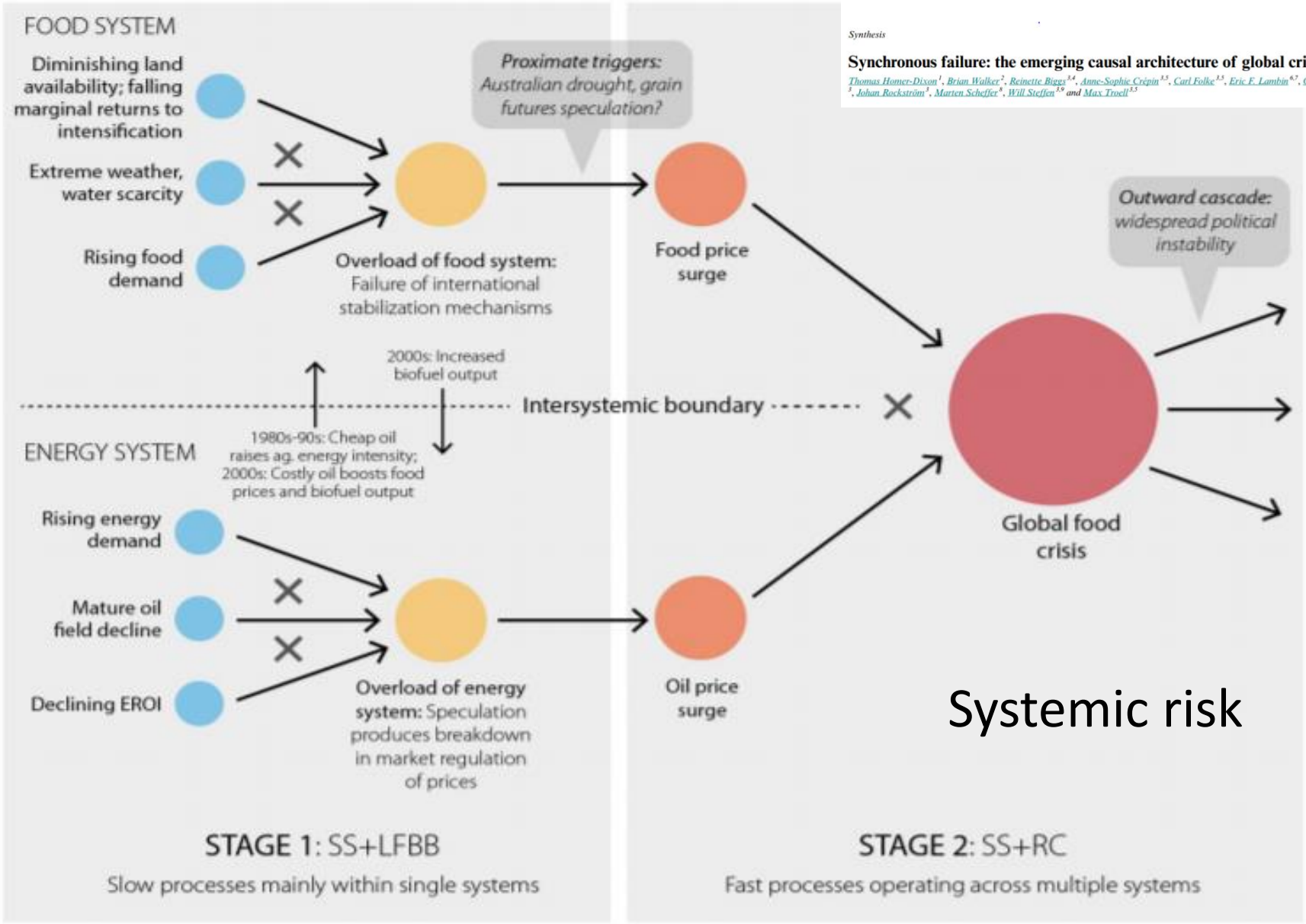
Fig. 3. The 2008 food-energy crisis. SS = simultaneous stresses; LFBB = long fuse big bang; RC = ramifying cascade.

Copyright © 2015 by the author(s). Published here under license by the Resilience Alliance.
Homer-Dixon, T., B. Walker, R. Biggs, A.-S. Crépin, C. Folke, E. F. Lambin, G. D. Peterson, J. Rockström, M. Scheffer, W. Steffen, and M. Troell. 2015. Synchronous failure: the emerging causal architecture of global crisis. *Ecology and Society* **20**(3): 6. http://dx.doi.org/10.5751/ES-07681-200306

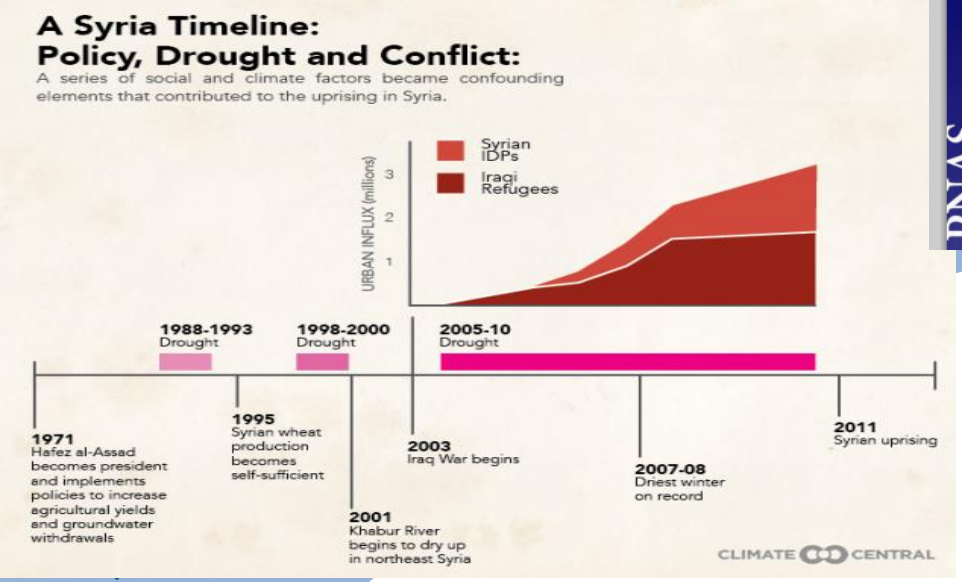
Synthesis

Synchronous failure: the emerging causal architecture of global crisis

Thomas Homer-Dixon[1], *Brian Walker*[2], *Reinette Biggs*[3,4], *Anne-Sophie Crépin*[3,5], *Carl Folke*[3,5], *Eric F. Lambin*[6,7], *Garry D. Peterson*[3], *Johan Rockström*[3], *Marten Scheffer*[8], *Will Steffen*[3,9] *and Max Troell*[3,5]



Systemic risk



International Affairs

PNAS

Climate change in the Fertile Crescent and implications of the recent Syrian drought

Colin P. Kelley[a,1], Shahrzad Mohtadi[b], Mark A. Cane[c], Richard Seager[c], and Yochanan Kushnir[c]

[a]University of California, Santa Barbara, CA 93106; [b]School of International and Public Affairs, Columbia University, New York, NY 10027; and [c]Lamont–Doherty Earth Observatory, Columbia University, Palisades, NY 10964

Edited by Brian John Hoskins, Imperial College London, London, United Kingdom, and approved January 30, 2015 (received for review November 16, 2014)

Before the Syrian uprising that began in 2011, the greater Fertile Crescent experienced the most severe drought in the instrumental

Syria's water security by exploiting limited land and water resources without regard for sustainability (10).

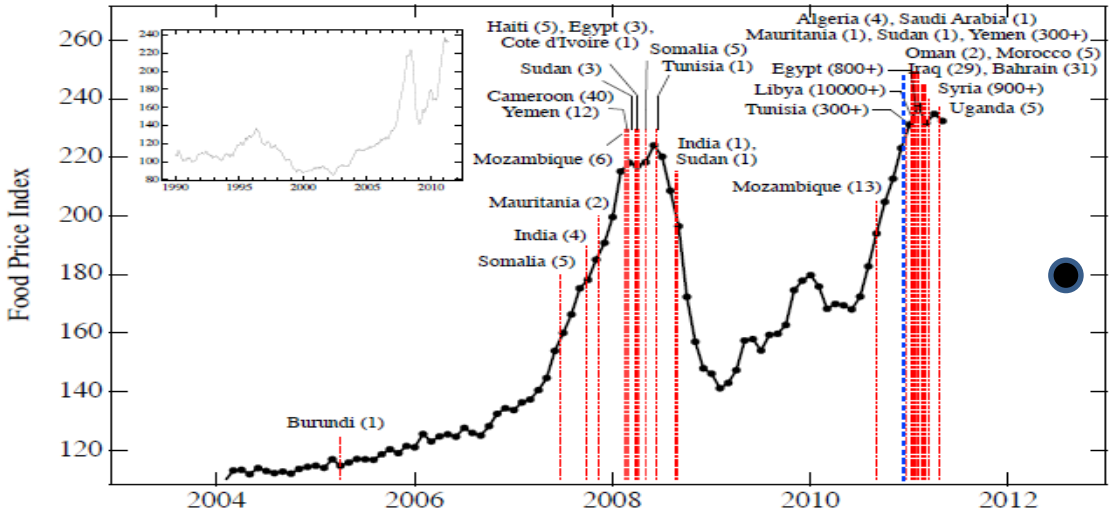


FIG. 1: Time dependence of FAO Food Price Index from January 2004 to May 2011. Red dashed vertical lines correspond to beginning dates of "food riots" and protests associated with the major recent unrest in North Africa and the Middle East. The overall death toll is reported in parentheses [26–55]. Blue vertical line indicates the date, December 13, 2010, on which we submitted a report to the U.S. government, warning of the link between food prices, social unrest and political instability [56]. Inset shows FAO Food Price Index from 1990 to 2011.

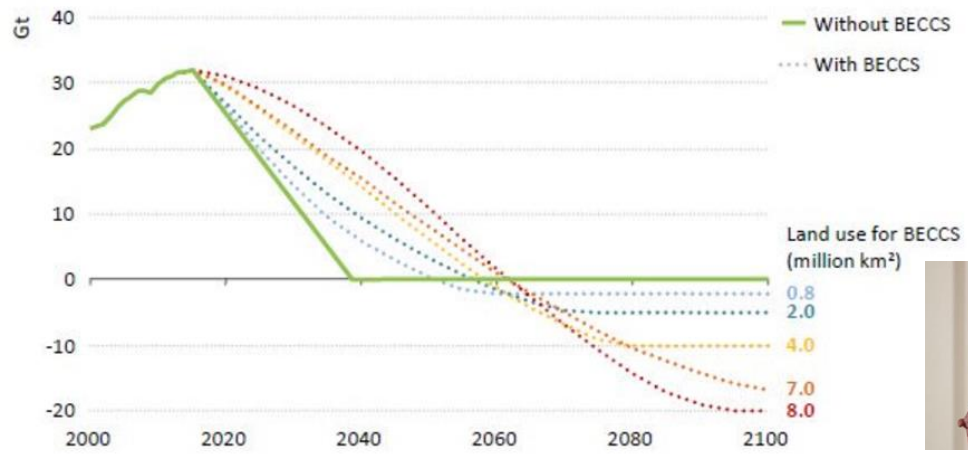
UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

INTERNATIONAL AGREEMENTS IMPLY CHANGE

Game changers: 2015

Figure 8.16 ▷ Energy sector CO_2 emission pathways consistent with a 1.5 °C temperature rise



CO_2 emissions need to fall to zero between 2040 and 2060 to stay below 1.5 °C

IEA/OECD WEO 2016

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

SUSTAINABLE DEVELOPMENT GOALS

People

We are determined to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment.

Planet

We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.

Obersteiner et al 2016 *Science Advances* 2 show food price potent policy lever to manage trade-offs

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Dietary change more important for reducing emissions than farming change

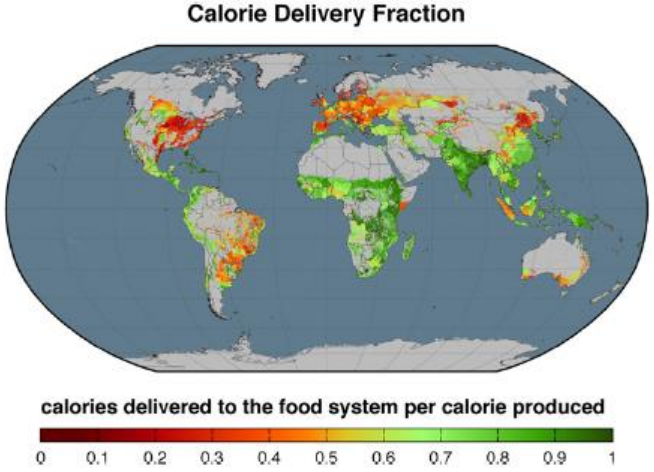
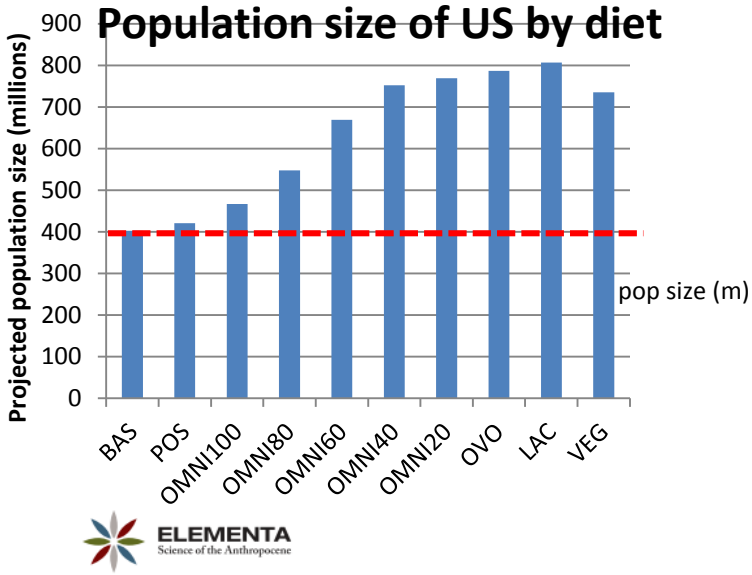


Figure 1. Calorie delivery fraction per hectare. The proportions of produced calories that are delivered as food are shown.

E S Cassidy *et al* Environ. Res. Lett. **8** (2013) 034015

The population of all Asia is 4.2bn



ELEMENTA
Science of the Anthropocene

Carrying capacity of U.S. agricultural land: Ten diet scenarios

Christian J. Peters[1*] · Jamie Picardy[2] · Amelia F. Darrouzet-Nardi[3] · Jennifer L. Wilkins[4] · Timothy S. Griffin[4] · Gary W. Fick[5]

Elementa: Science of the Anthropocene · 4: 000116 · doi: 10.12952/journal.elementa.000116
elementascience.org

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

THE FUTURES OF FOOD

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Alternative futures

Free trade, global markets

Carbon tax; “polluter pays”; education; climate costs mount: Food becomes more expensive

Unsustainable and unhealthy diets

sustainable and healthy diets

Food tax; healthy eating incentive schemes; health insurance; public health education

Local or regional markets

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

https://www.weforum.org/whitepapers/shaping-the-future-of-global-food-systems-a-scenarios-analysis

Future food

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Free trade, global markets

Growing corporate power (TTIP); drive for economic growth; stable world and governance; strong international co-op

Unsustainable and unhealthy diets

sustainable and healthy diets

Protectionism; nationalism
Break-up of rules-based international cooperation
War/terrorism; climate migrants
Lack of resilience in trade due to climate/extreme weather

Local or regional markets

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

https://www.weforum.org/whitepapers/shaping-the-future-of-global-food-systems-a-scenarios-analysis

Futures of food

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Free trade, global markets

Unchecked consumption
- *Growing ill-health*
- *More climate change*
- *More natural resources required*
- *MNC interests dominate politics*

Sustainable, high-tech world
- *Global innovations and tech platforms*
- *High efficiency*
- *App-driven personalised nutritious diets*
- *Consumers buy attributes*

Unsustainable and unhealthy diets

sustainable and healthy diets

Money talks most
- *Disconnected world with weak economic growth*
- *"post war economy"*
- *Unsustainable production to meet demands locally*
- *"spatial inequality"*

Local is lovely
- *Sustainable nutrition drives local industry*
- *"local food" SMES and artisanal food valued*
- *Holistic economies – low waste, high health and well being*
- *"spatial inequality"*

Local or regional markets

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

https://www.weforum.org/whitepapers/shaping-the-future-of-global-food-systems-a-scenarios-analysis

What role for technology?

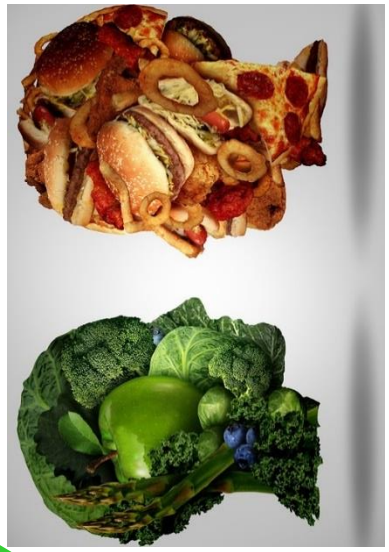
ee trade, global markets

Sustainable, high-tech world
- *Global innovations and tech platforms*
- *High efficiency*
- *App-driven personalised nutritious diets*
- *Consumers buy attributes*

sustainable and healthy diets

Local is lovely
- *Sustainable nutrition drives local industry*
- *"local food" SMES and artisanal food valued*
- *Holistic economies – low waste, high health and well being*
- *"spatial inequality"*

Local or regional markets



Commodity crops
Biotechnology and biofortification
Ultra-processed foods
Long supply chains

More varied diets to provide nutrients
More varied farming systems
Whole foods, cooked at home
Short supply chains

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Conclusions: the past and future will be radically different

- The current food system is globally unsustainable, externalising costs to health and environment
- The future and recent past are likely to diverge (and perhaps suddenly) depending on geopol stability, climate risks and healthcare costs
- The potential role of particular technologies in delivering the triple wins (health, economy, environment) depends on e.g. supply chain length, price vs convenience trade-offs, dietary choices etc
- Systemic risks are increasing and there is potential for sudden policy shifts that may change social preferences

https://www.morrisons-corporate.com/Global/local-foodmakers/BritishFoodReportFeb2017.pdf

UNIVERSITY OF LEEDS

CHATHAM HOUSE
The Royal Institute of International Affairs

Thank you!

t.g.benton@leeds.ac.uk

@timgbenton

www.foodsecurity.ac.uk