Impact of environmental stressors on fruit and vegetable quality & availability

Relevance for future diets

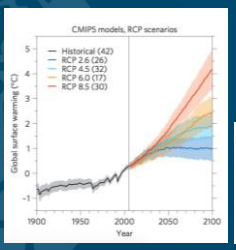
Improving health worldwide

www.lshtm.ac.uk

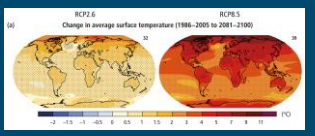
Pauline Scheelbeek – Research Fellow

Environmental stressor scenarios

Temperature



Scenarios based on range of different "storylines" about how environment and societal impact on environment might change in the future

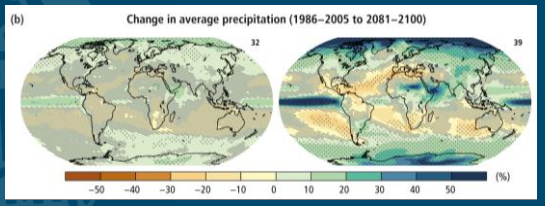


Representative Concentration Pathways (RCPs)

(IPCC, 2015)

Environmental stressor scenarios

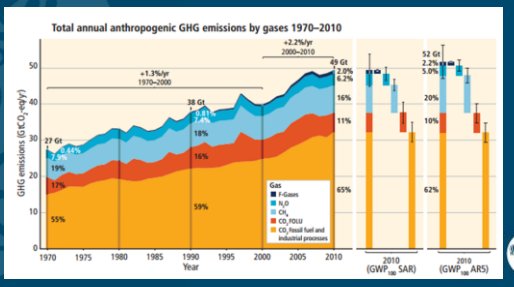
Precipitation



(IPCC, 2015)

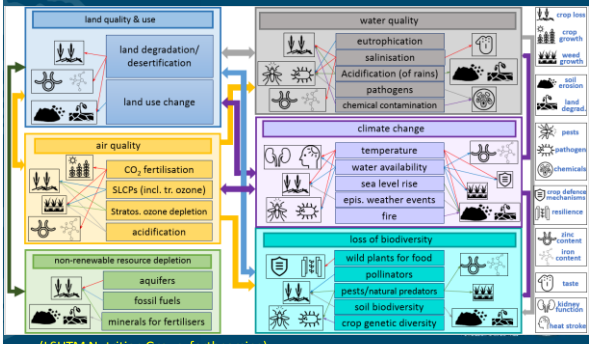
Environmental stressor scenarios

Carbon-dioxide (CO_2)



(IPCC, 2015)

Environmental stressors & agriculture



(LSHTM Nutrition Group, forthcoming)

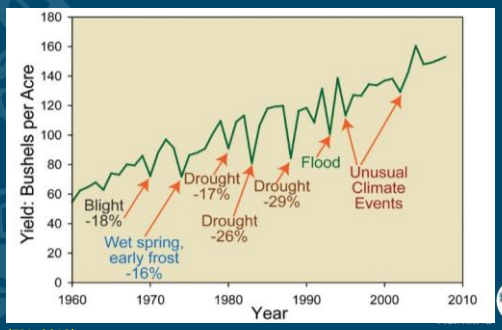
Global Food Price Crises 2007 & 2009

Recent example of link environmental change and diets/agriculture:

Result of combination of (a.o.):

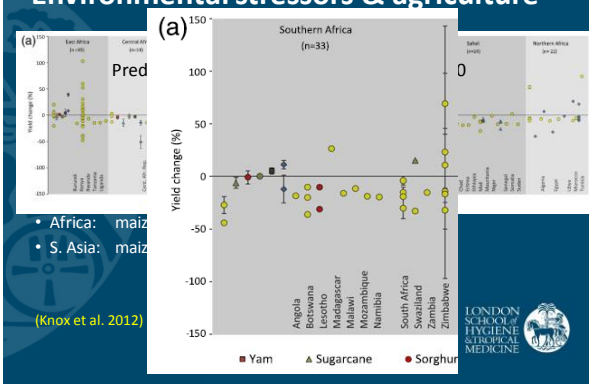
- Droughts, leading to reduced harvests
- Increased oil prices
- Increased demand for crops due to rising interest in biofuels
- Speculations – large entities buying up food supplies
- Under pressure due to ongoing population growth

Environmental stressors & agriculture



(EPA, 2012)

Environmental stressors & agriculture

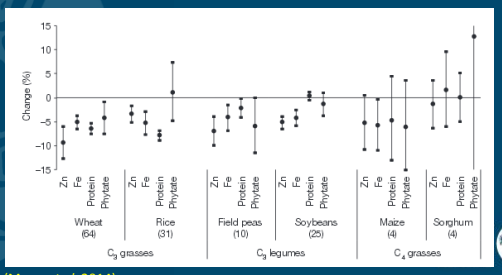


- Africa: maiz
- S. Asia: maiz

(Knox et al. 2012)

CO_2 elevation and staple crops

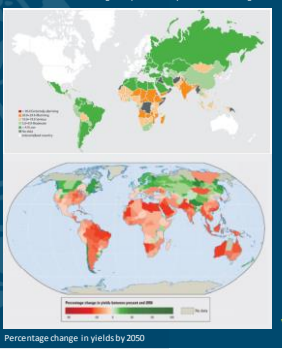
- Lower concentrations of zinc and iron
- Predicted for the middle of century



(Myers *et al*, 2014)

Distribution of impact

Global distribution of hunger - quantified by 2012 Global Hunger Index



Percentage change in yields by 2050

- Progress towards global food security is slowing and this is partly due to climate change
- So far, most impacts concentrated in regions already food insecure i.e. SSA, South Asia
- Could worsen: changes in temperature and rainfall are projected more extreme in hot & dry areas

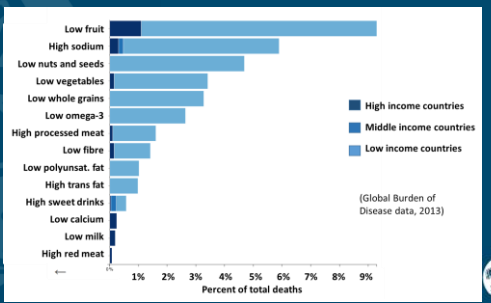
Wheeler *et al*, 2013

Role of fruits & vegetables in global diets

High nutritional importance (and in some areas more difficult to replace by other food group:

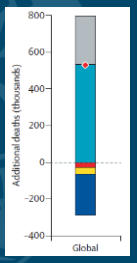
- Vitamins (A, C, etc.) and its precursors
- Minerals
- Iron
- Calcium
- Zinc
- Potassium
- Magnesium
- Folate
- Iodine
- Fibre
- Antioxidants (?)

Importance of specific food groups

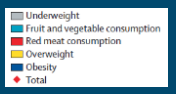


Affected food production and health

Forecast for 2050: important role for fruits and vegetables



- 3.2% reduction in global food availability
- 4 % reduction in consumption of fruits and vegetables
- 0.7 % reduction in red meat consumption
- Lead in 529,000 climate-related deaths worldwide
- Huge differences observed between geographical areas



Springmann et al. (2016)

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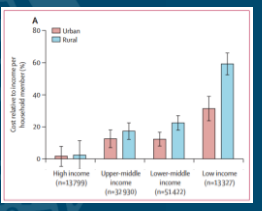
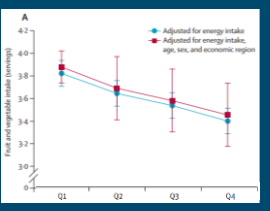
Role of fruits & vegetables in global diets





Miller et al. (2016)

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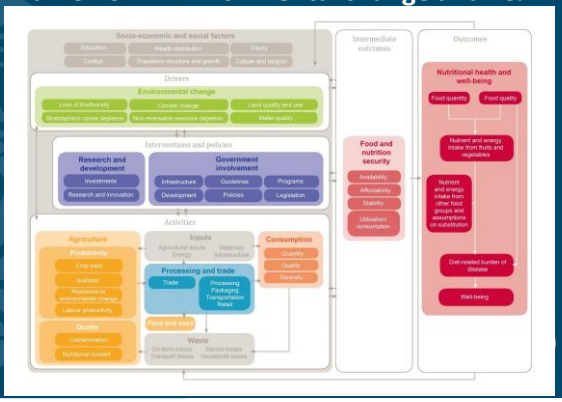
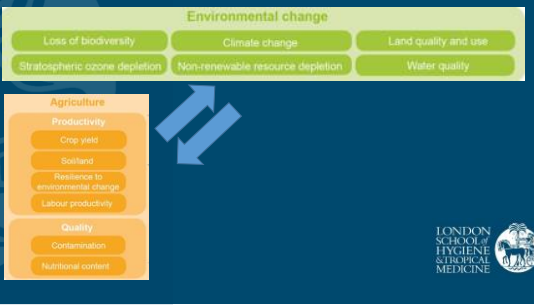
Framework: Environmental change and F&V



Focussing on Environmental Change and Agriculture

- Fruit and Vegetable Quantity and Quality: 2 Systematic Reviews



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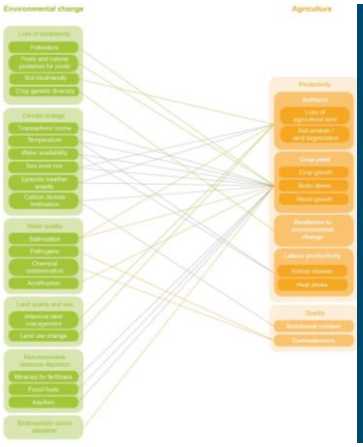

Systematic Reviews

- Productivity
- Quality

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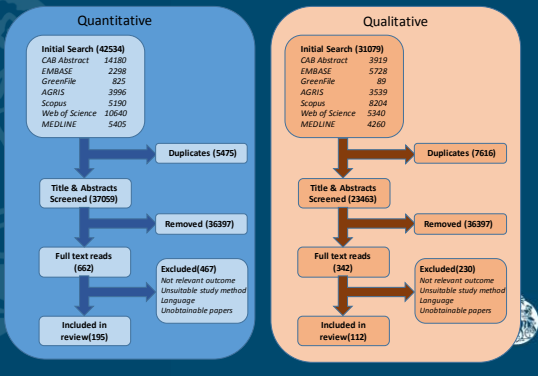
Systematic Reviews



Impact on crop quantity

Availability of evidence:

- Majority of papers: irrigation studies
- Many field studies in Middle East (Iran, Turkey & Egypt) – farmers worried about increasing frequency/length water stress
- Crops can be shifted to more temperate region or further uphill

Main findings:

Positive influences on yield:

- enhanced yield with increased exposures to CO_2
- temperate zones show general increase in yield with future climate scenarios: longer growing seasons, decreased frost risks, etc.

Negative influences on yield:

- irrigation deficit (mainly legumes)
- decreased rainfall
- increased temperature
- increased tropospheric ozone
- Combined models (temp, CO_2 & rainfall)
- (sub)tropical zones respond negatively to scenarios (increased rainfall variability and heat stress)

Impact on crop quality

Dependent on the "optimal range"

Table 1. Major climate factors affecting apple quality and the optimal indices.

Climate Factors	Major Affecting Indices	Optimal Range	Literature Source
Average annual temperature (*T* °C)	Fruit shape index, titratable acid content, vitamin C (VC), peel anthocyanin	8–13°C	[13,21–27]
Annual precipitation (*P* mm)	Fruit shape index, hardness, soluble sugar, peel anthocyanin	500–800 mm	[13,21–24]
Annual sunshine durations (*S* h)	Fruit shape index, peel anthocyanin, sugar-acid ratio	2200–2600 h	[21,22,25]
Average summer temperature (*Ts* °C)	Titratable acid content, hardness, peel anthocyanin, sugar-acid ratio	18–22°C	[21,25–30]
Average summer diurnal temperature variation (*SRT* °C)	Hardness, soluble sugar, sugar-acid ratio	10–12°C	[22,23,25–29]
Average summer relative humidity (*RHs* %)	VC, hardness, soluble sugar, peel anthocyanin	60%–75%	[13,22,24–26,28,29]

Qu et al. (2016)

Many more positive influences on the quality side!

Impact on crop quality

Evidence found on the following effects:

- Hours of sunshine, light intensity (and cloud cover)
  - + Vitamin content, mineral accumulation, anti-oxidant activity
  - + Shape, colour, size
  - - if outside optimal range: sugar content, hardness
- Drought stress (and temperature stress)
  - + predominantly positive: could increase stress-induced synthesis of secondary compounds: some with nutritional value
- Temperature
  - + Similar to sunshine ours + fatty acid content
  - - in temperate zones: disturbs dormant phase of crops
  - - above 35°: blocking of ripening process – decreased starch, sugars, protein and minerals

Impact on crop quality

Evidence found on the following effects:

- CO_2
  - - predominantly negative: rapid growth leads to decreased mineral uptake, lower protein content and malformations
- Tropospheric ozone
  - + Increase in vitamin C, β-carotene, lutein, lycopene post-harvest (though inconsistant)
  - - can cause visual injury and decreased sugar content
- Pollinator loss
  - - predominantly negative, but small effects measured so far
- Interactions important to study to assess whether advantages outweigh disadvantages (also in yield).

Impact on crop quality

Table 4. Possible effects of climate change on apple quality in China.

	Fruit Hardness	Fruit Shape Index	Peel Anthocyanin	VC Content	Soluble sugar	Titratable Acid	Sugar-acid ratio
Loess Plateau (PL)	↓+	↑+	↑+	↑+	↑+	↓+	↑+
Bohai Bay (BG)	↓−	↓−	↓−	↑+	↓−	↑−	↓−
Old Course of the Yellow River (LY)	↓−	↓−	↓−	↑+	↓−	↑−	↓−
Southwest Highland (SW)	↓+	↓−	↓−	↑+	↑+	↓+	↑+
Xinjiang (XJ)	↓+	↑+	↑+	↑+	↓+	↑+	↓+

↑: Increase; ↓: Decrease; +: Positive effect; −: Negative effect.

Qu et al. (2016)

Hypotheses to explore in the future

Next Steps & questions to be answered:

- Taking into account all positive and negative effects: which geographical areas will be "hit" first? What magnitude?
- What role do fruits and vegetables play in overall diet
- Substitution behaviour – consumer and farmer
- Estimation of likelihood of nutrient deficiencies – burden of NCDs
- For high income countries: how will this effect import of fruits and vegetables: what about the quality?
- Would it also effect the lower social economic classes in a country like the UK? Price-elasticities?
- Modelling: environmental change scenarios in low, middle and high income countries

Discussion & possible implications

- We found evidence for a considerable influence of environmental change on fruit and vegetable quality and quantity
- The magnitude and direction of this change are very complex to assess and depend on a number of (geophysical) characteristics. Current modelling effort often show substantial caveats
- The effects will probably be most noticeable in already food-scarce areas where substitution possibilities are limited: study likelihood that this could lead to crucial nutrient deficiencies.

For whom will the outcomes be relevant?

- Agricultural planning and strategic decision making
- Health Programmes – nutrient deficiencies and non-communicable disease burden
- Policy recommendations: opportunities for interventions

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