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Global to Local Analysis of Systems Sustainability

Linking Food Availability and Waste in the Global Economy

Emiliano Lopez-Barrera and
Thomas W. Hertel
Department of Agricultural Economics
Purdue University

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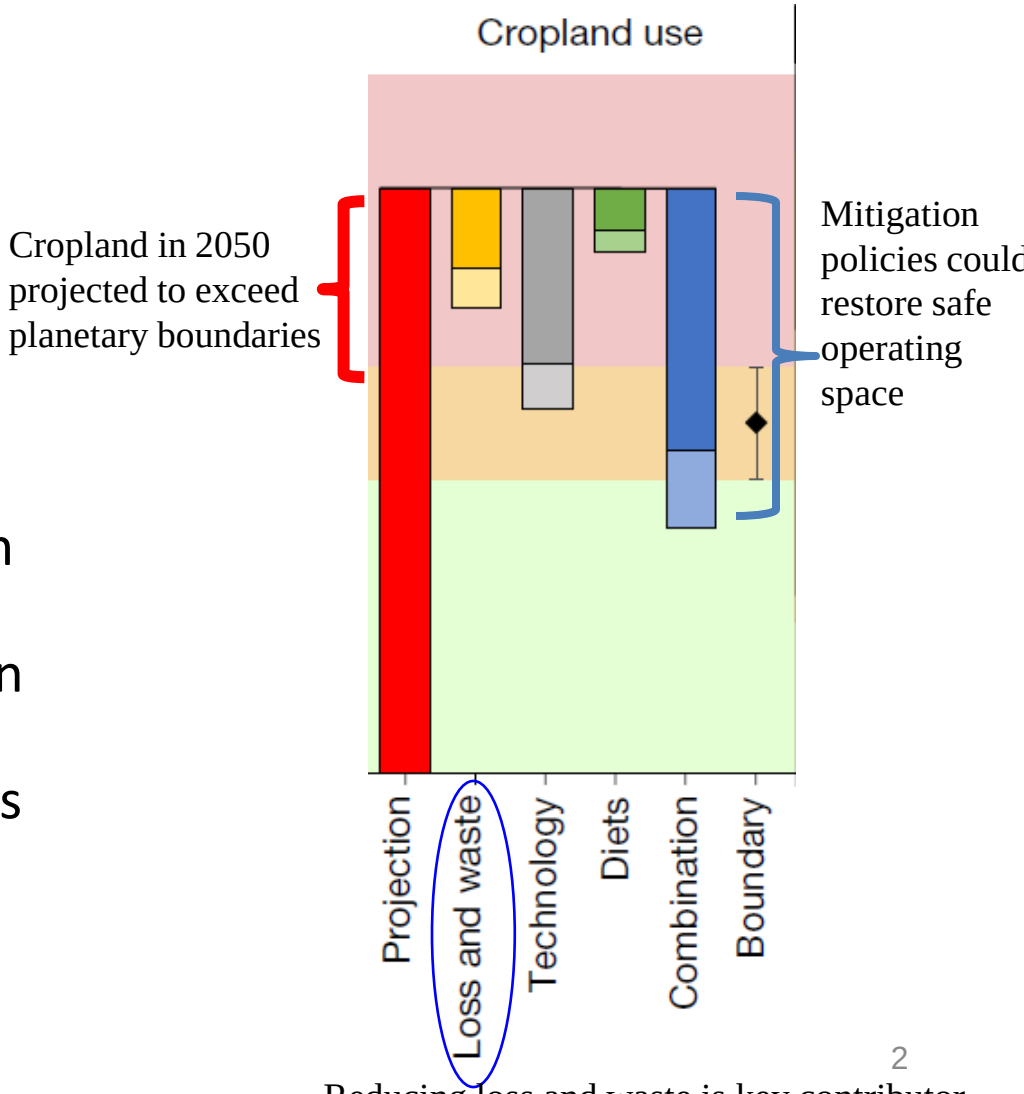
Food Loss & Waste are *key to achieving global environmental goals*

Springmann et al., *Nature*, 2018 (published last week) find that:

- Reducing food loss and waste more important than dietary change for remaining within planetary boundaries while feeding the world in 2050

Limitations include:

- Loss and Waste estimates from FAO (2011)
- Abstracts from future evolution of food waste and losses
- Simplistic Scenarios: reductions of 50% and 75% FLW globally



Reducing loss and waste is key contributor

Context

- **Most research** on food waste **focuses at the micro-level**: households & businesses are critically important
- Excellent national level work exists (e.g. USDA LAFA); however a **global perspective is also required**; here, empirical & analytical foundations are weak; most studies still rely on FAO's initial 2011 report
- We seek to address this limitation:
  - Offering **time series estimates of national food waste**
  - **Estimating relationship** between income and waste
  - Incorporating into economic model and **examining historical trends**, as well as **future projections** for food waste in the global economy
  - Considering **implications for food and environmental security of reducing food waste**

Previous International Estimates

- FAO (2011): loss and waste factors applied at each stage along supply chain; huge information requirements
- Hall et al. suggested method of deduction:

$$\textit{Food Waste} = \textit{Food Available} - \textit{Food Intake}$$

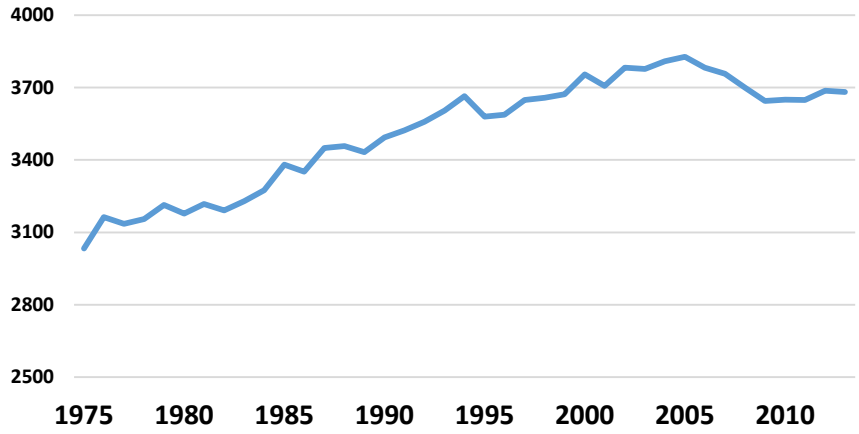
$$\textit{Food Intake} = \Delta\textit{Body weight}^{*}\rho + \textit{Energy Expenditure}$$

$$\textit{Energy Exp} = \textit{Phys Activity Level} * \textit{Basal Metabolic Rate}$$

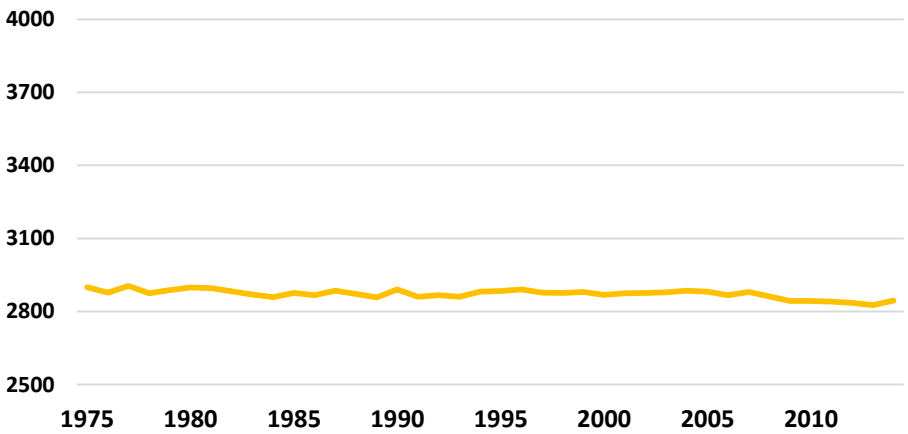
  - Verma et al.: apply Hall methodology to produce national estimates for 63 countries
  - Hic et al.: explore environmental impacts
  - We refine the deduction approach & provide international time series from which can estimate evolution of FW

Food Supply, Intake, and Waste in the US following methodology of Hall et al. (preliminary estimates*)

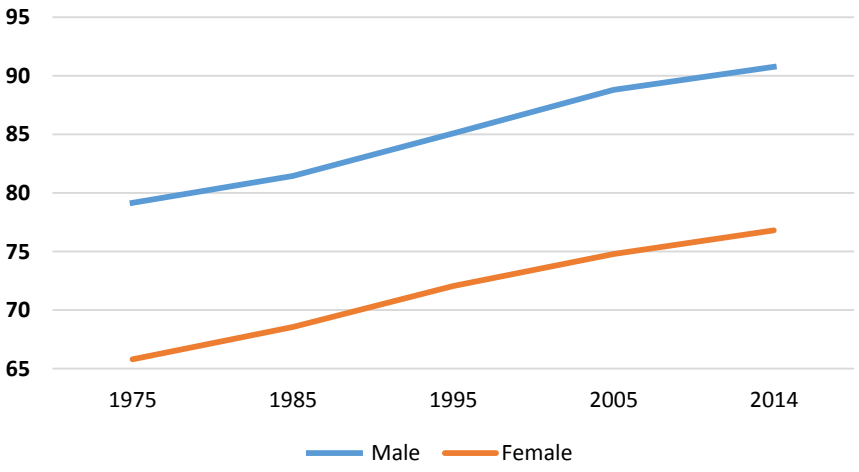
Energy availability (kcal/cap/day)



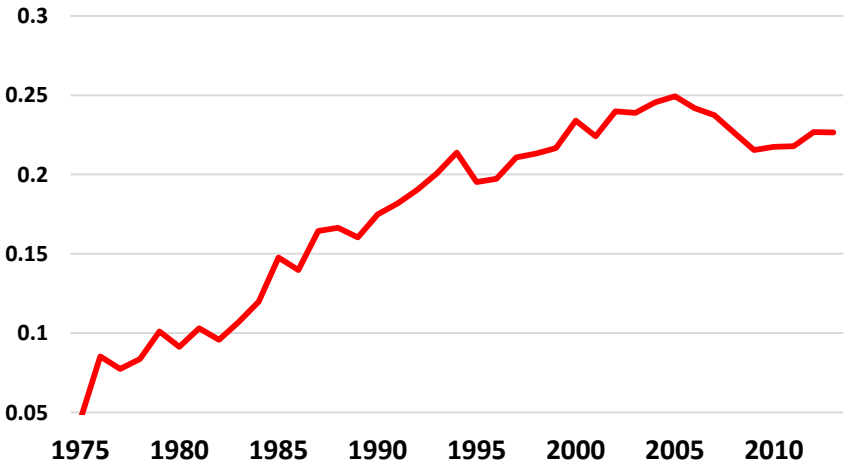
Minus average *adult** energy expenditure (kcal/cap/day)



Adjusting for Average Adult Weight (kg)



Yields share of available food wasted (kcal/cap/day)

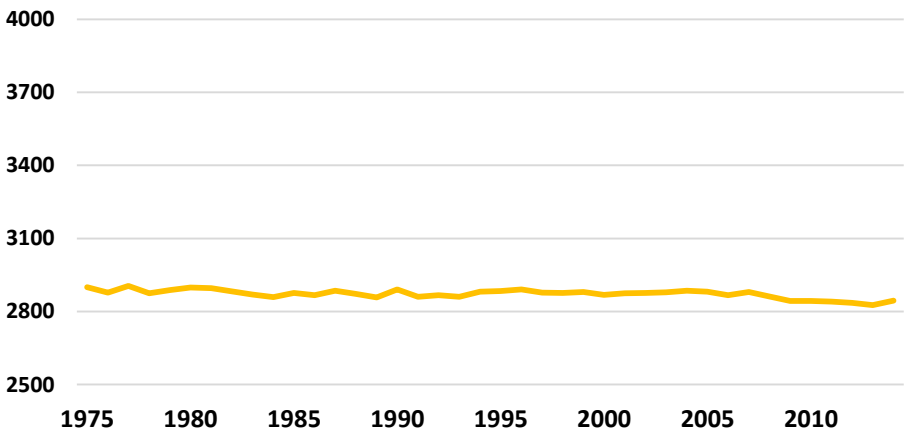


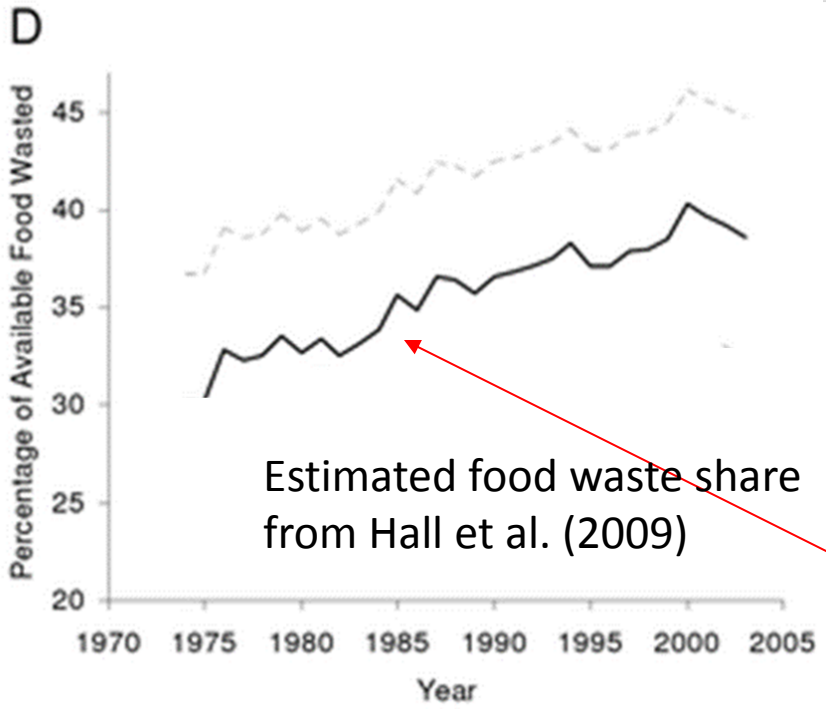
** Use of adults only overstates energy expenditure and underestimates food waste*

Food Supply, Intake, and Waste in the US comparison with Hall et al.

Energy availability (kcal/cap/day)

Minus average *adult energy expenditure (kcal/cap/day)**





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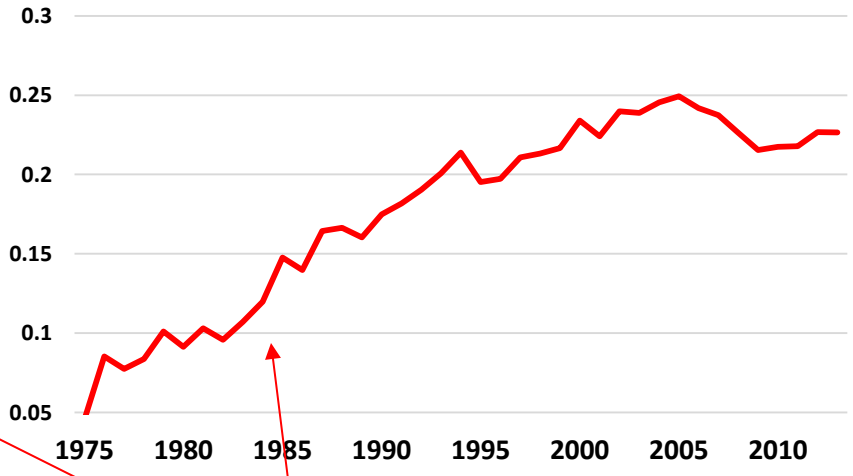

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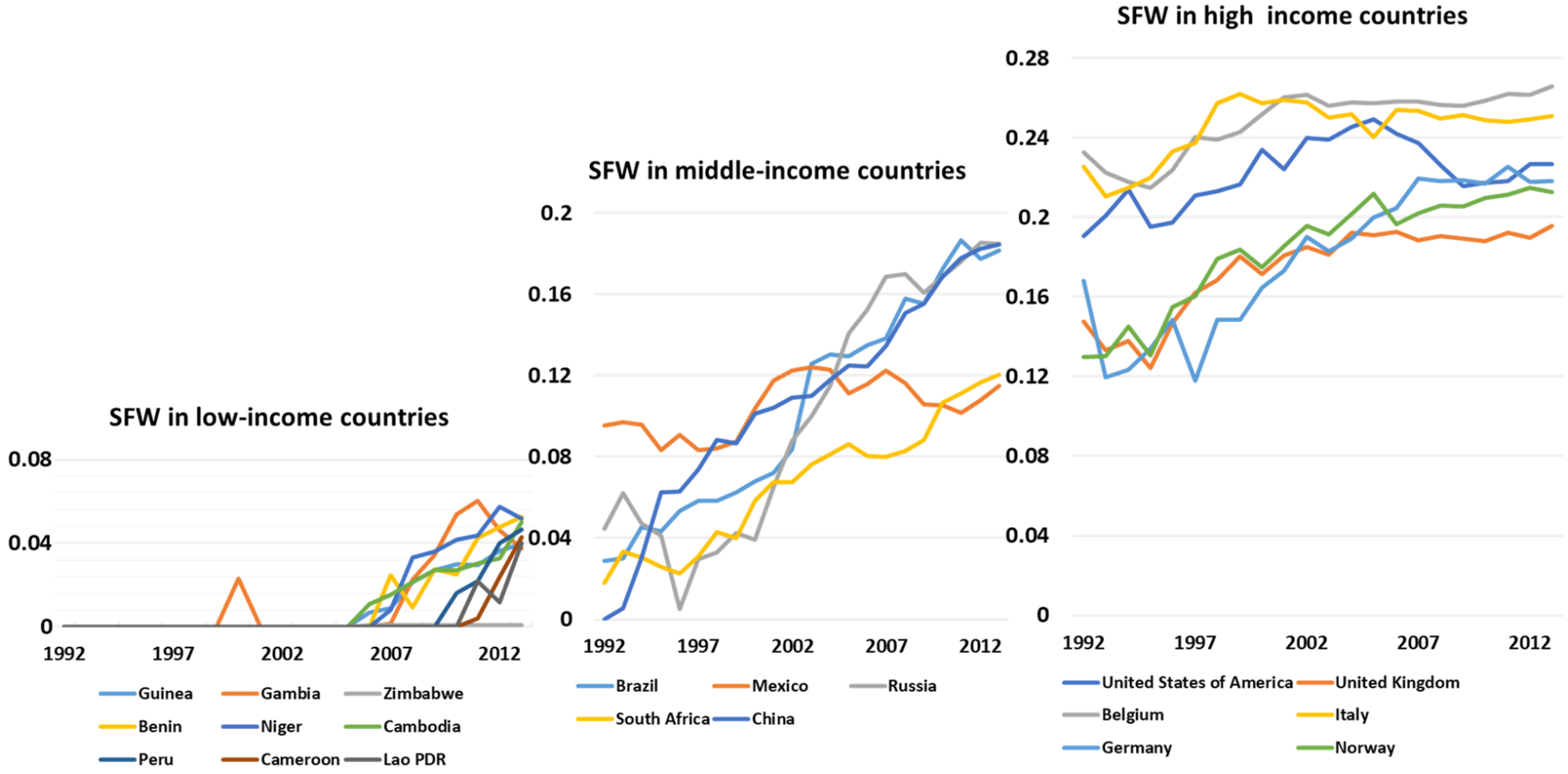
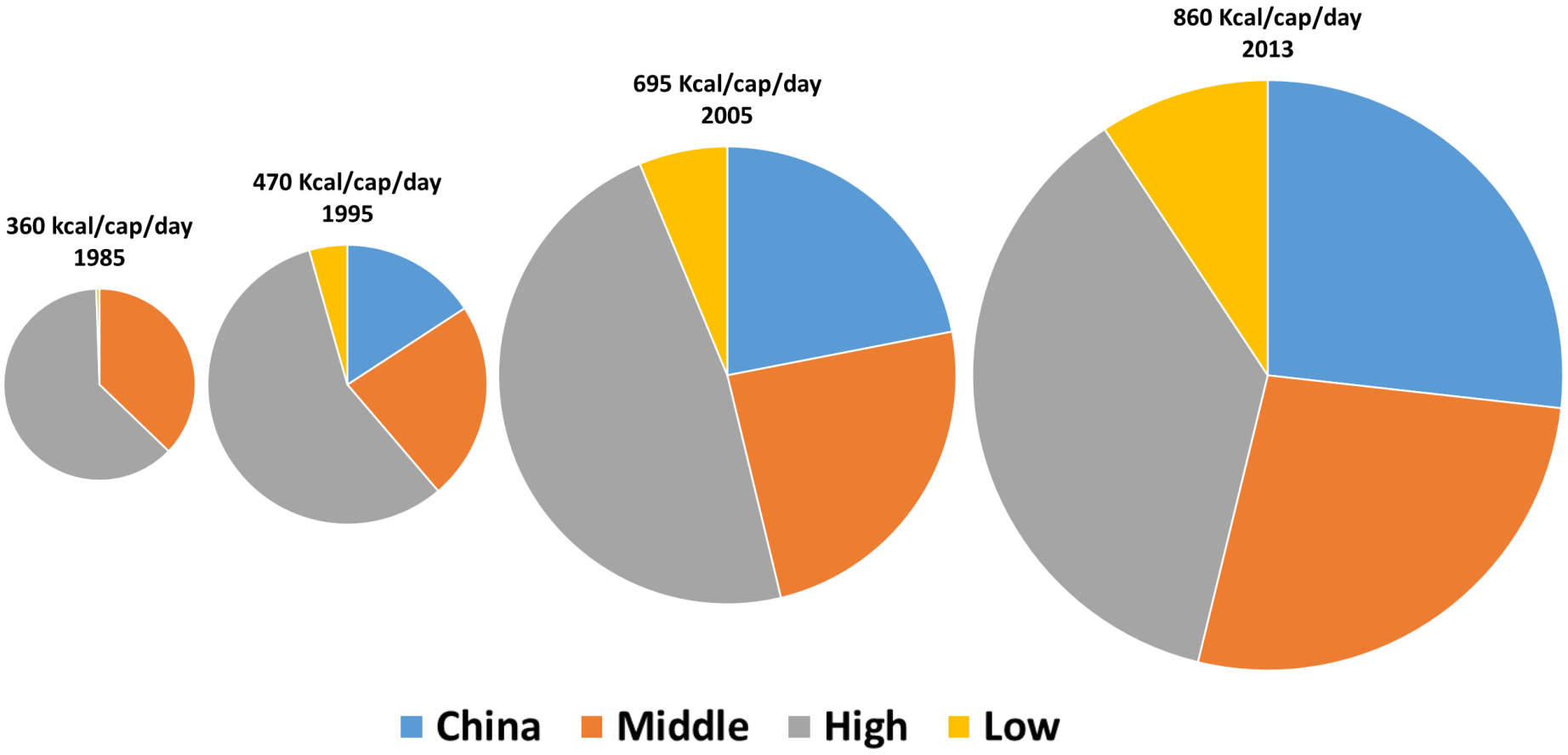
The evolution of the Share of Food Waste over time by income level

(World Bank 2006 income classification)



As per capita income rises, the SFW rises, eventually reaching a plateau.

Historical Evolution of Food Waste in a sample* of countries: 1985-2013



Largest contribution to global food waste comes from middle income countries

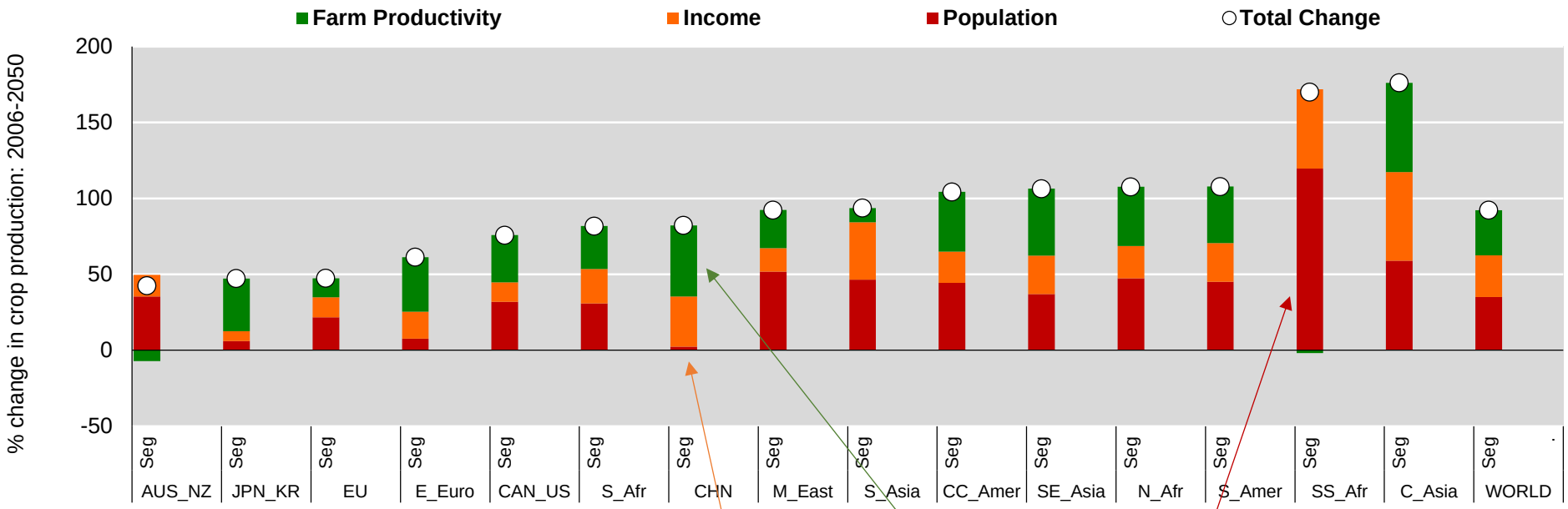
*108 countries classified according to World Bank income levels (2006)

Incorporating Food Waste into a Global Economic Model: SIMPLE

- SIMPLE stands for the *Simplified International Model of Prices Land use and the Environment*
- Framework developed to facilitate interdisciplinary teaching and research – many versions of SIMPLE; here we draw on Hertel and Baldos (2016)
- Validated against historical changes in crop production, land use, prices and under-nutrition
- Our work on obesity has drawn us into food waste: Need to understand how much of purchased food is actually consumed
- SIMPLE-FW incorporates the estimated relationship between the share of food availability wasted and per capita income, by country
- As nations become richer, the portion of caloric purchases wasted grows, but at a decreasing rate; overall share of waste levels off

Projected changes in *crop output growth*, by region: 2006-2050, assuming historical trade frictions

Decomposition by underlying drivers: pop, income, productivity

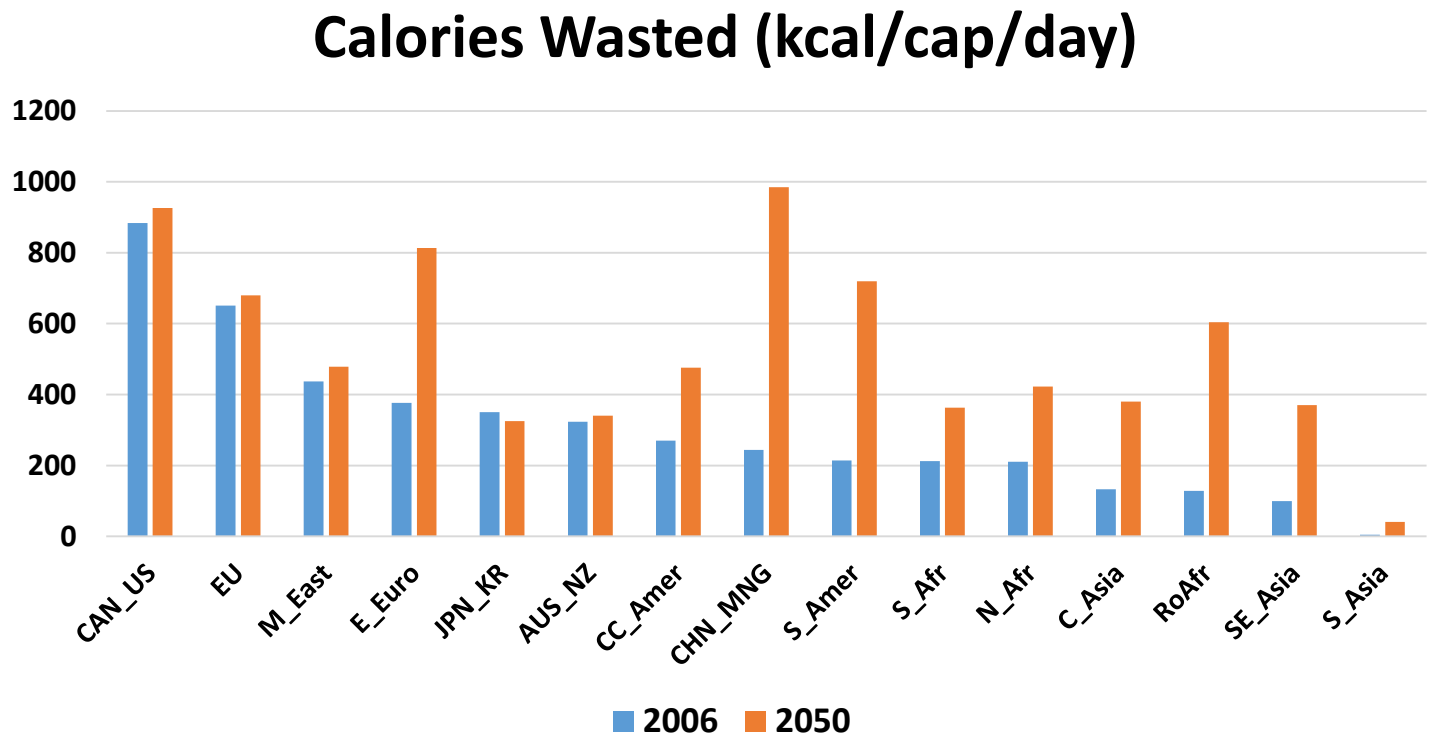


Growth in China driven by income and productivity

Rapid crop output growth in Africa – driven by population growth

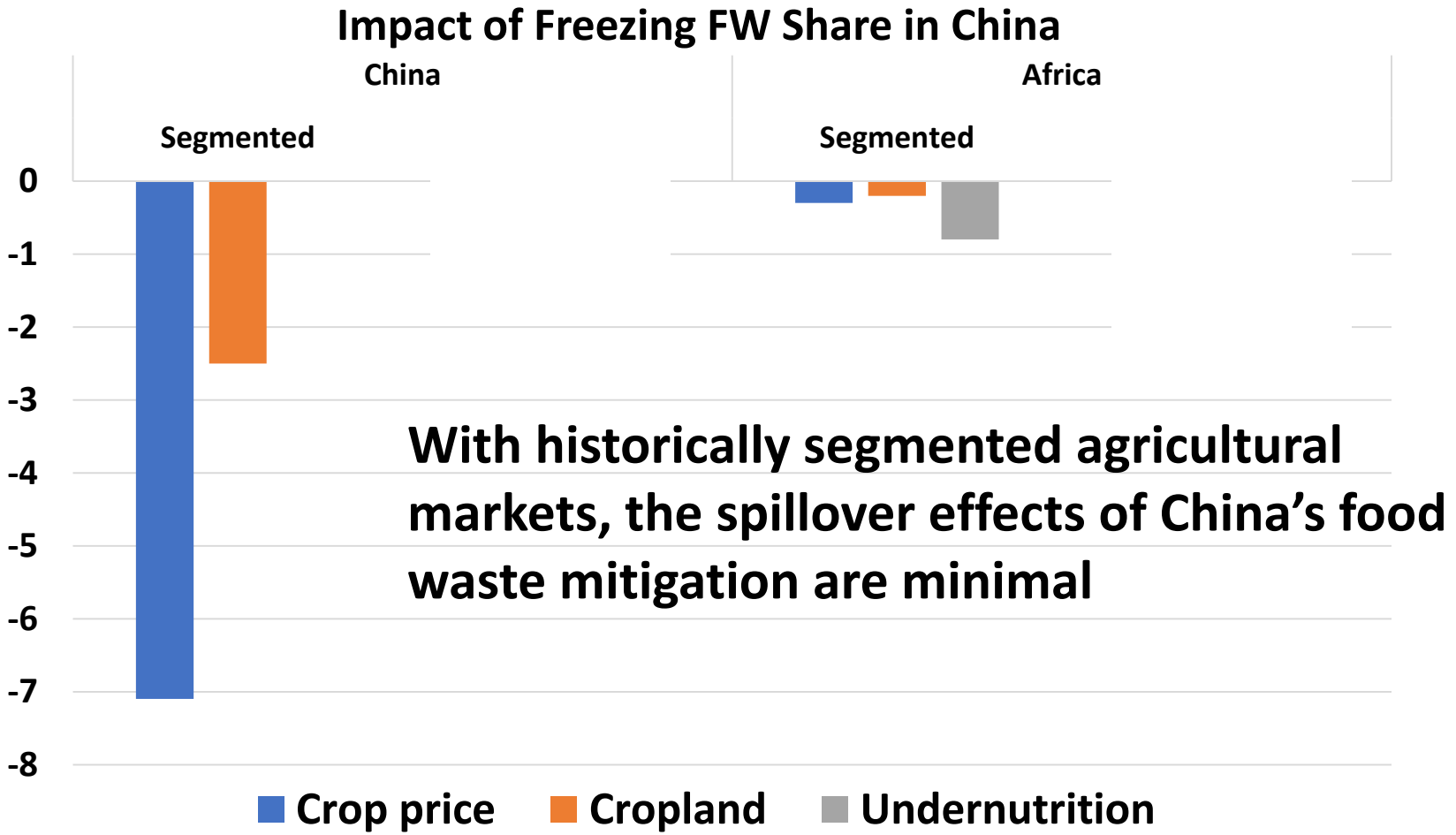
Source: Hertel and Baldos. (2016) "Attaining Food and Environmental Security in an Era of Globalization", Global Environmental Change, 41:195-205.

Projected* growth in per capita calories wasted: 2006 vs. 2050



*Projections build on Hertel and Baldos (2016)

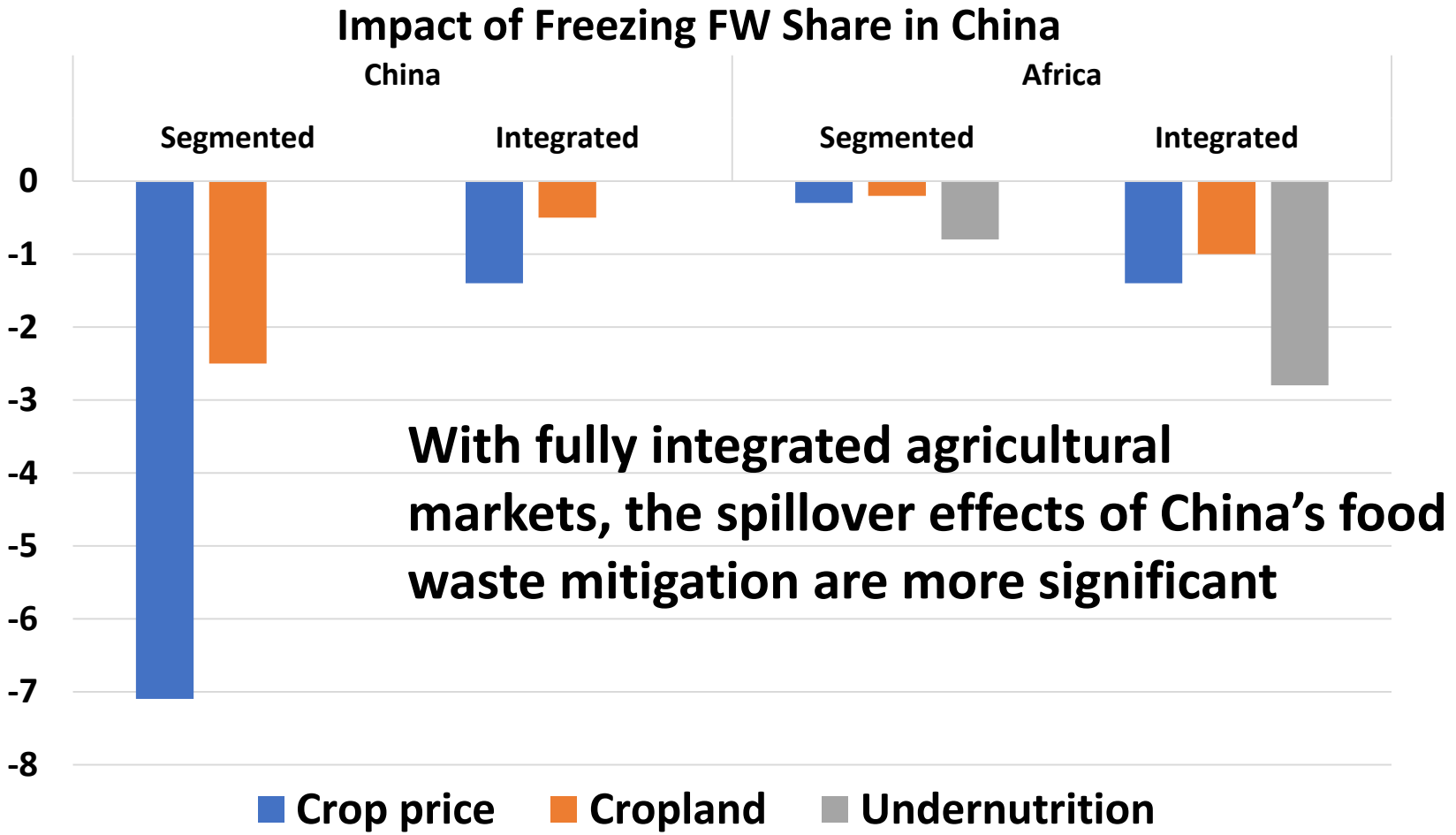
Implications of freezing China's share of food waste in availability at 2006 levels
(historical trade frictions = segmented markets)



With historically segmented agricultural markets, the spillover effects of China's food waste mitigation are minimal

*Analysis using the SIMPLE model from Hertel and Baldos (2016)

Implications of freezing China's share of food waste in availability at 2006 levels
(segmented vs. fully integrated international markets)



*Analysis using the SIMPLE model from Hertel and Baldos (2016)

Summary and Conclusions

- Important work underway at the micro-level understanding the determinants of food waste and implementing potential solutions
- In some cases this is reflected in national estimates; WRI-led FLW protocol 1.0 is a promising, bottom-up, long term global effort
- However, global pattern of food waste is evolving rapidly:
  - While share of available food wasted has leveled off in rich countries,
  - It is growing rapidly in middle income countries. Absent mitigation policies, China is projected to dominate the global food waste landscape
  - Consequences of FLW reductions interact with trade policies
- Mitigation of food waste and loss is key to attaining global environmental goals, including remaining within the planet's 'safe operating space' for land, water availability and quality & GHGs
- Measurement is foundation of international action; need approaches which can be implemented today; incorporated into quantitative models

Extra slides

Food Waste is not directly observable at the National level: International Data Sources for deduction of per capita national waste

Food waste is quantified as the difference between the available food (kcal/cap/day) and the intake of food (kcal/cap/day) .

Country specific **food availability** (kcal/cap/day) is obtained from the **FAO food balance sheets** (period 1975-2014)

The country specific average increase $\boldsymbol{\Delta Body\ weight\ (BW)}$ is obtained from the **differences in BMI** reported for the years 1975,85,95,2005, and 2014 (Finucane, et al. 2011) and heights (NCD, 2016). Then converted to calories applying a weight change model (Thomas et al. ,2011).

The country specific average adult* EE energy are calculated from country specific **BMR's (Basal metabolic rate) based on demographics and PAL (Physical activity level) on different lifestyles retrieved from FAO, 2004.**

** Use of adults only overstates energy expenditure and underestimates food waste*

Figure 1. Food Supply, Intake, and Waste in America from Hall et al.

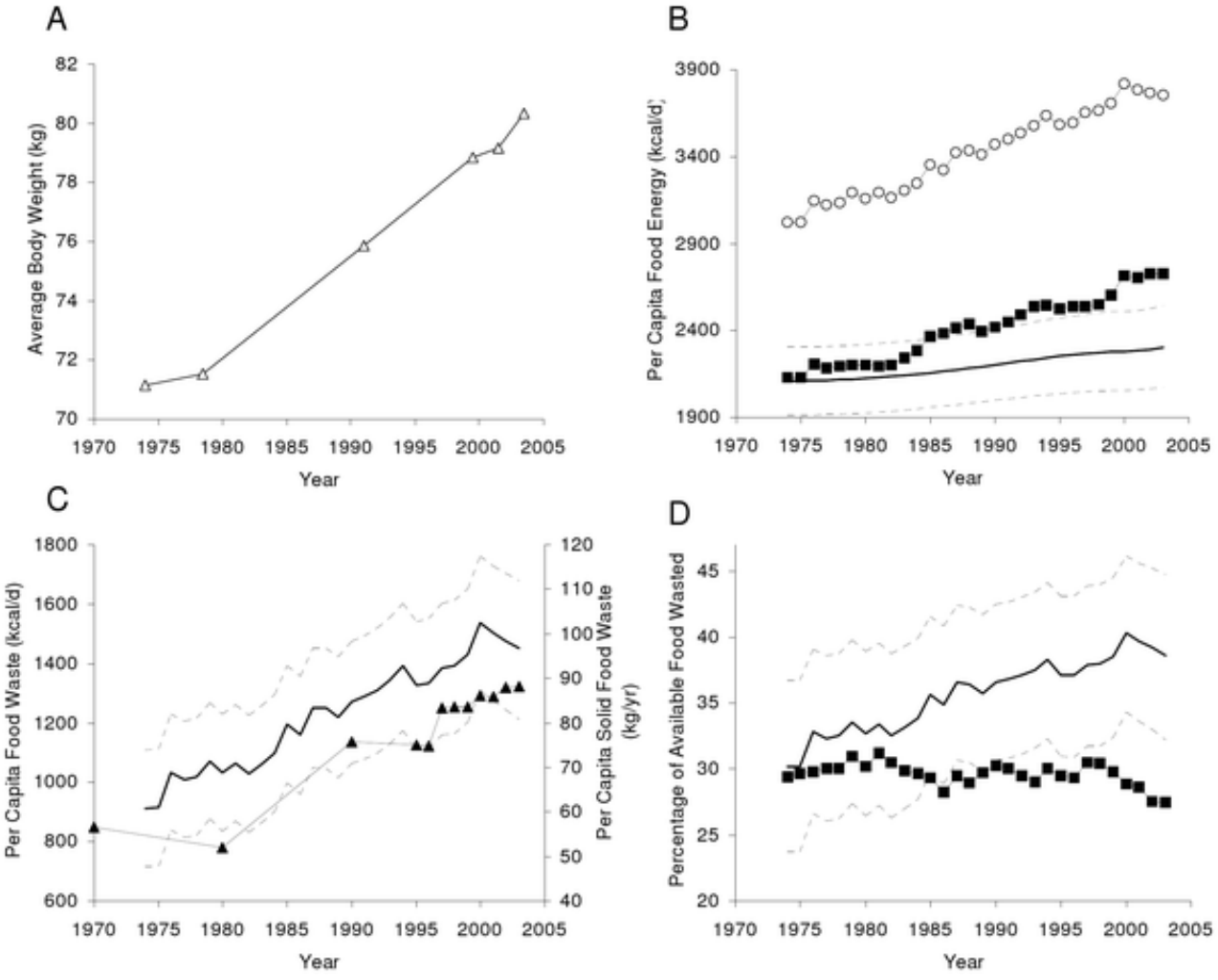


Figure 1B shows our model predicted average food intake (solid curve) and 95% confidence intervals (dashed curves) underlying the observed weight gain. Figure 1B also plots the US food supply data from the FAO food balance sheets (open circles)[7] and the US Department of Agriculture (USDA) food availability data adjusted for wastage (dark squares)

Figure 1C shows that our estimate of the increasing energy content of US food waste is corroborated by the parallel increase of the per capita annual mass of municipal solid food waste (dark triangles) calculated from data supplied by the US Environmental Protection Agency.

Hall KD, Guo J, Dore M, Chow CC (2009) The Progressive Increase of Food Waste in America and Its Environmental Impact. PLOS ONE 4(11): e7940. https://doi.org/10.1371/journal.pone.0007940
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0007940