

AAEES 2016 E3  
Superior Achievement Award:

# **Improved Water Quality in Ixcan Guatemala**

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Missouri University of Science and Technology

# Outline

- The scope of the problem
  - 663 million people lack access to improved sources of drinking water
  - 946 million people practice open defecation
- The solution we developed
  - Empowering communities with appropriate technology
  - Assessment using structural equation modeling
- Our take home message to you
  - primum nil nocere (first, do no harm)
  - “... the services provided by engineers ... must be dedicated to the protection of the public health, safety, and welfare.” (preamble to NSPE code of ethics)
- Future work we have underway
  - Creating income generating activities
  - Evaluating environmental enteropathy



# United Nations MDGs to SDGs 1990 - 2030



## Millennium Development Goals

1990 - 2015

1. Poverty and hunger
2. Primary education
3. Gender equality
4. Child mortality
5. Maternal health
6. HIV, malaria, others
7. **Environment**
  - Improved drinking water
  - Improved Sanitation
8. Partnerships

From: <http://www.un.org/millenniumgoals/>

## Sustainable Development Goals

2015 - 2030

1. Poverty
2. Hunger
3. Well-being
4. Education
5. Gender
6. **Environment**
7. Energy
8. Jobs
9. Infrastructure
10. Inequalities
11. Urban
12. Consumption
13. Climate
14. Oceans
15. Ecology
16. Institutions
17. Partnerships

From: <https://sustainabledevelopment.un.org/>

**6.1** By 2030, achieve universal and equitable access to safe and affordable drinking water for all

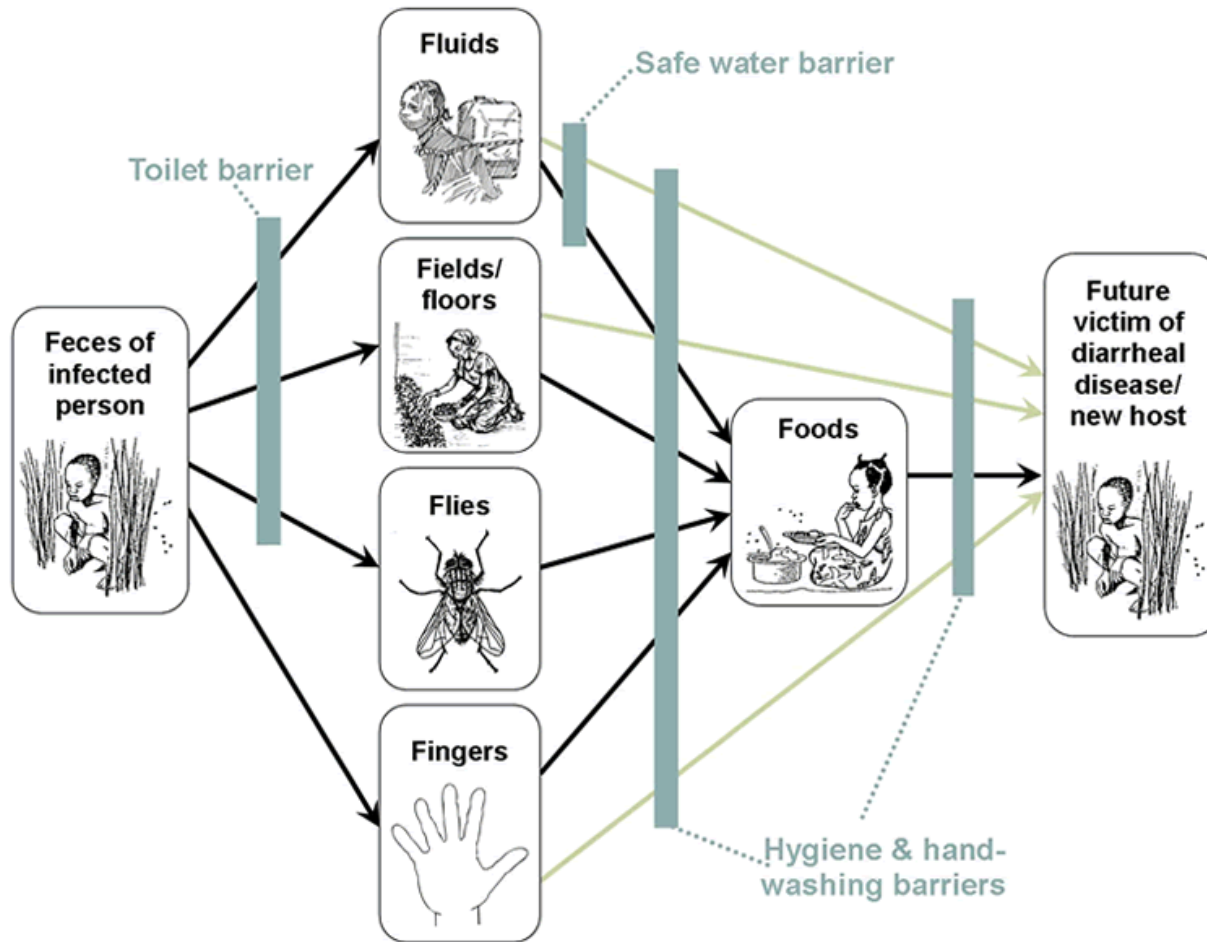
**6.2** By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

2

2

8

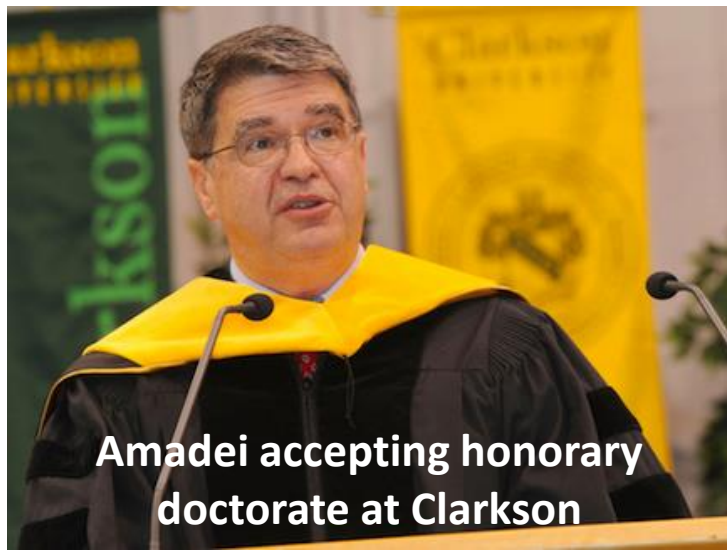
# We know the problem



# We know the solution

## Point of Use Household Drinking Water Filtration: A Practical, Effective Solution for Providing Sustained Access to Safe Drinking Water in the Developing World

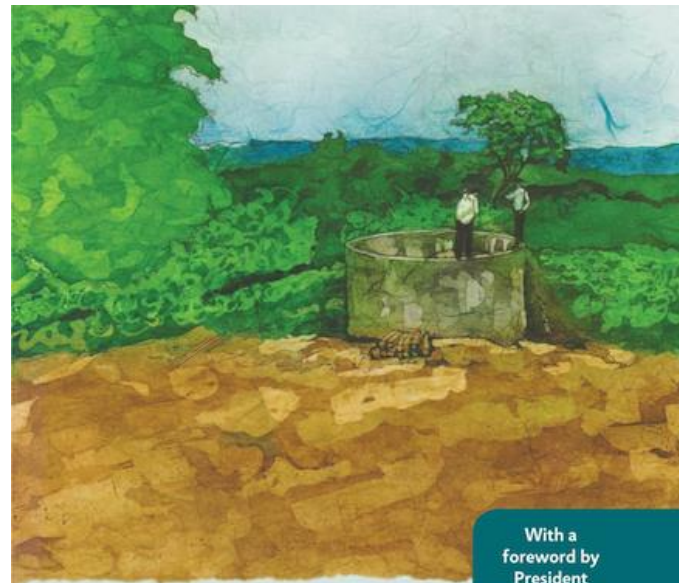
MARK D. SOBSEY,\*  
CHRISTINE E. STAUBER,  
LISA M. CASANOVA, JOSEPH M. BROWN,†  
AND MARK A. ELLIOTT



Amadei accepting honorary doctorate at Clarkson

08/15/2012

## Caltech Wins Toilet Challenge



With a  
foreword by  
President  
Jimmy Carter

### Field Guide to Environmental Engineering for Development Workers

Water, Sanitation, and Indoor Air

James R. Mihelcic, Ph.D.  
Lauren M. Fry  
Elizabeth A. Myre

Linda D. Phillips, P.E.  
Brian D. Barkdoll, Ph.D., P.E.

**ASCE**  
PRESS

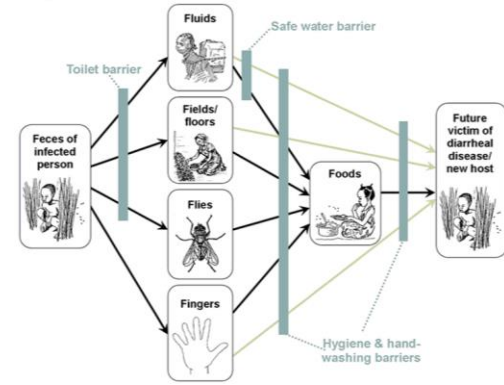
# This is simple! So, let's get to work!



Fecal → Fluids → Oral



# But it's really not simple...



Fingers

Fields

Fecal → Fluids → Oral

Flies

Food





# Social Entrepreneurship and Design Thinking

- While 'business entrepreneurs' typically measure return on investment as financial gains, 'social entrepreneurs' take into account a positive return to society in terms of improved **human capacity** and **trust relationships**.
- Design thinking is defined as combining **empathy** for the context of a problem, **creativity** in the generation of insights and solutions, and **rationality** in analyzing and fitting various solutions to the problem context.



Gerber Perez

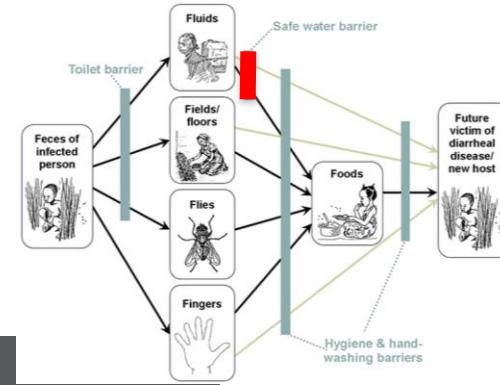
## Ixcán, Guatemala

- The northern most municipality (county) of the Quiché district (state) within Guatemala consisting of 176 communities (villages) with a total population of approximately 70,000 people.
- The region has a storied history including forced displacement of Mayan dialect speaking natives, coordinated efforts to harvest oil and timber natural resources without benefits to the rural poor, and the establishment of artificial villages composed of transplanted indigenous refugees of the Guatemalan Civil War who suffer isolation due to incompatible languages and diverse cultural backgrounds.
- Sanitary survey conducted by our team confirmed local Health Department observation that only 75% of the Ixcán population have access to improved sources of drinking water (compared to a national average of 93% access).



From: [https://commons.wikimedia.org/wiki/File:Guatemala\\_map\\_hu.svg](https://commons.wikimedia.org/wiki/File:Guatemala_map_hu.svg)

# Drinking water treatment: CAWST Biosand Filter



Contaminated water is poured into the BioSand Filter

Gravity pulls the water down through the filter

The biolayer consumes harmful bacteria, parasites and viruses

Sand filters out small particles; the remaining microbes suffocate from lack of oxygen

Clean, purified water passes out through a tube and into a storage container

## THE BIOSAND FILTER

BioSand Filters bring clean water to the developing world by using locally-available, low-cost materials

BioSand Filters use carefully-prepared layers of gravel and sand to filter water as it passes through a chimney-like container.

The secret ingredient is a biolayer, an accumulation of microbes atop the first layer of sand. Cultivated over a period of two to four weeks, the biolayer develops as oxygen and nutrients interact in a small reserve of water on top of the filter. The fully functioning BioSand Filter can remove 90 - 99% of bacteria and up to 100% of viruses. The more the filter is used, the more effective it becomes.

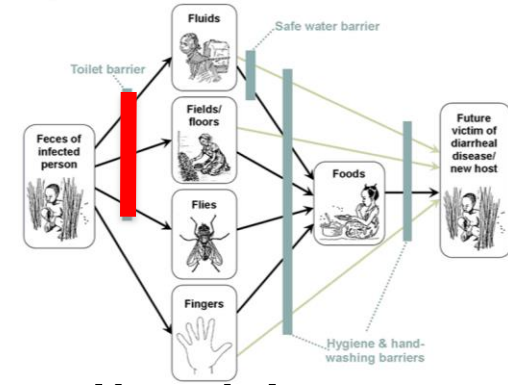
The filtered water is clean, odorless, tasteless and even cool.

Invented in Canada  
by Dr. David Manz

Illustration by: Jacob Buurma



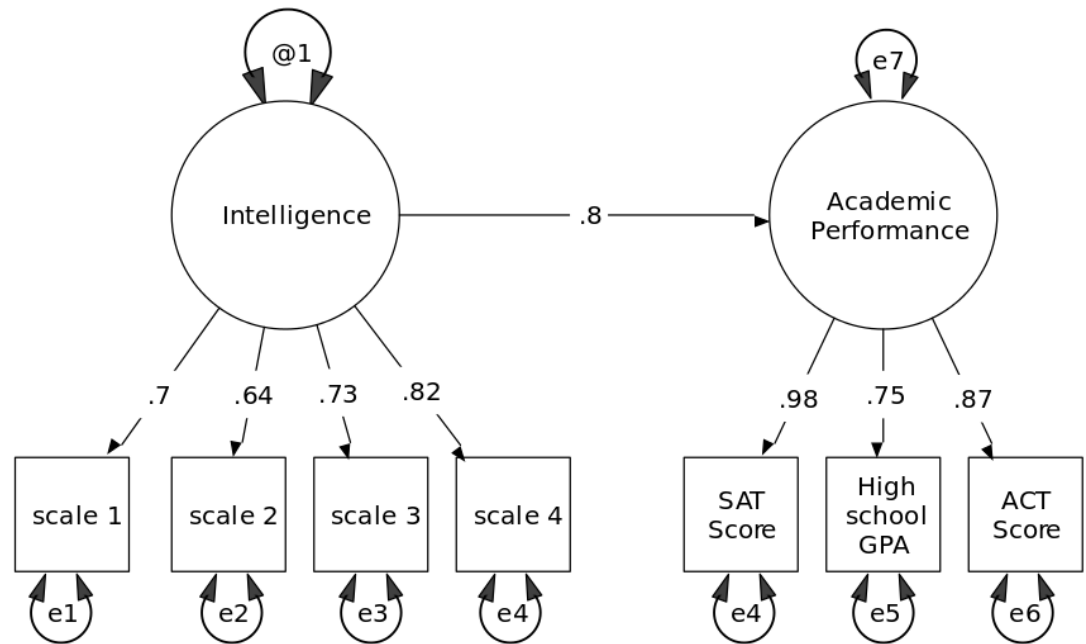
# 'Sewage' treatment



- Septic systems – separate solids from liquids and facilitate some degradation of solids
- Pit latrines – all in one hole
- Composting toilet – separate urine for fertilizer and composting feces to produce humanure
- Urine diverting dry toilet – separate urine for fertilizer and collect and dispose of solids separately

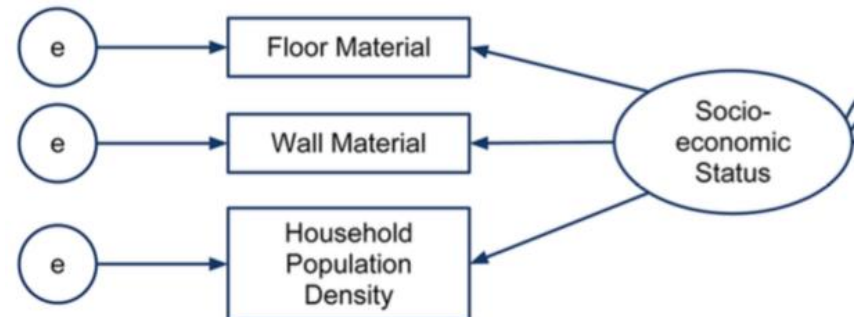
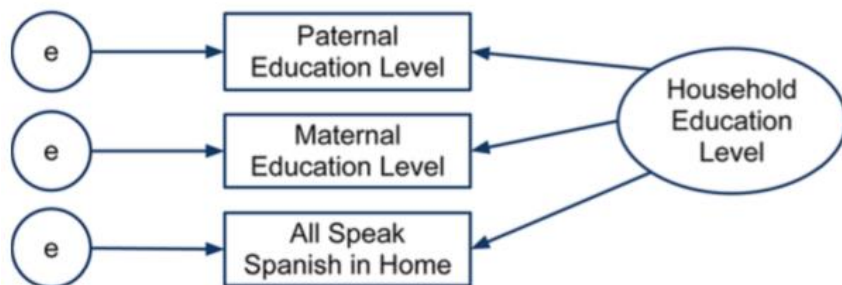
# Assessment with Structural Equation Modeling (SEM)

- SEM is a set of tools allowing a user to fit networks to sets of data.
- The user starts with a thorough review of the literature and a direct review of the system.
- The user then displays the critical system members as a set of observed and latent variables combined using explicit relationships.
- A variety of statistical tools are used to report the strength of the relationships and to account for error.



# Examples of variables in our SEM

- Read and write plus sum of formal years of education
- Spanish is a second language indicating greater education
- Dirt or concrete/tile floor
- Wood/cane or concrete block walls
- Number living in house divided by number of rooms

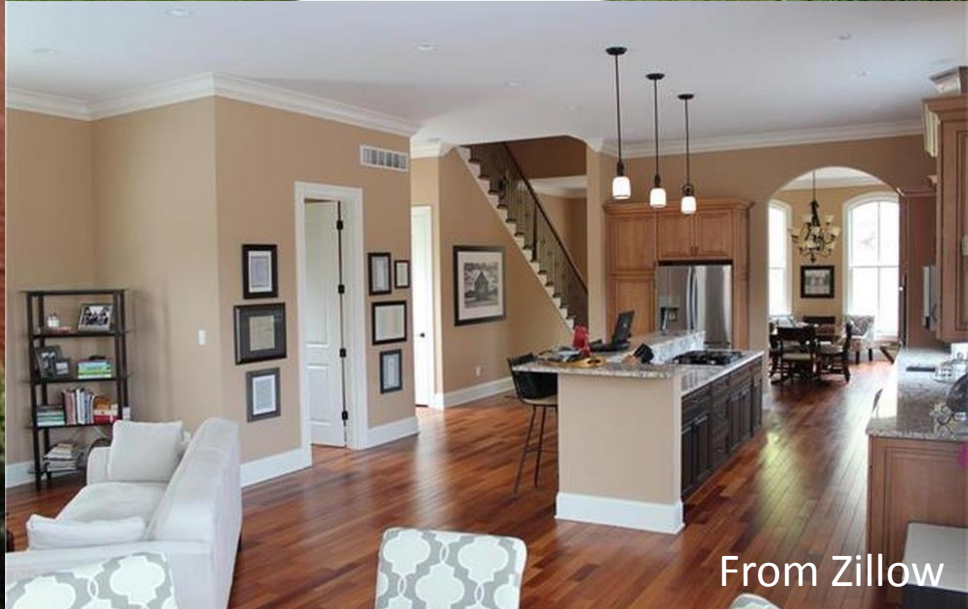


# Why not just ask...

- To determine socio economic status, why not just ask how much money you earn, or how much money you have in the bank, or how much did your house cost?



# SEM provides greater information: \$550,000 home in St. Louis

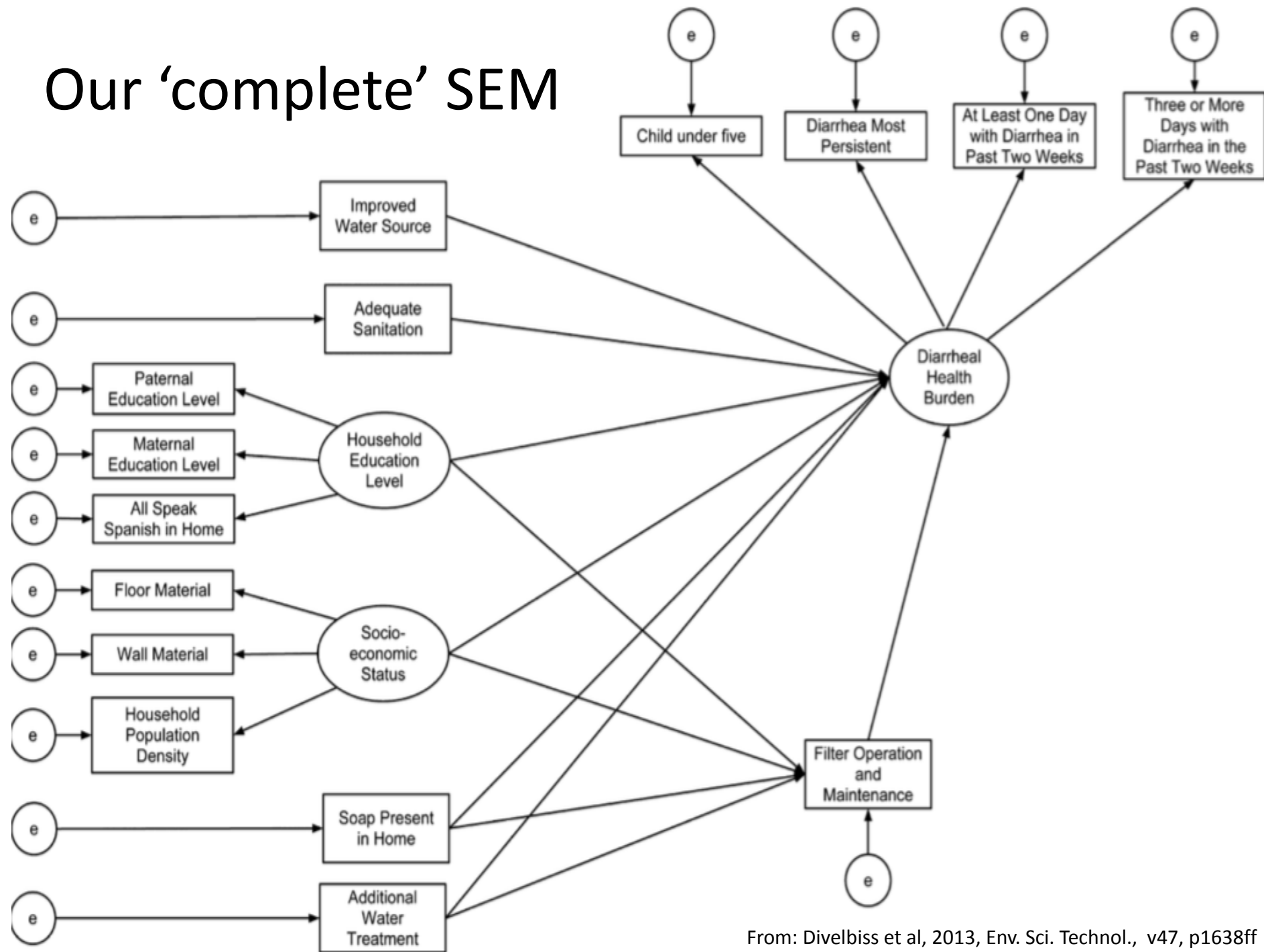


From Zillow

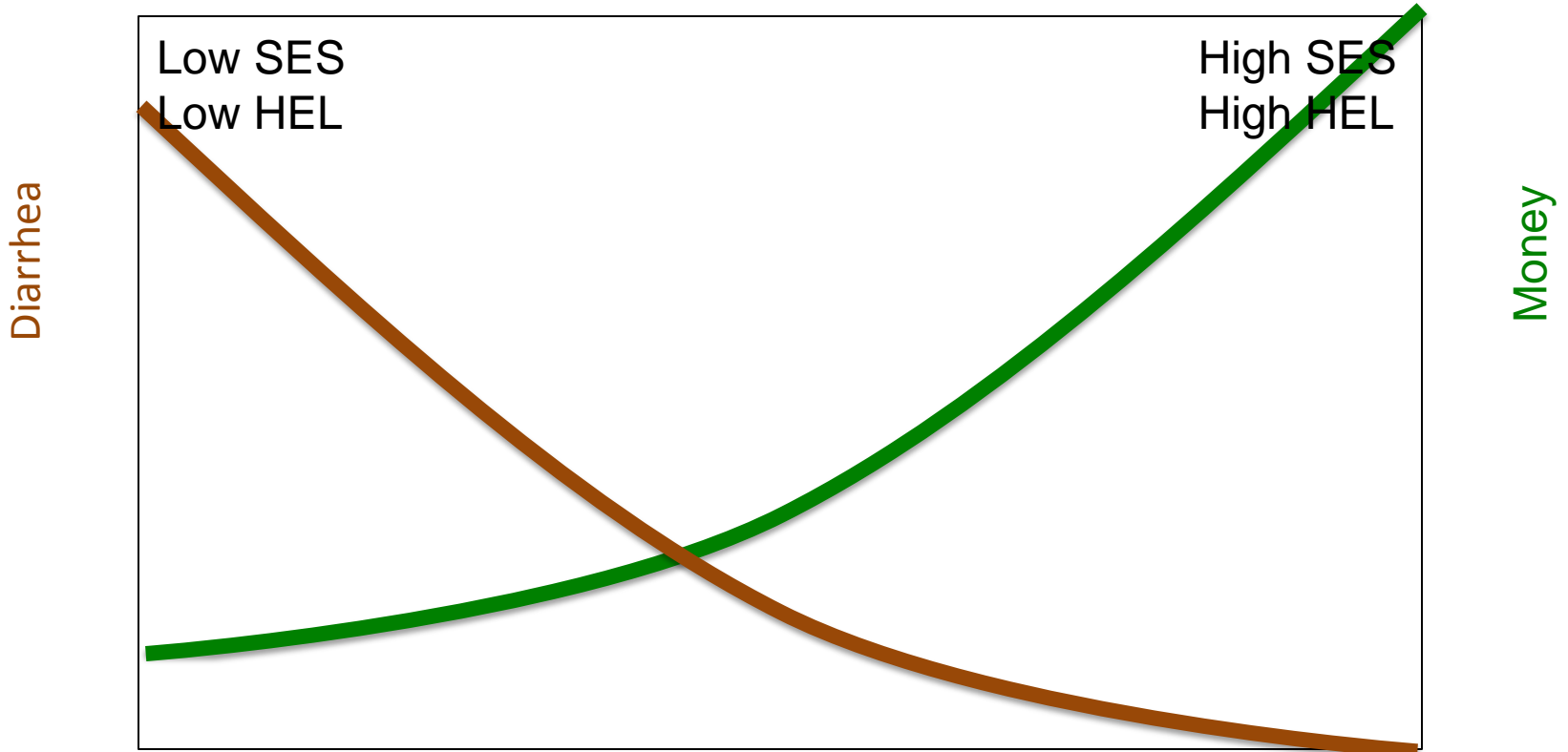
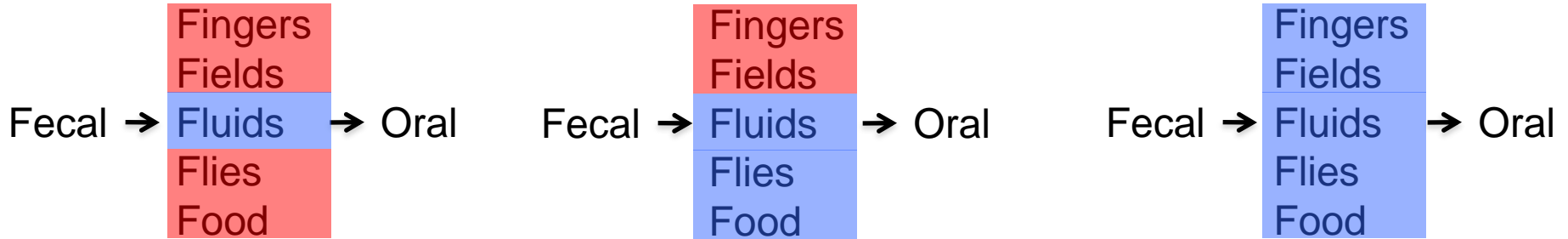
# SEM provides greater information: \$550,000 home in DC



# Our 'complete' SEM



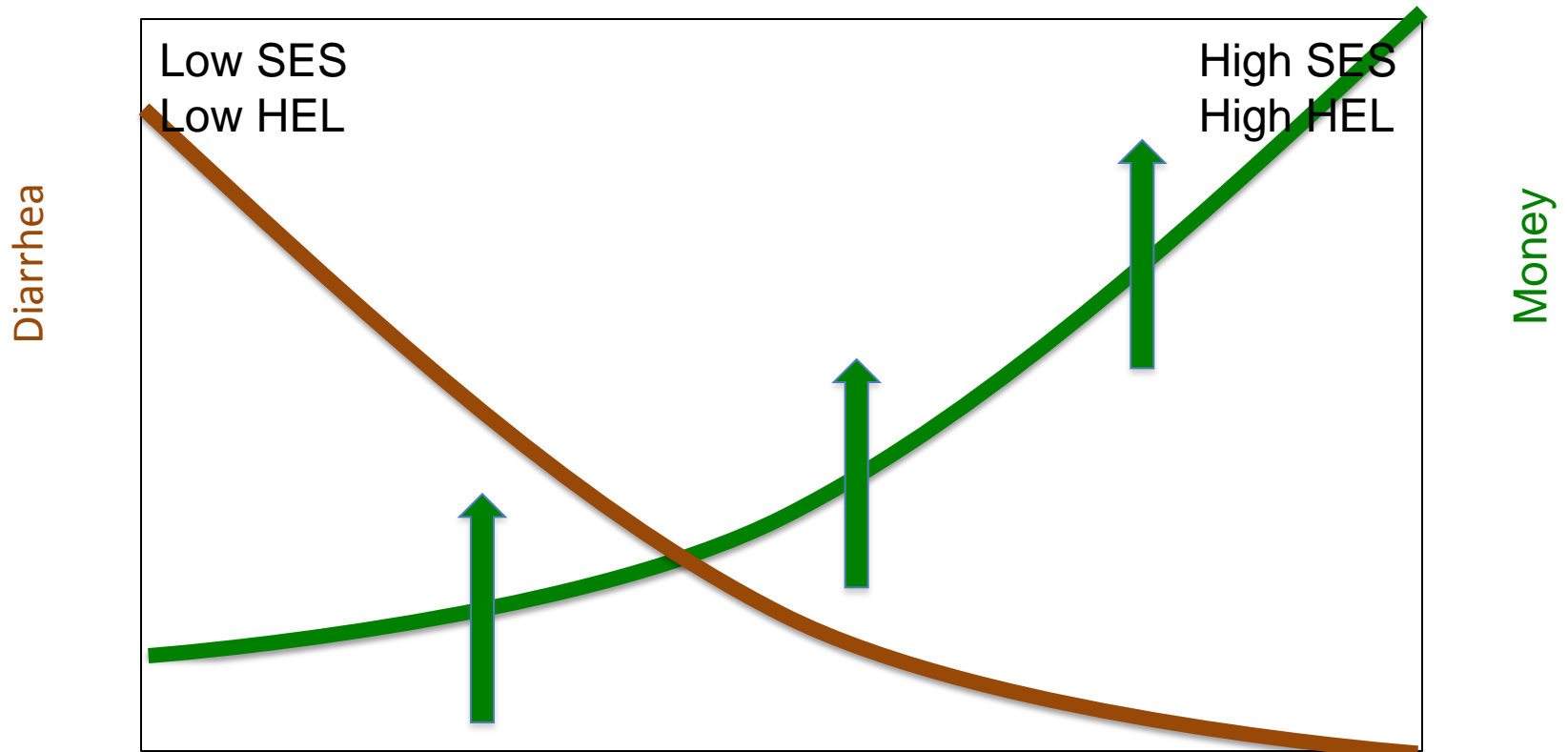
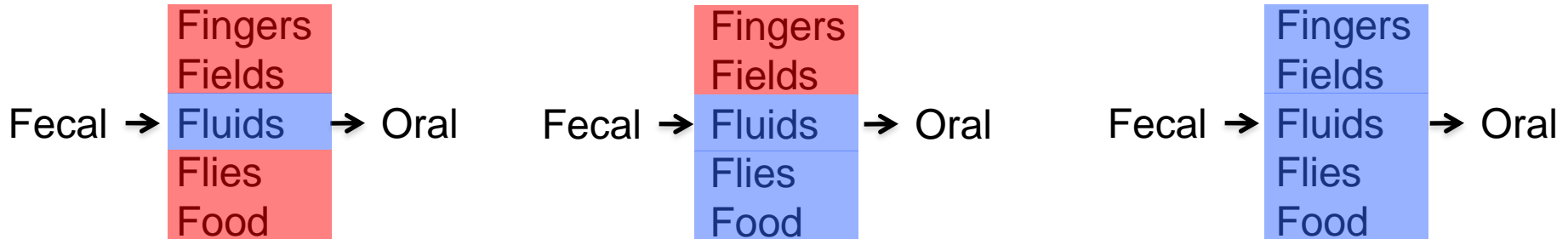
# What we discovered



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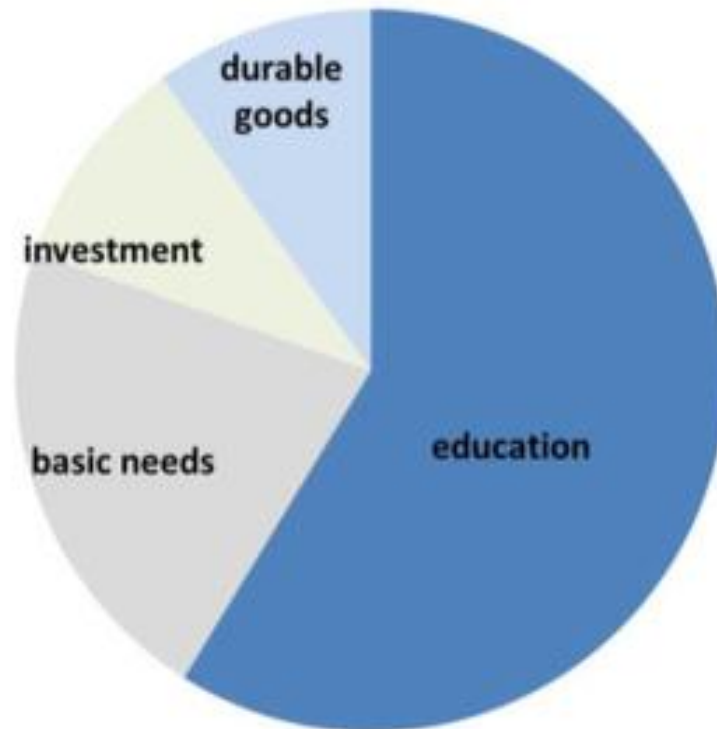
# More money (and more education)



# Back to East Africa



# And how did Kenyan's invest their earnings?





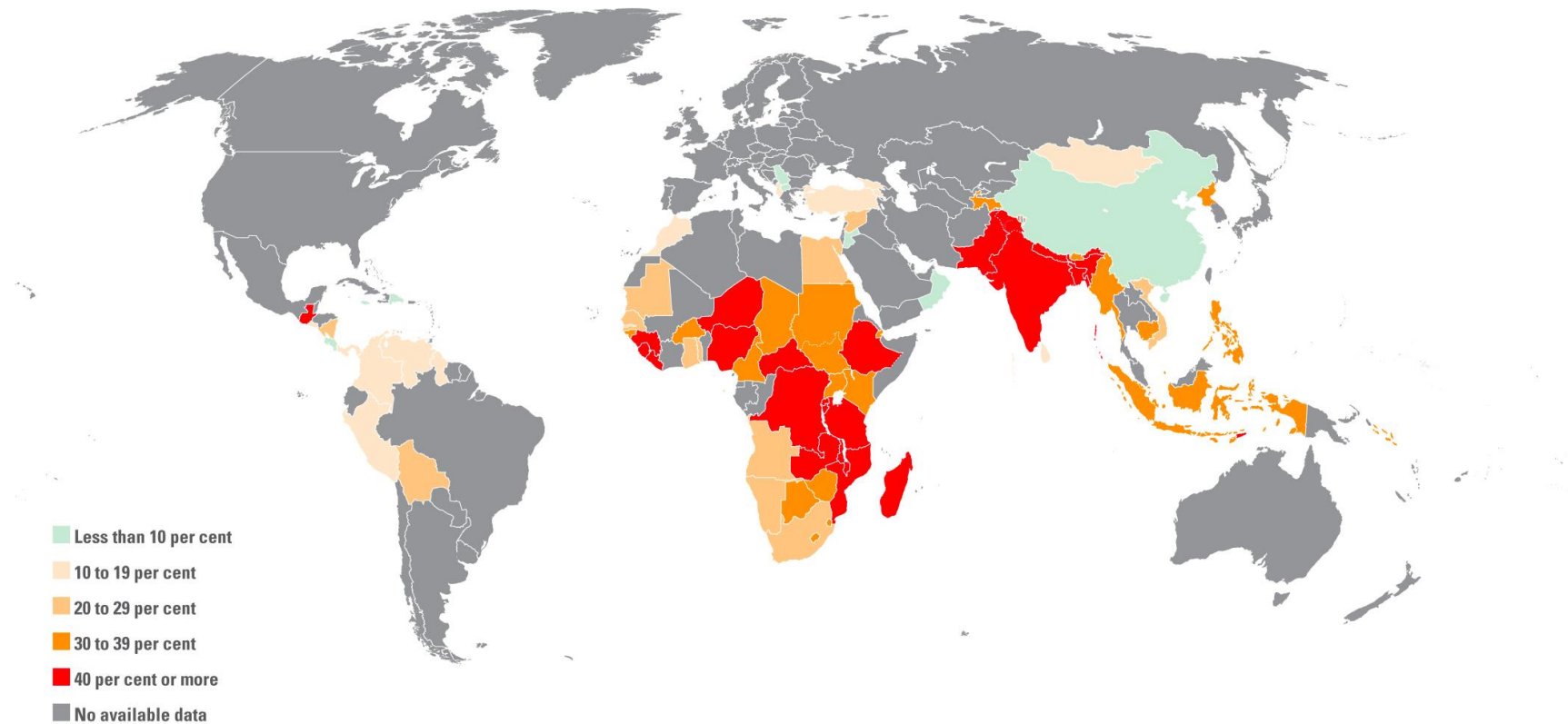
# Combating Stunting



# Anticipated

**FIGURE 4** Stunting prevalence is highest in sub-Saharan Africa and South Asia

Percentage of children under age 5 who are moderately or severely stunted



# Surprise!



Thank you