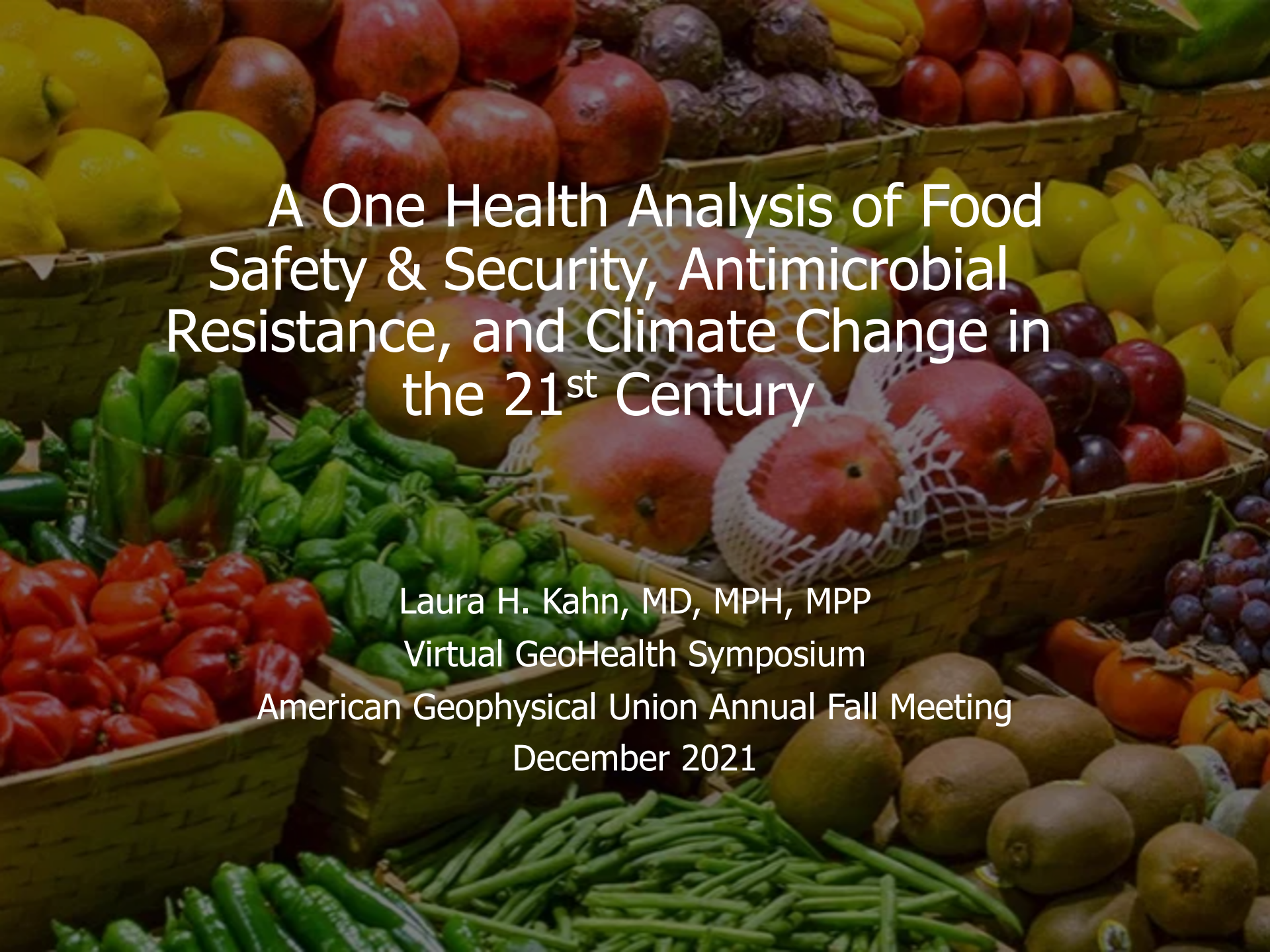


A One Health Analysis of Food Safety & Security, Antimicrobial Resistance, and Climate Change in the 21st Century

Laura H. Kahn, MD, MPH, MPP

Virtual GeoHealth Symposium
American Geophysical Union Annual Fall Meeting
December 2021

Climate Change Threatens
Agriculture and Food Security

Agriculture:
Foundation of Civilization

Antimicrobial Resistance Threatens
Antimicrobial Use and Food Safety

Antimicrobials:
Foundation of Modern Medicine

Definitions

FOOD SYSTEMS

Food Systems include all activities related to the production, distribution, and consumption of food that affect nutrition and health.

FOOD SECURITY

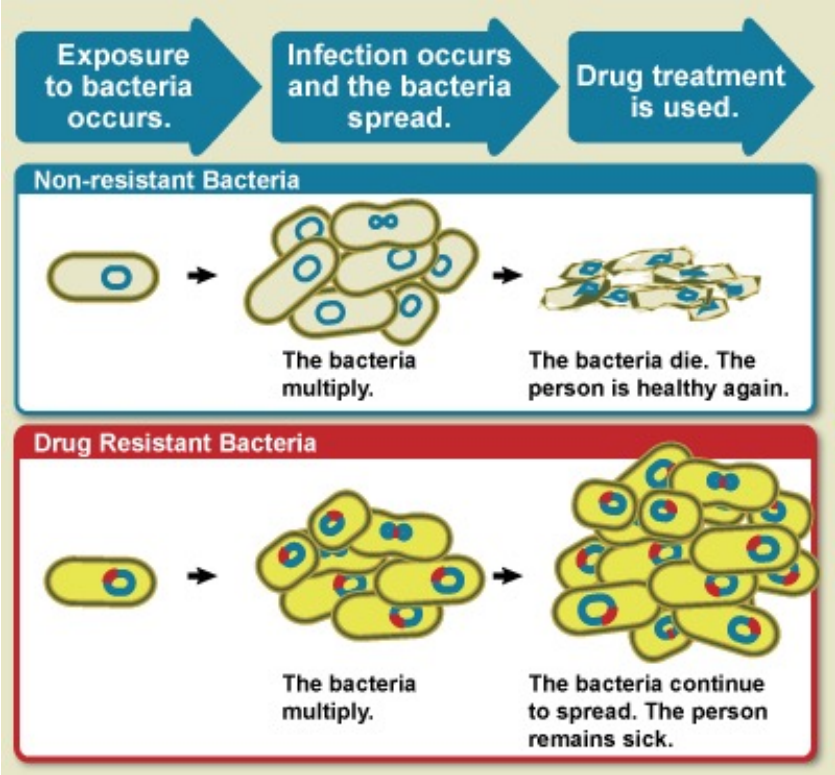
Food Security exists when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

FOOD SAFETY

Food Safety includes activities, processes, and policies encompassing the food chain, aimed at ensuring food is safe for consumption.

Food Security means No Hunger

Food Safety means No Foodborne Illness



AMR means bacteria resistant to antibiotics

The One Health concept: human, animal, plant, environmental & ecosystem health are linked.

This concept provides a useful framework for examining complex issues such as food safety & security, AMR, and climate change.

We must examine the root causes of spillover events if we are to develop effective policies to address them.

People interact with their environment every day by inhaling air, drinking water, and ingesting plants and animals (i.e. food).

http://www.onehealthinitiative.com

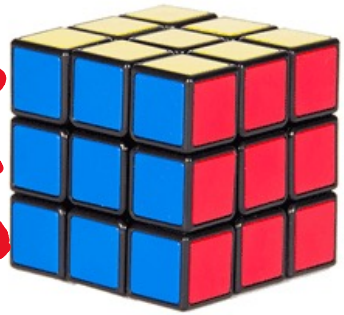
Multi-Dimensional One Health Matrix: A Cube

One Health Factors

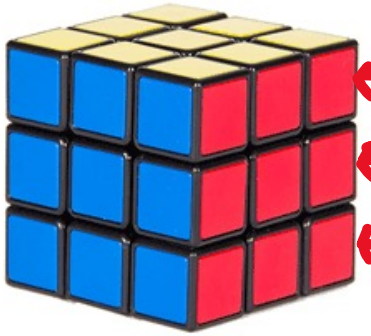
Humans & Animals

Plants

Environments & Ecosystems



Complexity Factors

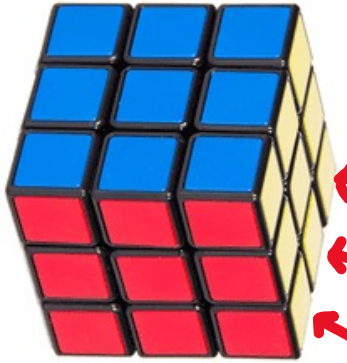


Microbial

Individual

Population

Political, Social, Economic Factors



Local/Regional

National

International/Global

Adapted by L. Kahn for policy development from Rabinowitz, et al. BMC Med Educ. 2017. 17(1): 45. https://doi.org/10.1186/s12909-017-0883-6.

One Health Framework in 2 Dimensions

One Health and Complexity Factors	Microbial	Individual	Population
Humans			
Animals			
Plants			
Environments & Ecosystems			
Political, Social, Economic Factors	**Local & Regional**	**National**	**International & Global**

Environments: abiotic (e.g. soil, water, air) aspects of defined geographic areas.
Ecosystems: biotic interactions (e.g. microbial, flora, fauna) within defined geographic areas.

Adapted by L. Kahn for policy development from Rabinowitz, et al. BMC Med Educ. 2017. 17(1): 45. https://doi.org/10.1186/s12909-017-0883-6.

A One Health Analysis

One Health Factors:

Humans
& Animals
(Domesticated,
Terrestrial Livestock)

Complexity Factors:

Microbial & Populations
(Fecal Microbes)

Plants
(Cereal Crops)

Microbial & Populations
(Fecal Microbes)

Environments &
Ecosystems
(Water, Soil, Air)
(Global Resistome)

Microbial & Populations
(Fecal Microbes)

Political, Social, Economic Factors:
International/Global Food Security
Global Demand for Meat

Time Factor: Years

A One Health Satellite Perspective

First One Health Analysis

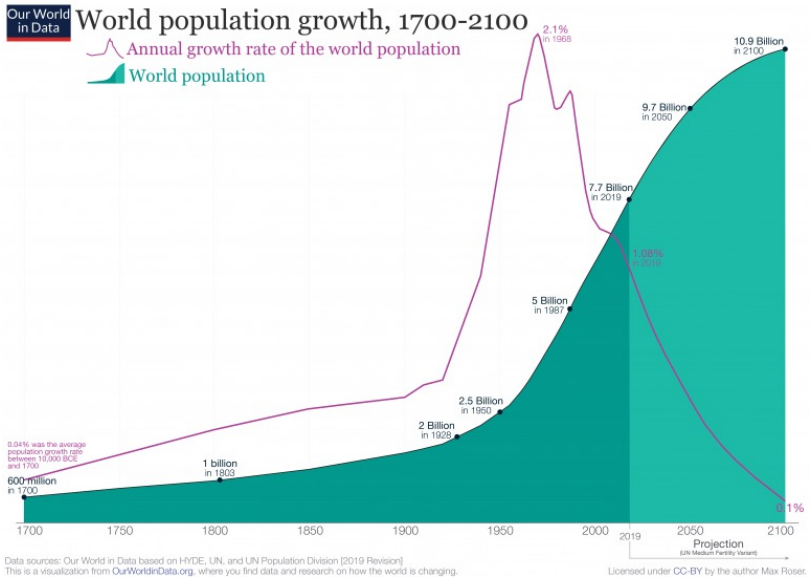
Humans & Animals (Domesticated Livestock)

Microbial & Populations

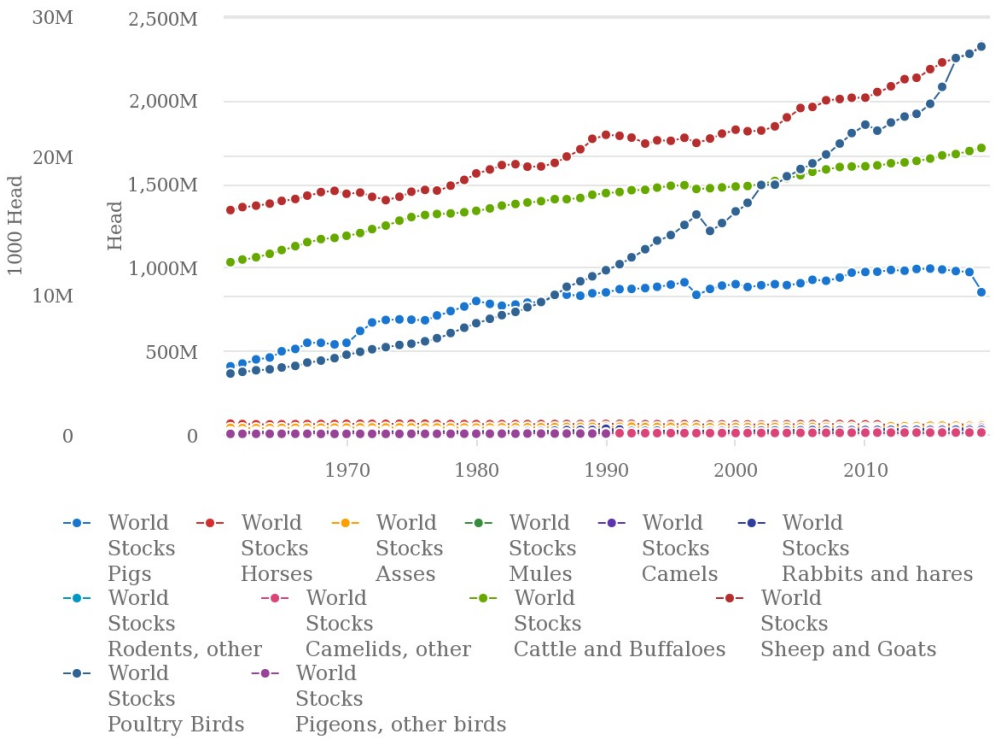
International/Global

Global Human & Animal Populations

Almost 8 Billion Humans



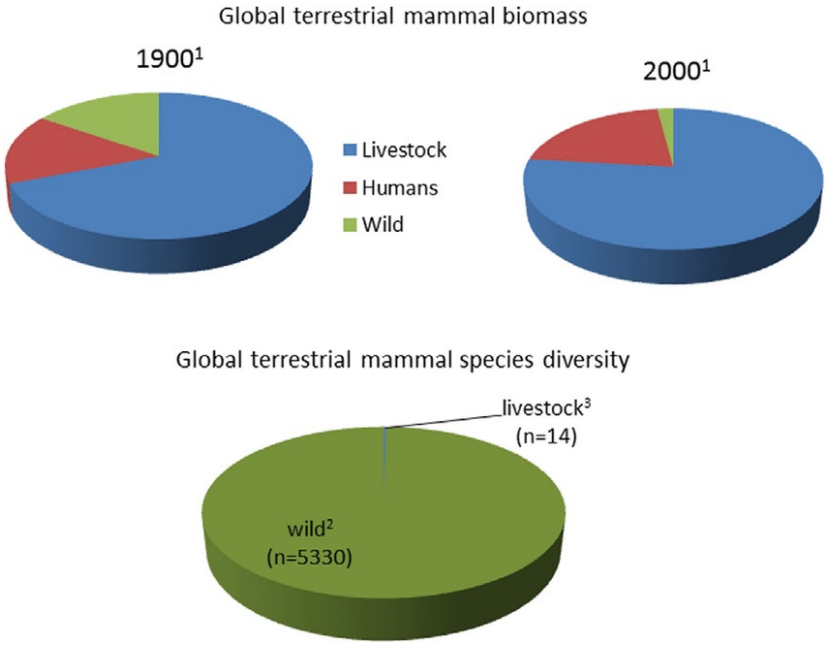
Around 30 Billion Terrestrial Food Animals



Source: FAOSTAT (Jul 19, 2021)

Pigs	2019	2019	Head	850320154
Horses	2019	2019	Head	59041725
Asses	2019	2019	Head	50583572
Mules	2019	2019	Head	7936978
Camels	2019	2019	Head	37509691
Rabbits and hares	2019	2019	1000 Head	299945
Rodents, other	2019	2019	1000 Head	19258
Camelids, other	2019	2019	Head	9160334
Cattle and Buffaloes	2019	2019	Head	1715363494
Sheep and Goats	2019	2019	Head	2332787886
Poultry Birds	2019	2019	1000 Head	27883057

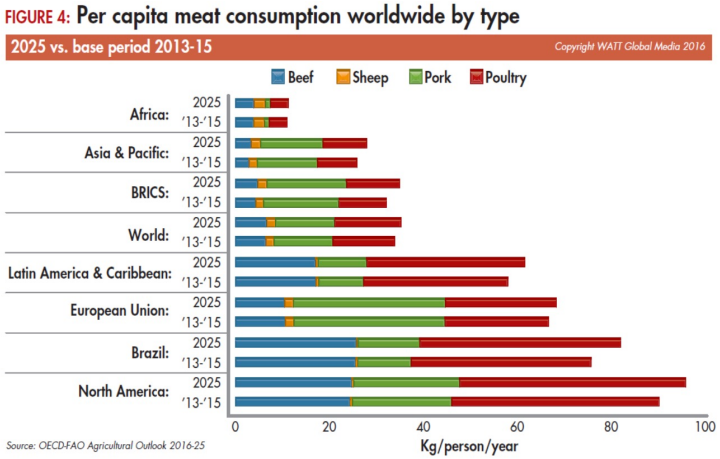
Biodiversity, land use and ecosystem services



Humans and domesticated livestock constitute approximately 96 to 98% of global terrestrial mammalian biomass.

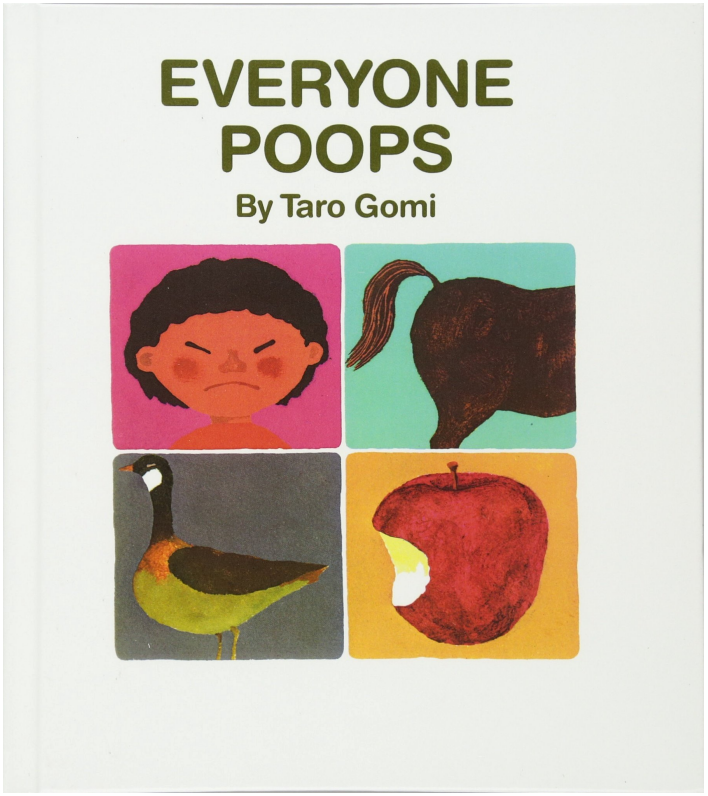
Zeller U, Starik N, Gottert T. *Global Ecology and Conservation* 2017; 10: 114-125; Diamond (2002) Rondinini et al (2011); Smil (2011)

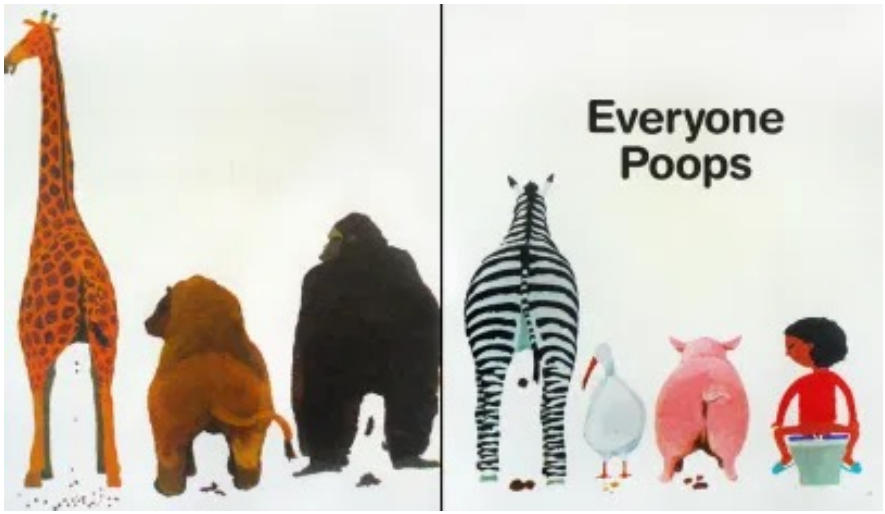
Broiler chickens are a signal of a human reconfigured biosphere



Broiler chickens combined mass exceeds all other birds on Earth. Standing population of almost 23 billion.

Bennett CE, Thomas R, Williams M, et al. Royal Society Open Science 2018; 5: rsos.180325
https://www.wattagnet.com/Per-capita-meat-consumption-worldwide-by-type-2013-15-vs-2025





All animals eat so…

We produce around 4 trillion kilograms of feces each year!

Article | Published: 13 November 2018

Estimation of global recoverable human and animal faecal biomass

David M. Berendes, Patricia J. Yang, Amanda Lai, David Hu & Joe Brown

Nature Sustainability **1**, 679–685 (2018) | Cite this article

Table 1 2014 estimates of WHO (World Health Organization) regional animal population, animal faecal production, human population and human faecal production

From: Estimation of global recoverable human and animal faecal biomass

Region	Animal population, 2014	Animal faeces (kg yr^{-1})	Human population, 2014	Human faeces (kg yr^{-1})	Total faeces (kg yr^{-1})
Africa	2.34×10^{9}	4.01×10^{11}	9.62×10^{8}	1.06×10^{11}	5.07×10^{11}
Americas	6.74×10^{9}	7.84×10^{11}	9.75×10^{8}	1.27×10^{11}	9.11×10^{11}
EastMed	3.49×10^{9}	2.98×10^{11}	6.39×10^{8}	8.00×10^{10}	3.78×10^{11}
Europe	4.00×10^{9}	3.70×10^{11}	9.09×10^{8}	1.14×10^{11}	4.84×10^{11}
SEAsia	4.26×10^{9}	4.87×10^{11}	1.90×10^{9}	2.01×10^{11}	6.88×10^{11}
WPacific	8.91×10^{9}	7.79×10^{11}	1.83×10^{9}	2.16×10^{11}	9.95×10^{11}
World	2.97×10^{10}	3.12×10^{12}	7.22×10^{9}	8.10×10^{11}	3.93×10^{12}

Total fecal matter produced by humans and livestock in 2014 would…

fill over 1.6 million Olympic-sized swimming pools,
and by 2030, over 1.8 million Olympic-sized swimming pools
with feces.

Or, to put it another way…

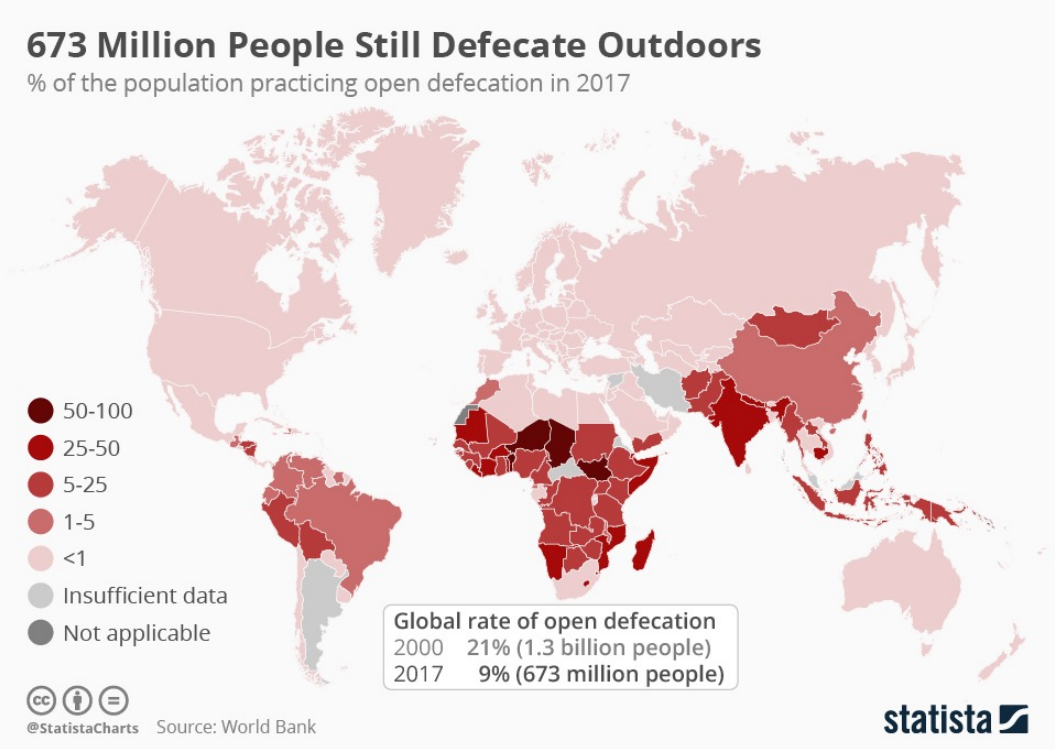
Los Angeles, CA

New York, NY

bury the entire surface areas of
Los Angeles + NYC
in 6 feet of feces.

We produce increasing amounts each year.

Human Fecal Matter



Animal Fecal Matter (Manure)

Global Assessment of Manure Management Policies and Practices

E. Teenstra[1,2], T. Vellinga[2], N. Aektasaeng[3], W. Amatayakul[3], A. Ndambi[4], D. Pelster[4], L. Germer[5], A. Jenet[5], C. Opio[1], K. Andeweg[2].

1 Food and Agriculture Oganization of the United Nations (FAO)
2 Wageningen UR Livestock Research
3 Stockholm Environment Institute (SEI)
4 International Livestock Research Institute (ILRI)
5 Tropical Agricultural Research and Higher Education Center (CATIE)

Wageningen UR Livestock Research
Wageningen, December 2014

2.1 Manure Policies

Thirty out of the 34 countries in the survey have national policies related to manure management. The map in Figure 1 shows the responding countries with and without manure related policies.

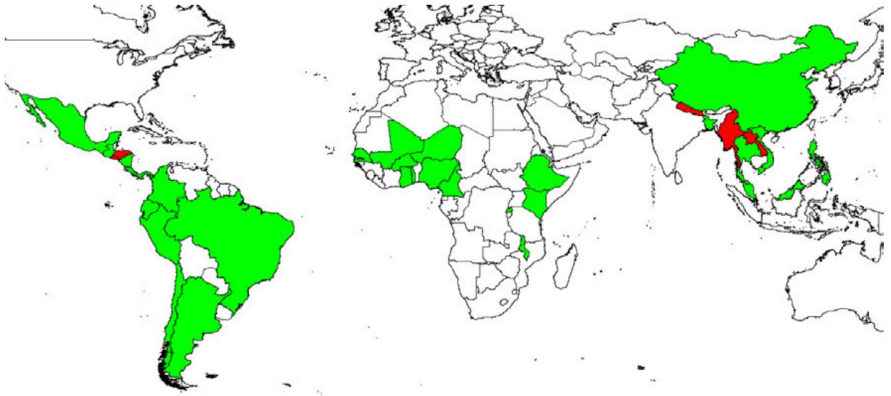


Figure 1. Surveyed countries with (green) and without (red) manure management related policies.

Having legislation on manure management is one thing, enforcing it is a whole other issue. Generally, enforcement of manure policies is regarded as being weak (Figure 3). Particularly in situations where multiple ministries are involved, there is often a lack of coordination between the ministries and their enforcing bodies resulting in unclear procedures and penalties. Enforcement of regulation was found to vary across the surveyed countries; respondents from China, Viet Nam, Malaysia, Panama, Ecuador and Chile indicated well-coordinated law enforcement.

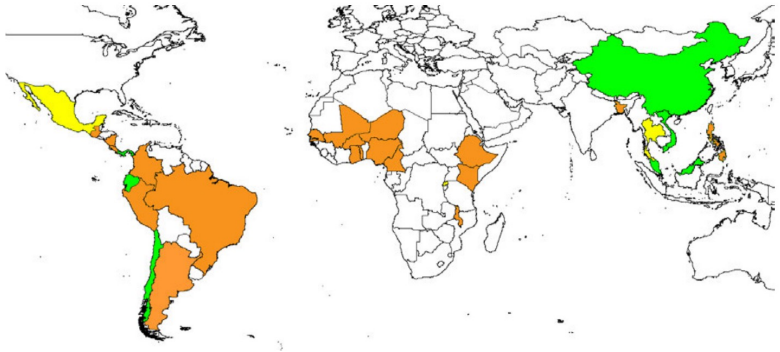
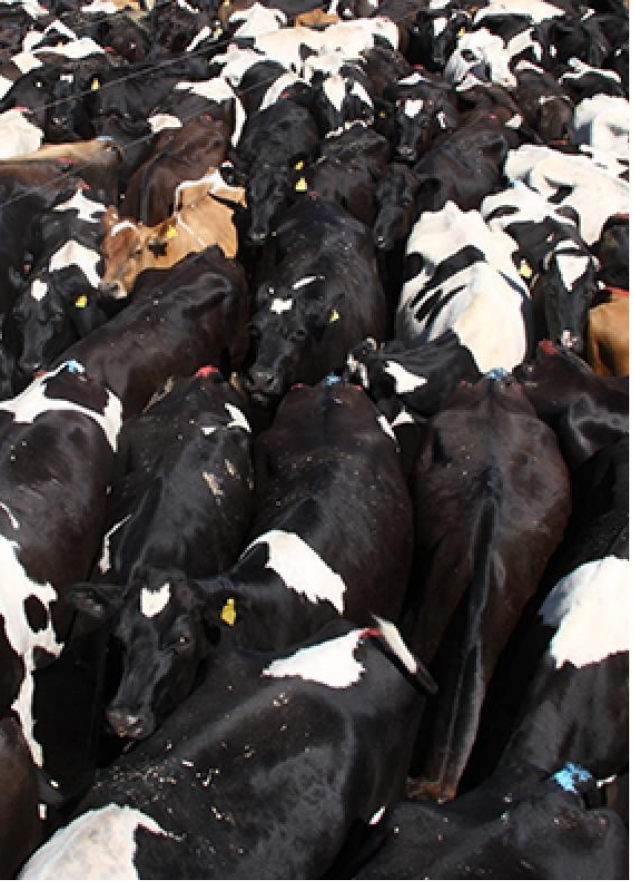


Figure 3. Level of enforcement
***Green** = very strict: non- compliance immediately leads to penalties;*
***Yellow** = moderate; strict but first a warning and a time frame within which improvements have to be made;*
***Orange** = weak/none: rules are not enforced or just on selected farms (based on size, location etc.).*



Concentrated Animal Feeding Operations (CAFO)

Report to Congressional Requesters:

United States Government Accountability Office:
GAO:

September 2008:

Concentrated Animal feeding operations:

EPA Needs More Information and a Clearly Defined Strategy to Protect Air and Water Quality from Pollutants of Concern:

GAO-08-944:

GAO Highlights:

Highlights of GAO-08-944, a report to congressional requesters.

What GAO Found:

Because no federal agency collects consistent, reliable data on CAFOs, GAO could not determine the trends in these operations over the past 30 years. However, using USDA data for large farms that raise animals as a proxy for CAFOs, it appears that the number of these operations increased by about 230 percent, going from about 3,600 in 1982 to almost 12,000 in 2002. Also, during this 20-year period the number of animals per farm had increased, although it varied by animal type. Moreover, GAO found that EPA does not have comprehensive, accurate information on the number of permitted CAFOs nationwide. As a result, EPA does not have the information it needs to effectively regulate these CAFOs. EPA is currently working with the states to establish a new national data system.

The amount of manure generated by large farms that raise animals depends on the type and number of animals raised, but large operations can produce more than 1.6 million tons of manure a year. Some large farms that raise animals can generate more raw waste than the populations of some U.S. cities produce annually. In addition, according to some agricultural experts, the clustering of large operations in certain geographic areas may result in large amounts of manure that cannot be effectively used as fertilizer on adjacent cropland and could increase the potential of pollutants reaching nearby waters and degrading water quality.

Pathogens in Human Feces

In the following tables a comprehensive list of the various microbes generally found in human excreta and the diseases caused due to each have been mentioned.

VIRAL PATHOGENIC EXCRETED IN FAECES

Viruses	Diseases	Symptom	Human Carrier	States Reservoir
Polioviruses	Poliomyelitis	Paralysis and other conditions	Yes	Human
Hepatitis A Virus	Infectious hepatitis		Yes	Human
Rotaviruses	Diarrhoea		Yes	Human
Echoviruses		Numerious conditions	Yes	Human
Coxsackie viruses		Numerious conditions	Yes	Human
Reoviruses		Numerious conditions	Yes	
Adenoviruses		Numerious conditions	Yes	Human
Astrovirus (many types)	Gastroenteritis			
Calicivirus (several types)	Gastroenteritis			
Corona virus	Gastroenteritis			
Entero viruses (many types)	Gastroenteritis	various		
Hepatitis E virus	Infectious hepatitis			
Norwalk virus	Gastroenteritis			
Norwalk-like viruses	Gastroenteritis			
Parvovirus (several types)	Fifth disease			others

BACTERIAL PATHOGENS EXCRETED IN FAECES

Bacteria	Diseases	Bacteria also excreted in urine	Symptom	Human carrier	States Reservoir
Salmonella typhi	Typhoid fever	Yes		Yes	Human
Para typhi	Paratyphoid	Yes		Yes	Human
Other salmonella	Food poisoning etc.	No		Yes	Human & Animal
Shigella	Bacillary dysentery	No		Yes	Human
V. Cholera	Cholera	No		Yes	Human
Pathogenic E. Coli	Diarrhoea or gastroenteritis	No		Yes	Human & Animal
Yersini	Yersiniosis	Yes		Yes	Animal & Man (b)
Campylobacter	Diarrhoea	No		Yes	Animal&Man(?)
Leptospira (spp.)	Leptospirosis				
Helicobacter pylori			Abdominal pain, peptic ulcers, gastric cancer		
Chlamydia trachomatis	Trachoma				

1. Each serotype is more or less specific to a particular animal host.
2. Some 30 or more serotypes appear to be associated with particular animal species. Any specific distinct serotypes, specific to prionates, is still under investigation.

ENVIS Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology

Hosted by International Institute of Health and Hygiene,New Delhi

Sponsored by Ministry of Environment, Forest & Climate Change, Govt of India

Pathogen means microbe that causes disease.

One gram of faeces contains:

- 10,000,000 Viruses
- 1,000,000 Bacteria
- 1,000 Parasite cysts
- 100 parasitic eggs.

These pathogens cause infections which lead to over 1.3 million deaths world-wide annually. Children and the immuno-depressed are the most vulnerable to these organisms which contributes to this burden, specifically bacteria, viruses and parasites.

Pathogens in Animal Feces

Environmental Science & Technology

Critical Review

Cite This: *Environ. Sci. Technol.* 2017, 51, 11537-11552

pubs.acs.org/est

Exposure to Animal Feces and Human Health: A Systematic Review and Proposed Research Priorities

Gauthami Penakalapati, Jenna Swarthout, Miranda J. Delahoy, Lydia McAliley, Breanna Wodnik, Karen Levy, and Matthew C. Freeman*

Department of Environmental Health, Emory University, Atlanta, Georgia 30322 United States

Supporting Information

Few studies examine pathogens in animal feces.

Table 1. Summary of Characteristics of Studies (n = 62)[a] Included in Review of Potential Health Impacts from Exposure to Animal Feces

Region	n (%)
Africa	
North Africa	1 (2%)
Sub-Saharan Africa	19 (31%)
Asia	
Middle East	1 (2%)
South Asia	19 (31%)
Southeast Asia	9 (15%)
East Asia	1 (2%)
South America	12 (19%)
Oceania	1 (2%)
Global	1 (2%)
Health Outcomes	n (%)
Diarrhea	18 (29%)
Environmental Enteric Dysfunction	2 (3%)
Helminth Seropositivity	5 (8%)
Mortality	1 (2%)
Nutrition and Growth Outcomes	8 (13%)
Pathogens Found in Stool	17 (27%)
Trachoma	3 (5%)
Hookworm-Related Cutaneous Larva Migrans	1 (2%)
Other: human behaviors/practices	5 (8%)
No Health Outcomes Specified	14 (23%)
Animal	n (%)
Livestock	
Buffalo	5 (8%)
Cattle	25 (40%)
Goats	19 (30%)
Sheep	14 (22%)
Pigs	9 (14%)
Poultry (chickens, ducks, geese, quail)	29 (46%)
Synanthropic Rodents	3 (5%)
Pets/Free-Roaming	
Cats	11 (17%)
Dogs	14 (22%)
Other (horses, guinea pigs, rabbits)	2 (3%)
Not Specified	13 (21%)

[a]A total of 62 unique publications were reviewed. The total N for *Regions*, *Health*, *Outcomes*, and *Animals* is greater than 62 because publications that assessed multiple regions, health outcomes, or animals in their study were counted for each unique region, health outcome, or animal.

Demographic Health Surveys (DHS) from 30 sub-Saharan African countries found an inconsistent relationship across

Table 2. Summary of Pathogen Characteristics of Studies (n = 62)[a] Included in Review of Potential Health Impacts from Exposure to Animal Feces

Pathogens	n (%)
Bacteria	
Aeromonas hydrophila	1 (2%)
Bacteriodales spp.	1 (2%)
Campylobacter spp.	9 (15%)
Chlamydia trachomatis	3 (5%)
Escherichia coli	11 (17%)
Klebsiella spp.	1 (2%)
Salmonella spp.	5 (8%)
Shigella spp.	5 (8%)
Vibrio spp.	4 (7%)
Yersinia spp.	2 (3%)
Helminths	
Ascaridia spp.	1 (2%)
Ascaris spp.	4 (7%)
Clonorchis spp.	1 (2%)
Echinococcus spp.	2 (3%)
Enterobius spp.	1 (2%)
Hookworm (*Ancylostoma* spp.)	7 (11%)
Hymenolepis spp.	1 (2%)
Schistosoma spp.	3 (5%)
Spirometra spp.	1 (2%)
Strongyloides spp.	3 (5%)
Taenia spp.	1 (2%)
Toxocara spp.	6 (10%)
Trichuris spp.	6 (10%)
Microsporidia	
Enterocytozoon bieneusi	1 (2%)
Protozoa	
Blastocystis hominis	1 (2%)
Cryptosporidium spp.	10 (16%)
Cyclospora cayetanensis	2 (3%)
Entamoeba spp.	6 (10%)
Giardia spp.	15 (24%)
Isospora belli	2 (3%)
Toxoplasma spp.	1 (2%)
Trichomonas hominis	1 (2%)
Viruses	
Adenovirus	2 (3%)
Astrovirus	1 (2%)
Hepatitis E virus	1 (2%)
Rotavirus	5 (8%)

[a]A total of 62 unique publications were reviewed. The total N for all pathogens is greater than 62 because publications that assessed multiple pathogens were counted for each unique pathogen.

In 2015, WHO released a report estimating global burden of foodborne illnesses.

Figure 12. The global burden of foodborne disease (DALYS per 100 000 population) by hazard groups and by subregion, 2010.

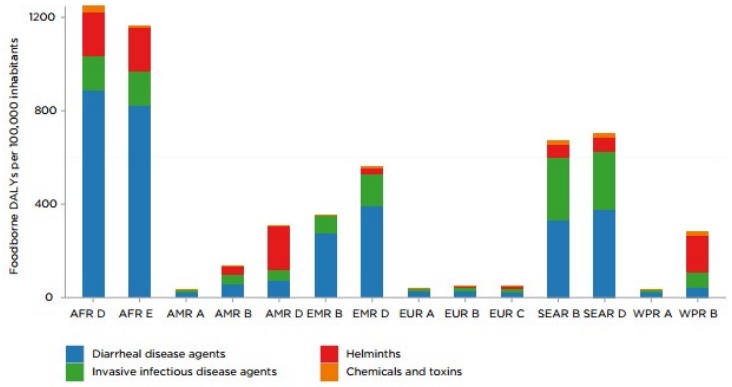


Image Source: WHO Estimates of the Global Burden of Foodborne Diseases, Foodborne diseases burden epidemiology reference group 2007-2015

About 1 in 10 people is sickened by food each year. Of the 600 million people who get sick, around 420,000 die. Children under 5 years make up 40% of the cases.

Diarrheal disease agents cause around 550 million illnesses and 230,000 deaths.

31 Foodborne Hazards in WHO Global Estimates	
Diarrheal Disease Agents	*Campylobacter* spp., *Cryptosporidium* spp., *Entamoeba histolytica*, Enteropathogenic *E. coli* (EPEC), Enterotoxigenic *E. coli* (ETEC), *Giardia* spp., Norovirus, *Salmonella enterica* (non-invasive infections) non-typhoidal, *Shigella* spp., Shiga toxin-producing *E. coli* (STEC), *Vibrio cholerae*
Invasive Infectious Disease Agents	*Brucella* spp., *Hepatitis A* virus, *Listeria* spp., *Mycobacterium bovis*, *Salmonella enterica* (invasive infections) non-typhoidal, *Salmonella enterica* Paratyphi A, *Salmonella enterica* Typhi
Helminths	*Ascaris* spp., *Echinococcus multilocularis*, *Echinococcus granulosus*, *Clonorchis sinensis*, *Fasciola* spp., Intestinal flukes, *Opisthorchis* spp., *Paragonimus* spp., *Taenia solium*, *Toxoplasma gondii*, *Trichinella* spp.
Chemicals	Aflatoxin, Cassava cyanide, Dioxin

Second One Health Analysis

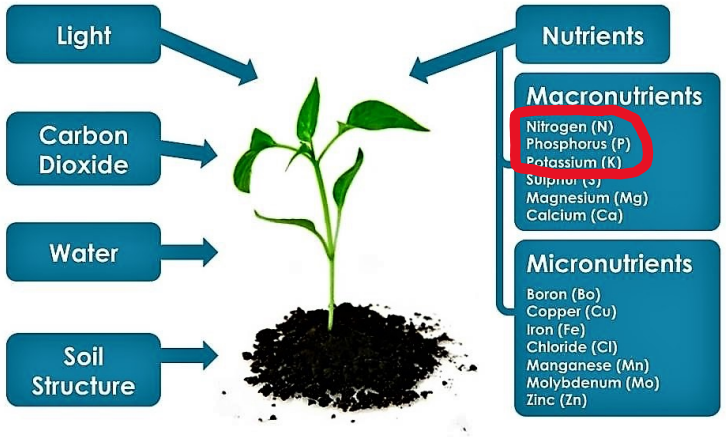
Plants
(Cereal Crops)

Microbial &
Populations

International/Global

The world has over 50 000 edible plants. Just three of them, rice, maize and wheat, provide 60 percent of the world's food energy intake.

Source: FAO



Source: SSWM & GENSCH (2010)

The Green Revolution

In 1944, Borlaug worked for the Rockefeller Foundation's technical assistance program in Mexico.

Production problems limited wheat harvests.

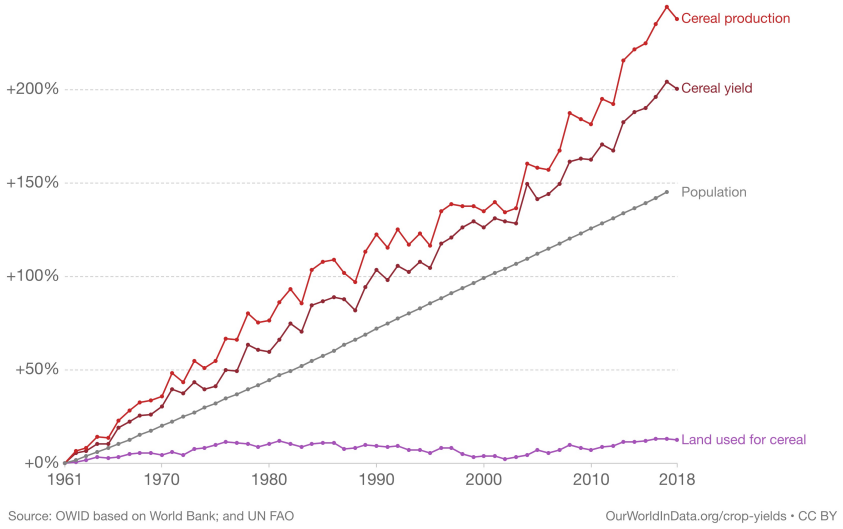
New wheat varieties with disease resistance, adapted to different growing conditions with high yields.

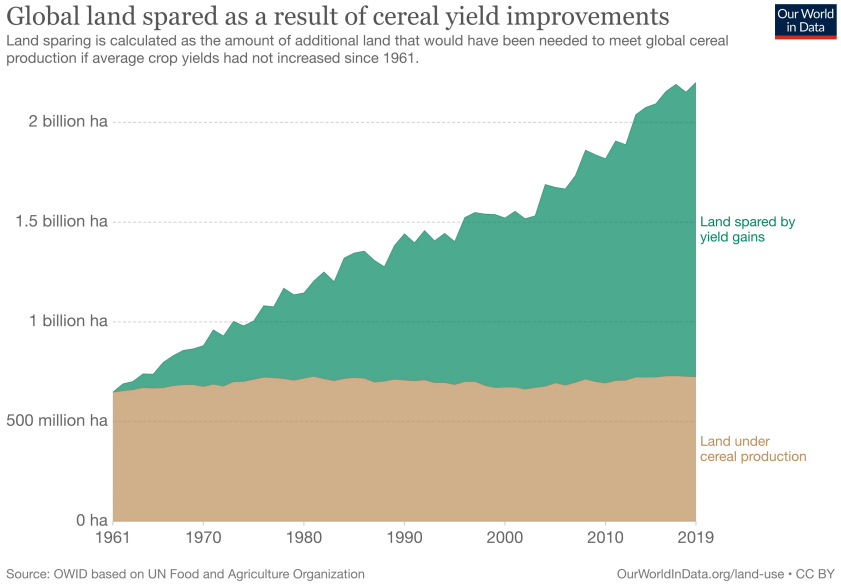
New wheat varieties and crop management practices spread from Mexico to Asia and South America becoming known as "The Green Revolution."

Dr. Norman Borlaug, plant pathologist.
Awarded 1970 Nobel Peace Prize for averting widespread hunger.
Founder, The World Food Prize

http://www.worldfoodprize.org/en/dr_norman_e_borlaug/about_norman_borlaug/

The Green Revolution

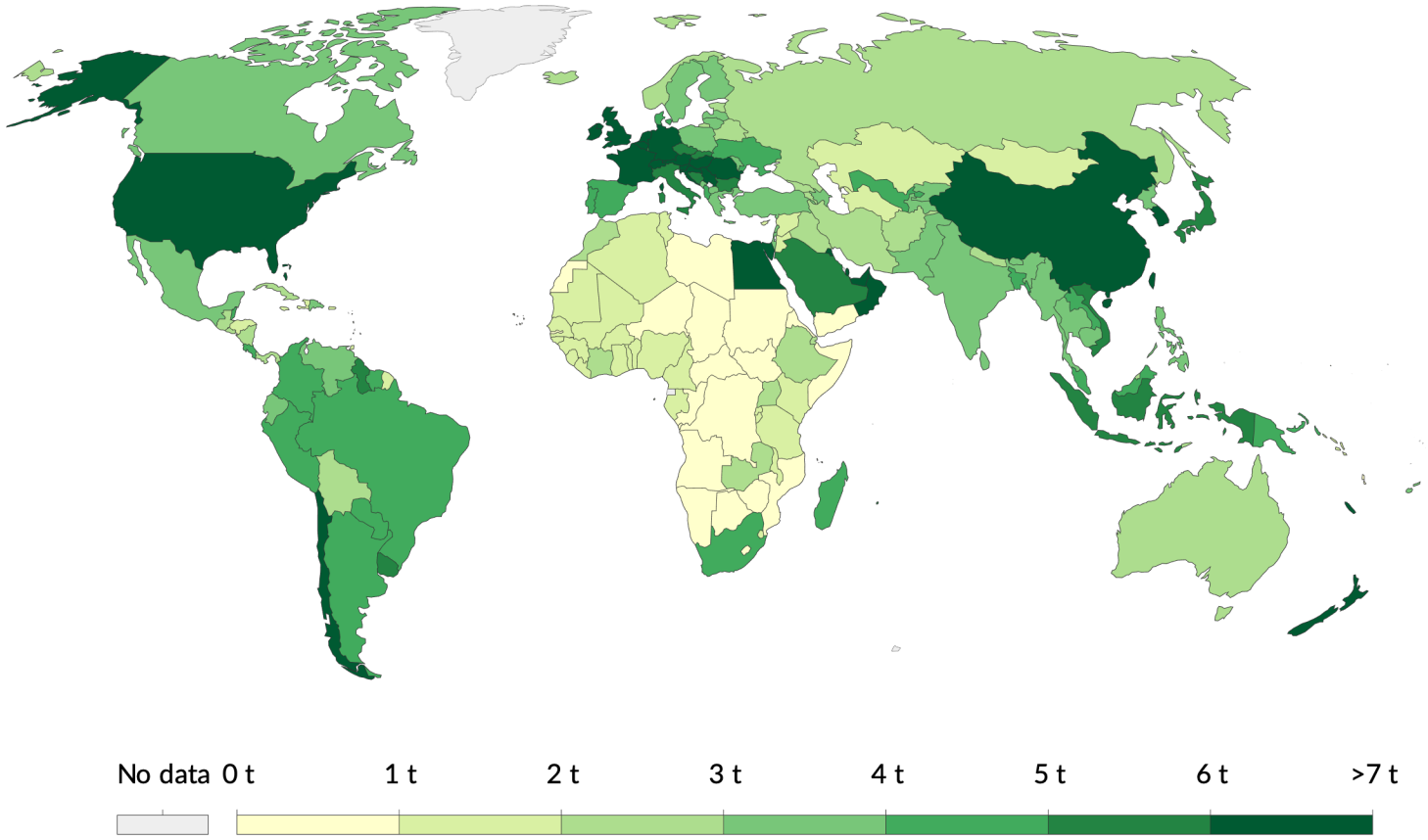




Cereal yield, 2018

Cereal yields are measured in tonnes per hectare. Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

Our World in Data



Source: UN Food and Agriculture Organization (FAO)

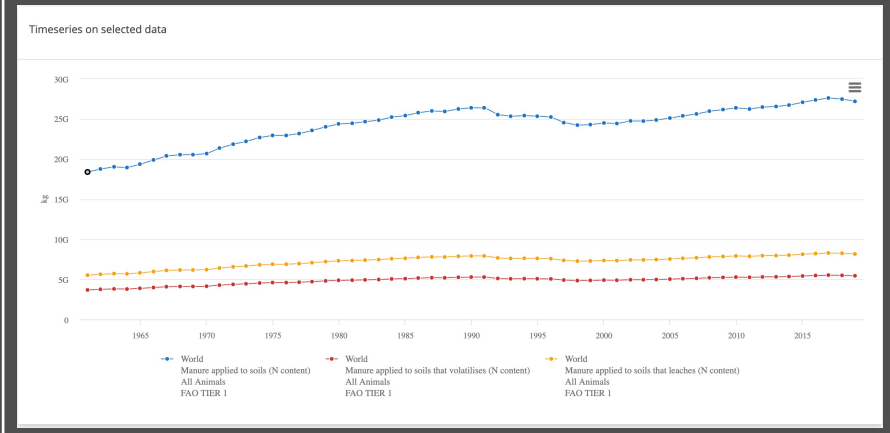
OurWorldInData.org/crop-yields • CC BY

Problems with Green Revolution

- Intensive farming practices
  - Soil erosion
  - Water shortages
  - Micronutrient deficiencies
  - Dependency on chemicals
  - Vulnerability to pests
  - Loss of control over seeds
- Genetically engineered crops (Genetically Modified Organisms—GMO's) led to political opposition.

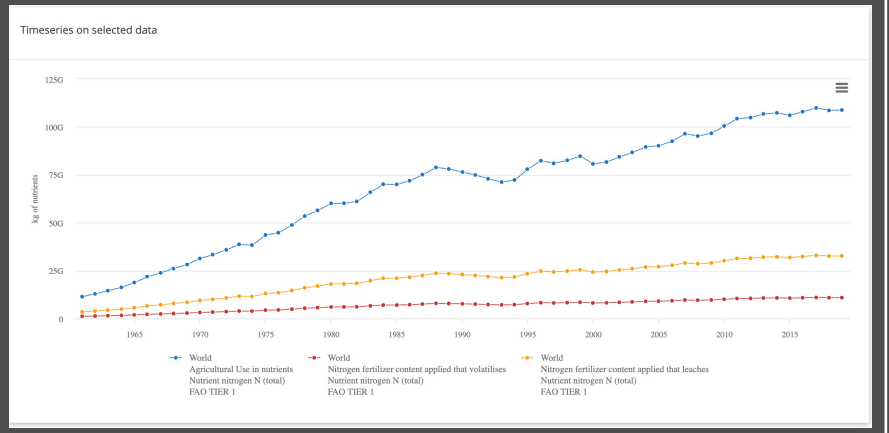
Manure Vs Synthetic Fertilizer Use in Agriculture

Manure (Nitrogen)



1961: 18.4 B kilograms
2019: 27.1 B kilograms

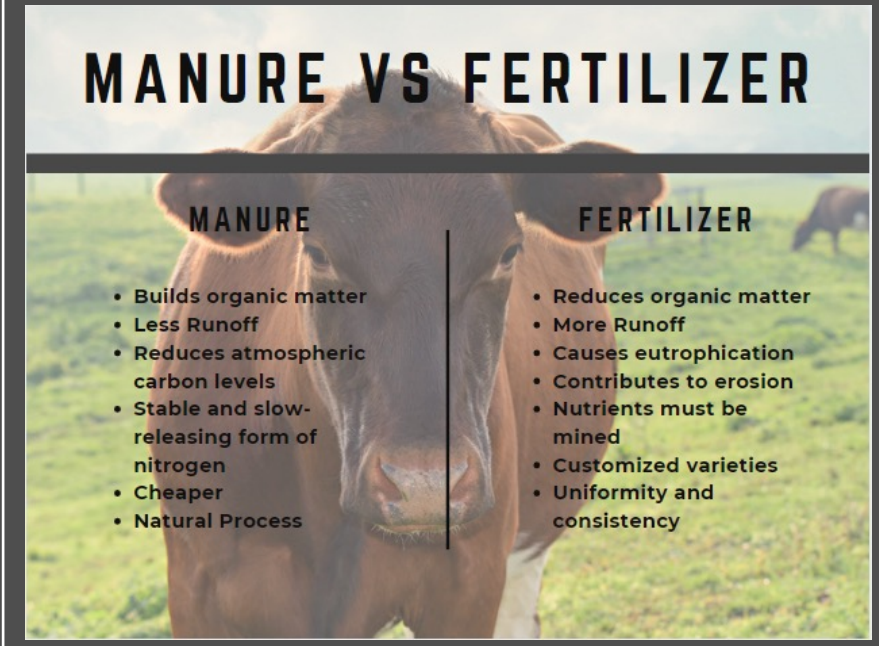
Synthetic Fertilizer (Nitrogen)

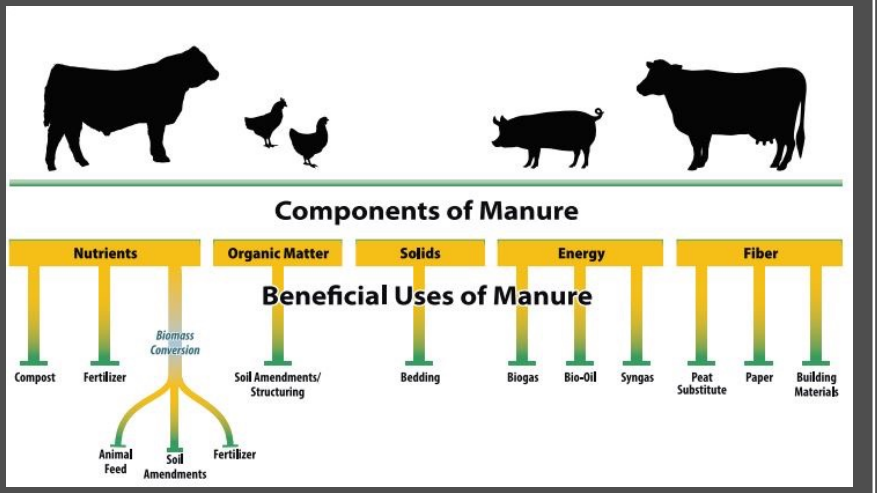


1961: 11.4 B kilograms
2019: 108.8 B kilograms

1961: 1.5 times more manure used than fertilizer
2019: 4 times more fertilizer used than manure

Source: FAOSTAT





If manure is not being used as fertilizer, what's being done with it?

https://www.artsway-ag.com/2020/06/09/manure-vs-fertilizer/

https://www.thepigsite.com/news/2015/11/the-scoop-on-poop-why-is-manure-important-1

Third One Health Analysis

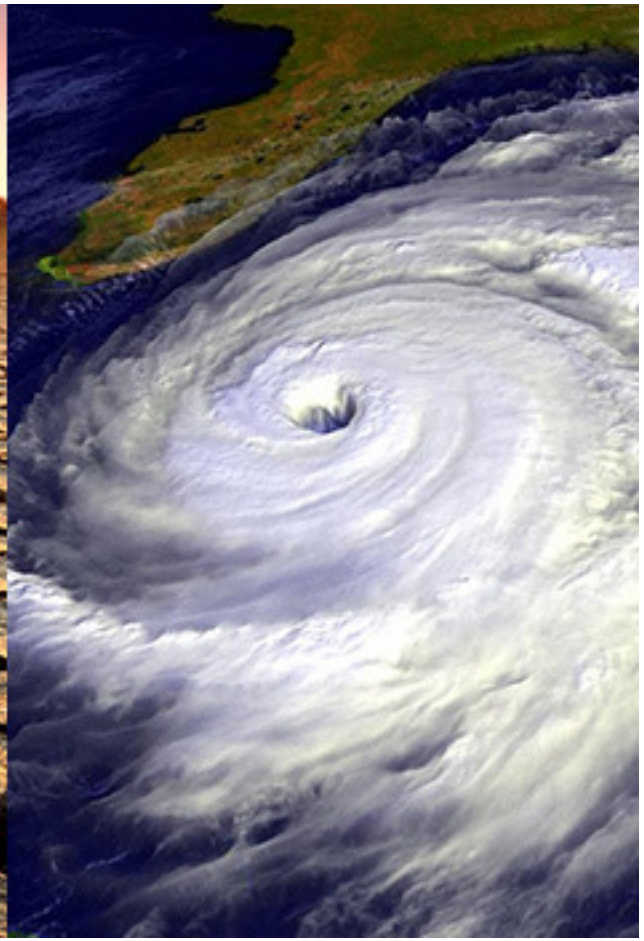
Environments
& Ecosystems

Microbial &
Populations

International/Global

Environments:
Climate Change Threatens Agriculture
Agriculture Worsens Climate Change

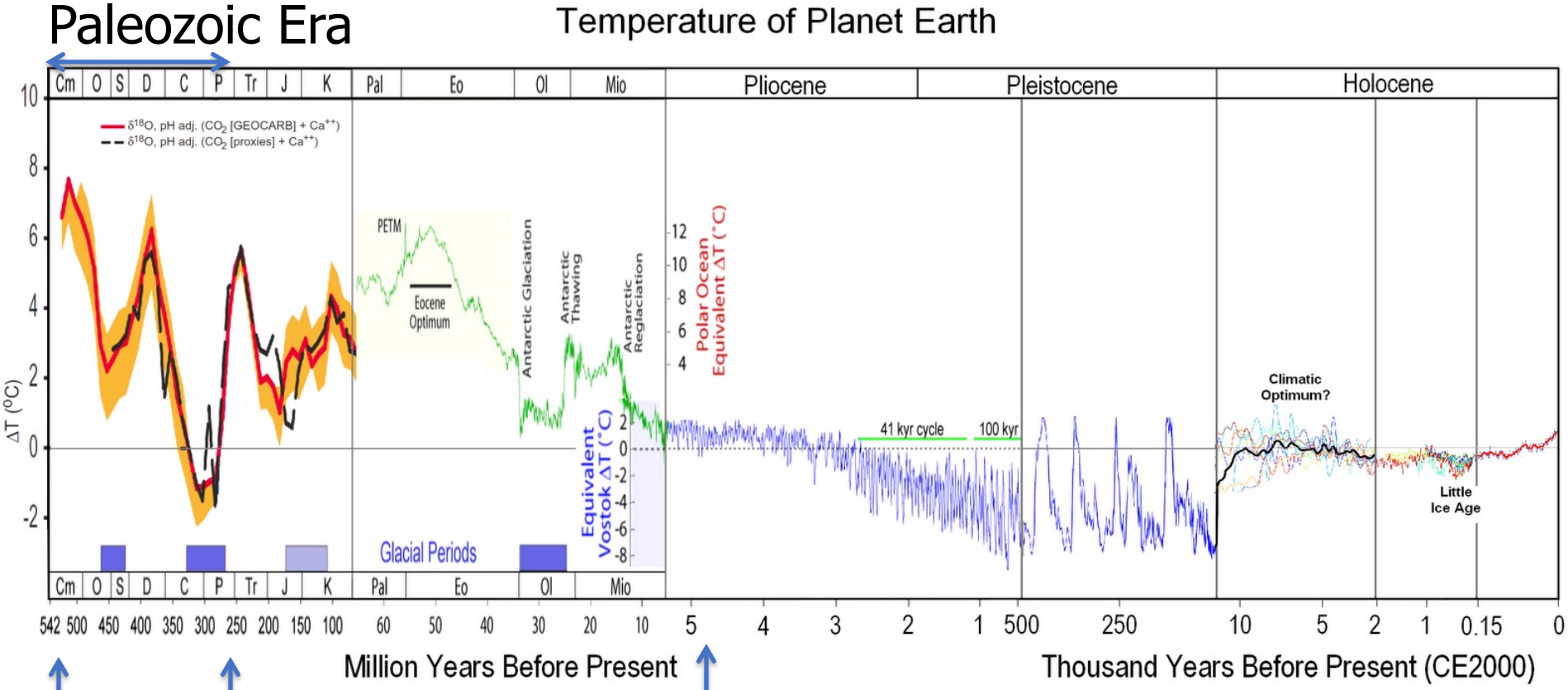




https://climate.nasa.gov/effects/

Time of Complex Life on Earth

Paleozoic Era

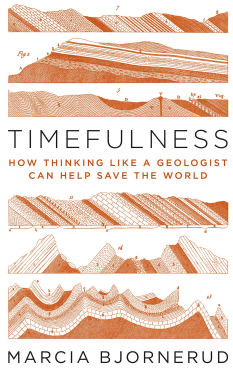


Early hominids

Permian-Triassic Extinction

Cambrian Explosion: Thriving life in seas but barren land

Earth is 4.5 Billion Years Old



https://commons.wikimedia.org/wiki/File:All_palaeotemps.png
http://gergs.net/2015/06/updating-the-geological-temperature-plot/all_palaeotemps/

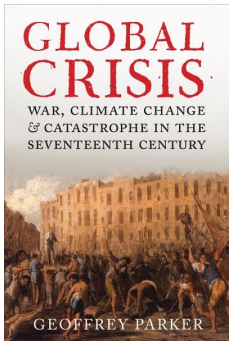
Little Ice Age from 1300 to 1850

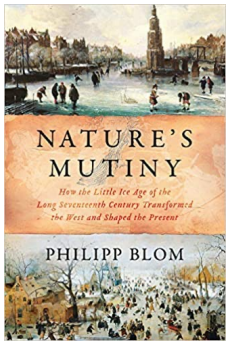
The Frozen Thames, Britain, 1677
Frost fairs lasted from 1607 to 1814

Ice skating on main canal of Pompenburg, Rotterdam, 1825.

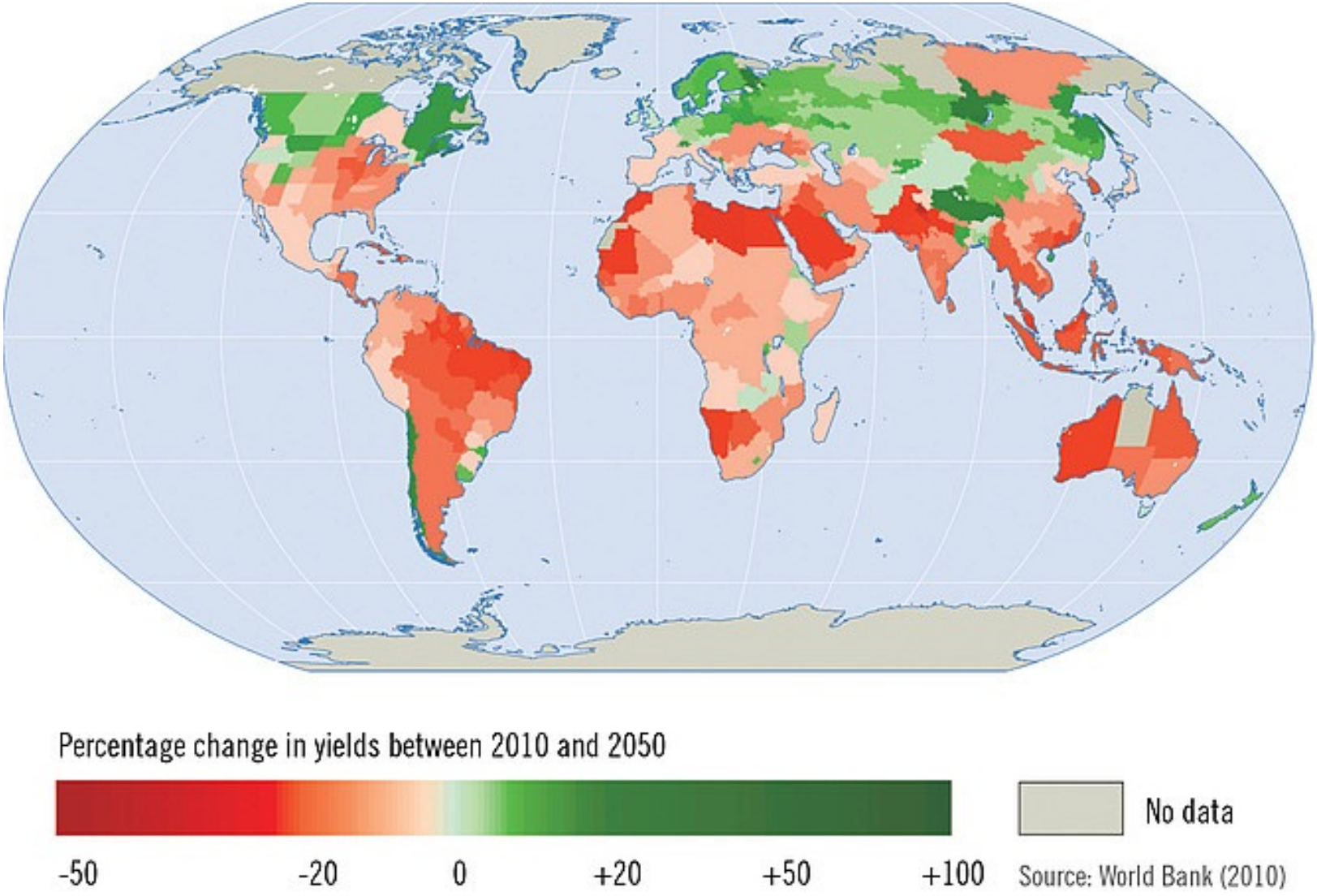
Little Ice Age noted for crop failures, bread riots, famine, wars.

The hunters in the snow, Pieter Brueghel the Elder, 1565



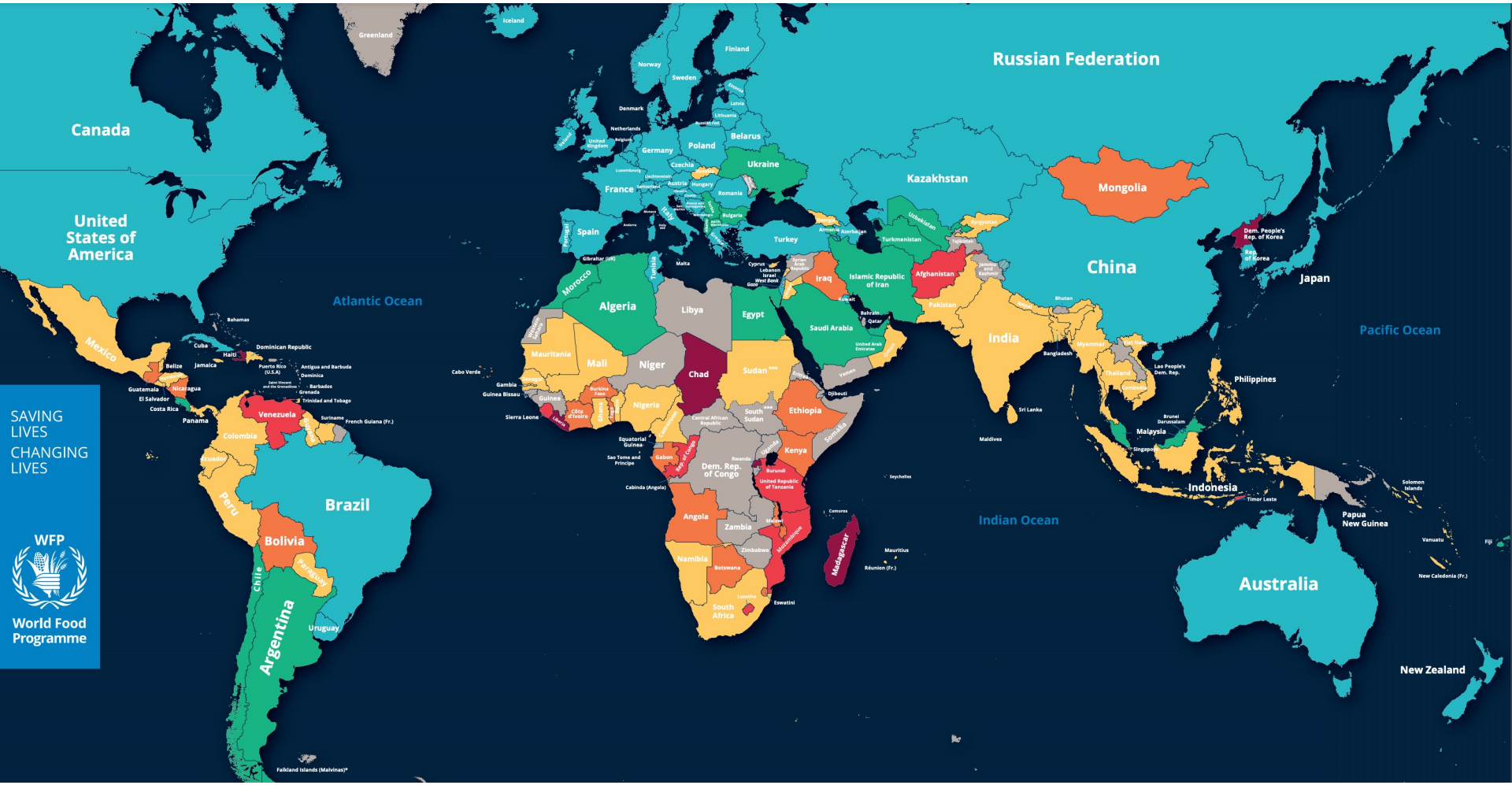


Estimated agricultural yields in 2050 due to climate change effects, assuming current agricultural practices and crop varieties.



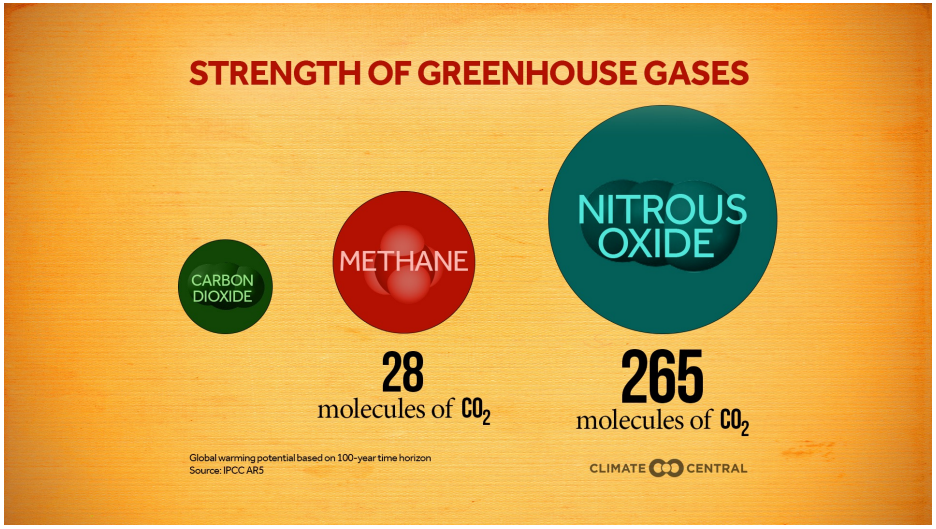
https://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1255547194560/WDR2010_BG_Note_Mueller.pdf
http://www.wri.org/sites/default/files/wri13_report_4c_wrr_online.pdf
https://openknowledge.worldbank.org/handle/10986/4387

2020 World Hunger Map

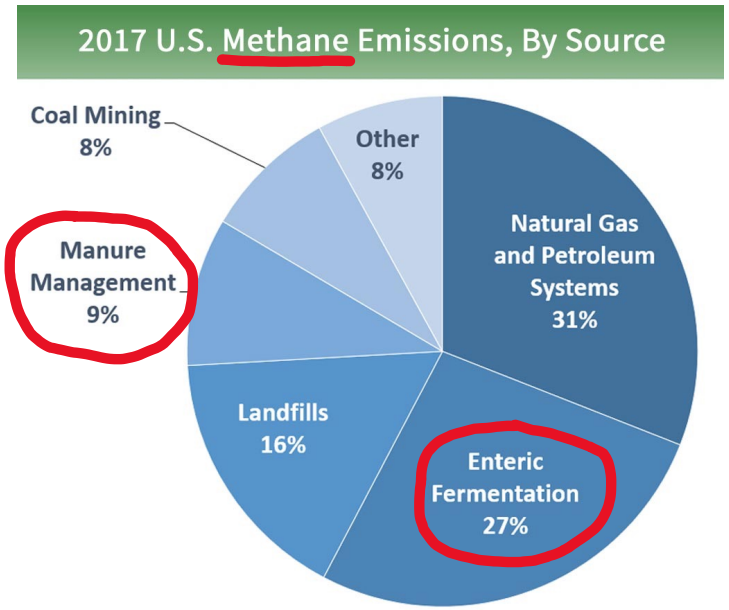


https://www.wfp.org/publications/hunger-map-2020

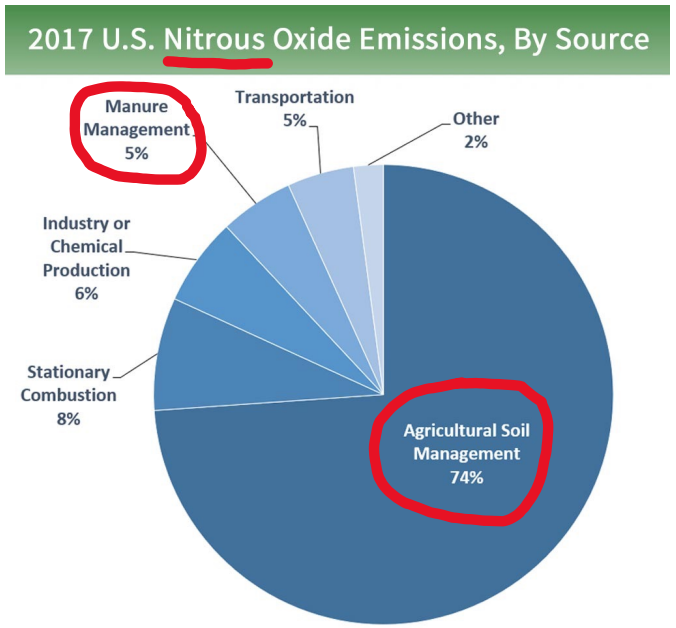
Manure (And Synthetic Fertilizers) Emit Greenhouse Gases



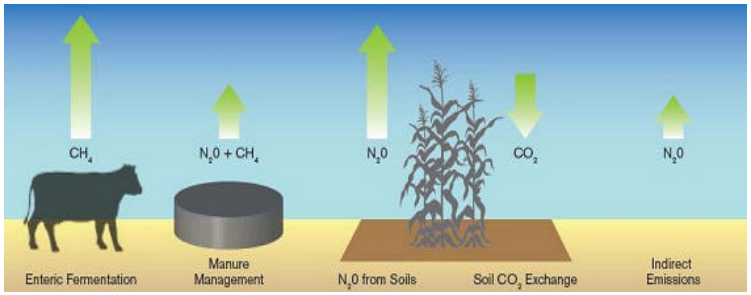
They are Major Sources of Methane and Nitrous Oxide



U.S. Environmental Protection Agency (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017



U.S. Environmental Protection Agency (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017



Enteric Fermentation + Manure Management
Contribute Approx. 36% of U.S. Methane Emissions

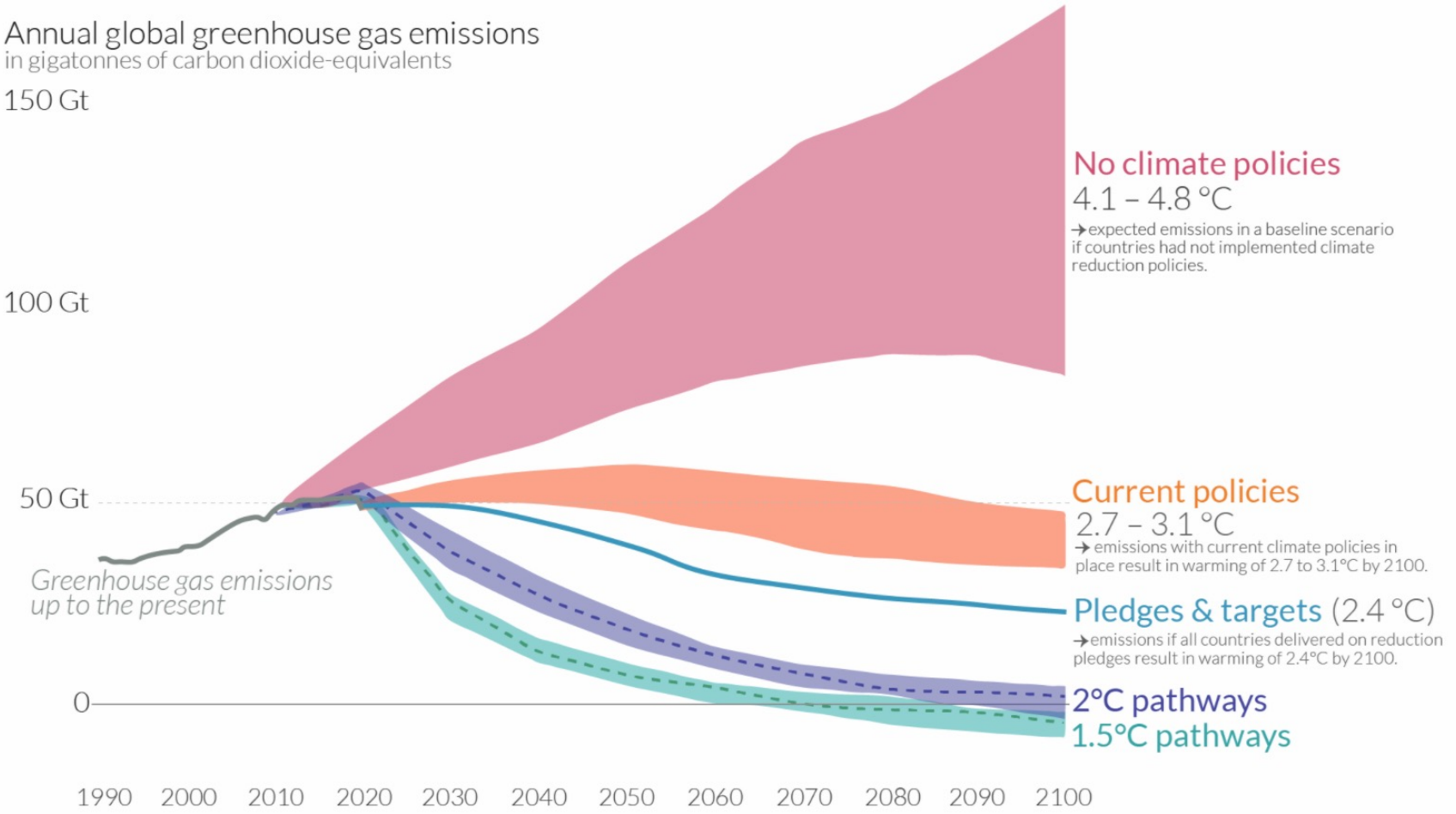
Agricultural Soil Management + Manure Management
Contribute Approx. 79% of U.S. Nitrous Oxide Emissions

https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane
https://www.epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide
http://www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/climate-change-and-agriculture/greenhouse-gases/?id=1329321969842

Global greenhouse gas emissions and warming scenarios

Our World in Data

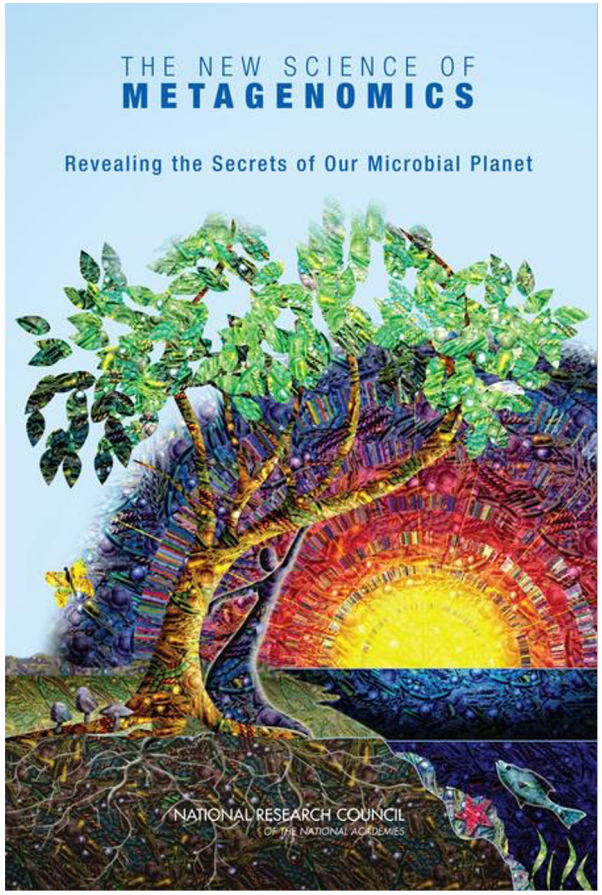
– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.



Data source: Climate Action Tracker (based on national policies and pledges as of May 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Last updated: July 2021.

Ecosystems: The Global Resistome



AMR is ancient & everywhere!

› Nature. 2011 Aug 31;477(7365):457-61. doi: 10.1038/nature10388.

Antibiotic resistance is ancient

Vanessa M D'Costa [1], Christine E King, Lindsay Kalan, Mariya Morar, Wilson W L Sung, Carsten Schwarz, Duane Froese, Grant Zazula, Fabrice Calmels, Regis Debruyne, G Brian Golding, Hendrik N Poinar, Gerard D Wright

Affiliations + expand

PMID: 21881561 DOI: 10.1038/nature10388

How are humans adversely impacting the Global Resistome?

- Poor sanitation
- Indiscriminate antibiotic use
- Untreated human and animal waste
- Land and water contamination
- Spread of resistant microbes and resistant genes by wildlife

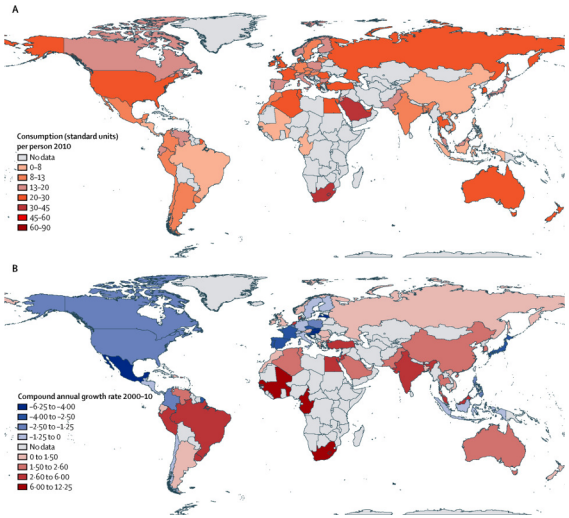
Environmental fecal waste and antibiotic use:

ARTICLES | VOLUME 14, ISSUE 8, P742-750, AUGUST 01, 2014

Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data

Thomas P Van Boeckel, PhD · Sumanth Gandra, MD · Ashvin Ashok, MPP · Quentin Caudron, PhD · Prof Bryan T Grenfell, PhD · Prof Simon A Levin, PhD · et al. Show all authors

Published: July 09, 2014 · DOI: https://doi.org/10.1016/S1473-3099(14)70780-7 Check for updates



Article | Published: 13 November 2018

Estimation of global recoverable human and animal faecal biomass

David M. Berendes, Patricia J. Yang, Amanda Lai, David Hu & Joe Brown

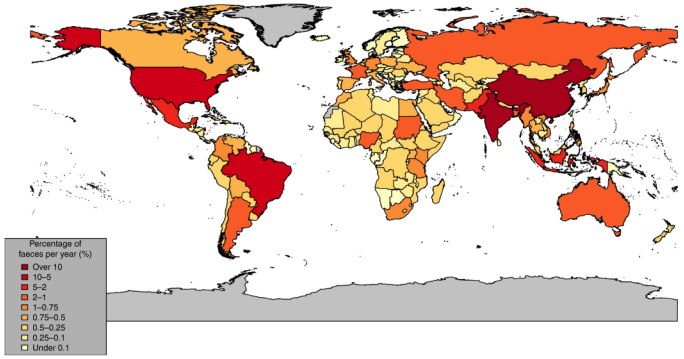
Nature Sustainability **1**, 679–685(2018) | Cite this article

934 Accesses | **21** Citations | **279** Altmetric | Metrics

Fig. 1: Country-level estimates for percentage of the world's faeces production in 2014.

From: Estimation of global recoverable human and animal faecal biomass

Combined animal and human faeces production (percentage of global total)

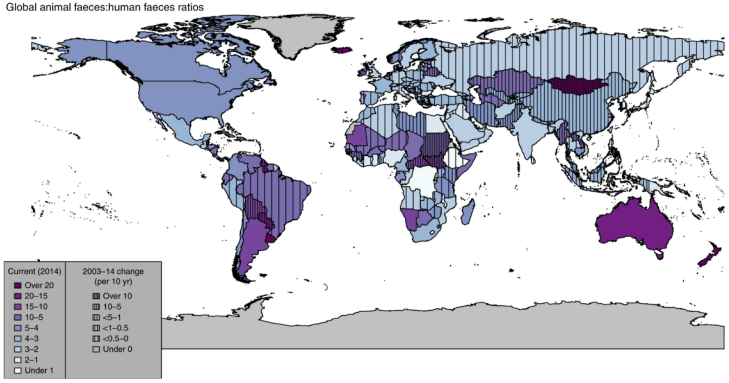


Darker red indicates larger production of faeces annually. Country borders are in black, while countries/regions in grey have no data.

Fig. 2: Country-level animal faeces to human faeces ratios.

From: Estimation of global recoverable human and animal faecal biomass

Global animal faeces:human faeces ratios



Colours represent 2014 ratios (darker purple indicates countries with larger ratios, while countries in white have ratios close to 1). Line density varies with the average change in ratios from 2003 to 2014 (presented per 10 years for ease of interpretation). Higher line density indicates larger, positive average changes in the ratio, while absence of lines indicates a negative change in ratio (with the exception of one country, all negative ratios were between −1 and 0). Countries in grey have no data available.

Is there a relationship?

veterinary sciences

MDPI

Review

Manure as a Potential Hotspot for Antibiotic Resistance Dissemination by Horizontal Gene Transfer Events

Tiago Lima [1,2], Sara Domingues [1,2,*] and Gabriela Jorge Da Silva [1,2]

1 Faculty of Pharmacy of University of Coimbra, University of Coimbra, 3000-458 Coimbra, Portugal; tiagoventurall@gmail.com (T.L.); gjsilva@ci.uc.pt (G.J.D.S.)
2 Center for Neuroscience and Cell Biology, University of Coimbra, 3004-517 Coimbra, Portugal
* Correspondence: saradomingues@ff.uc.pt; Tel.: +351-239-488-446

Received: 30 June 2020; Accepted: 10 August 2020; Published: 13 August 2020

Abstract: The increasing demand for animal-derived foods has led to intensive and large-scale livestock production with the consequent formation of large amounts of manure. Livestock manure is widely used in agricultural practices as soil fertilizer worldwide. However, several antibiotic residues, antibiotic resistance genes (ARGs) and antibiotic-resistant bacteria are frequently detected in manure and manure-amended soils. This review explores the role of manure in the persistence and dissemination of ARGs in the environment, analyzes the procedures used to decrease antimicrobial resistance in manure and the potential impact of manure application in public health. We highlight that manure shows unique features as a hotspot for antimicrobial gene dissemination by horizontal transfer events: richness in nutrients, a high abundance and diversity of bacteria populations and antibiotic residues that may exert a selective pressure on bacteria and trigger gene mobilization; reduction methodologies are able to reduce the concentrations of some, but not all, antimicrobials and microorganisms. Conjugation events are often seen in the manure environment, even after composting. Antibiotic resistance is considered a growing threat to human, animal and environmental health. Therefore, it is crucial to reduce the amount of antimicrobials and the load of antimicrobial resistant bacteria that end up in soil.

Fourth One Health Analysis

Humans

Populations

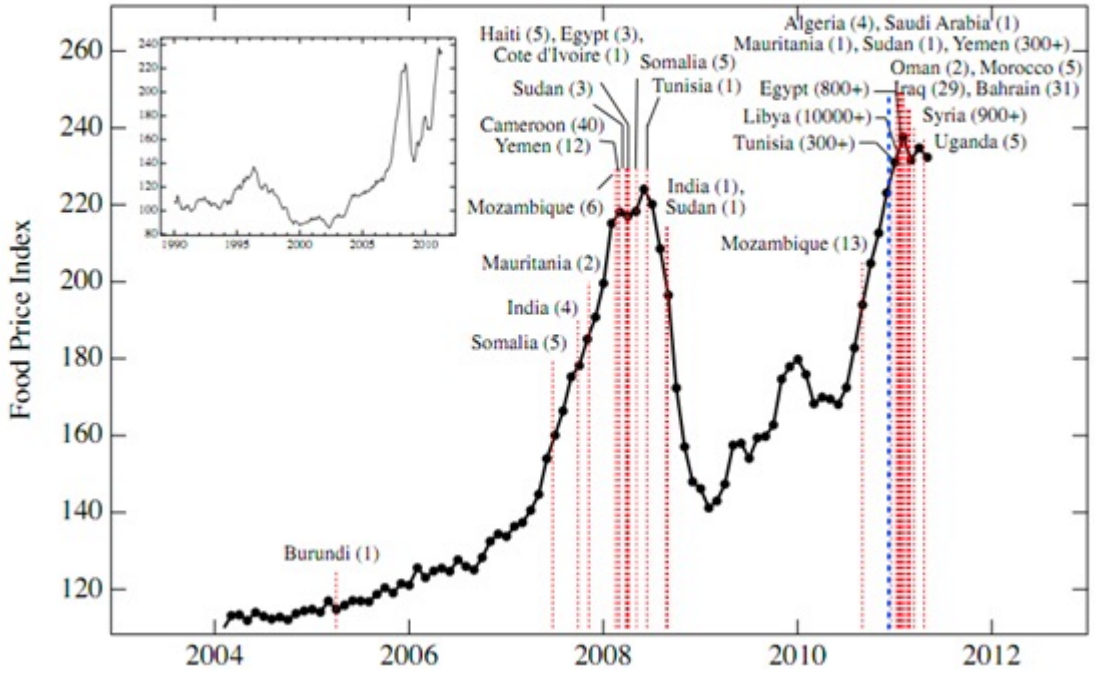
Political, Social, Economic Factors:
International/Global Food Security

Food Security: The Foundation of Civilization

- Food Security means no hungry people.
- Food Security is built on 3 pillars:
  - Food availability
  - Food access (affordability)
  - Food use

Food Security (Zero Hunger) United Nation's #2 SDG

Political Implications of Food Insecurity

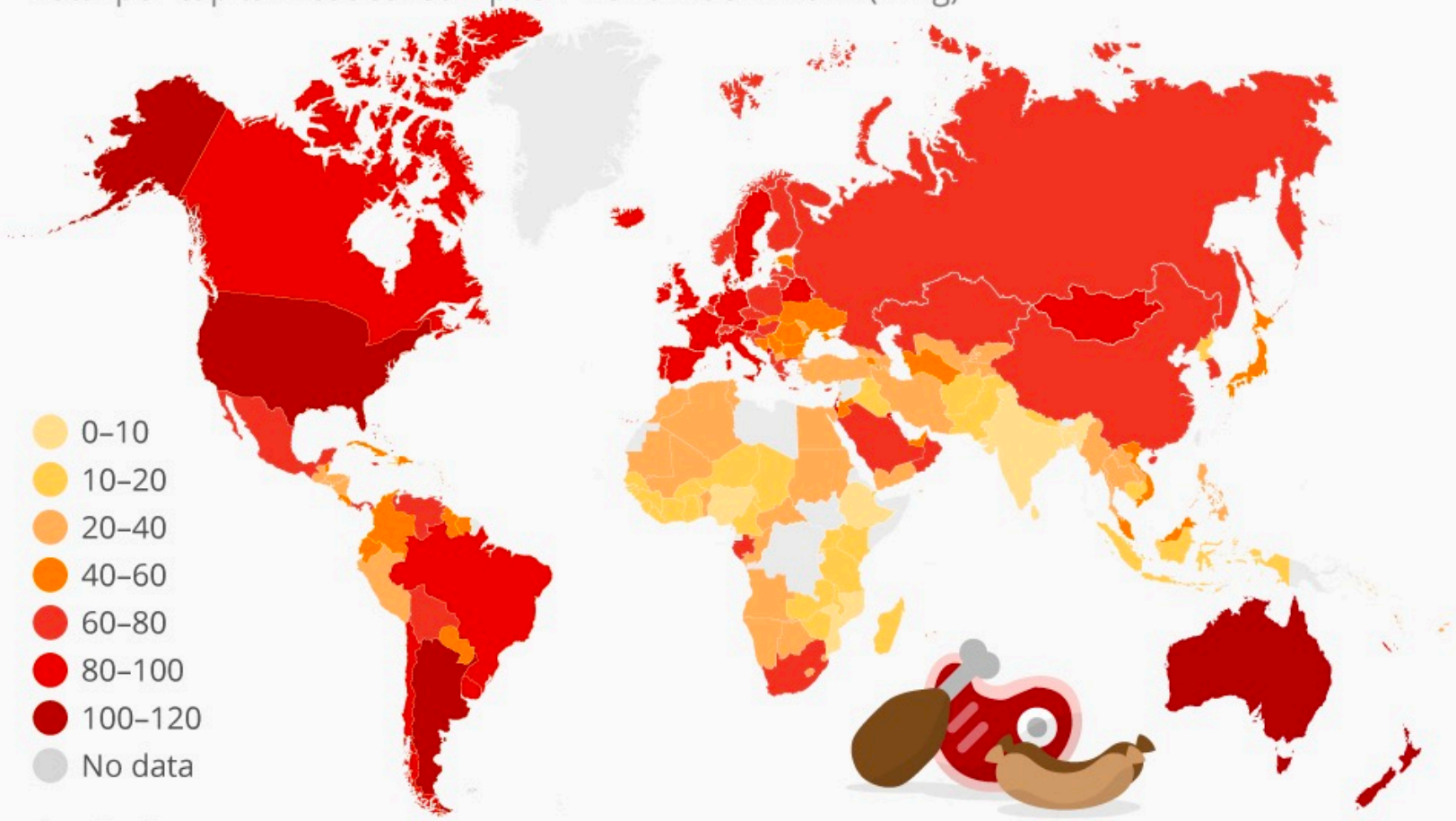


High food prices lead to civil unrest.
People riot when food becomes unavailable.
Civilization breaks down.

https://www.technologyreview.com/2011/08/15/192366/the-cause-of-riots-and-the-price-of-food/

Where Meat Consumption Is Highest & Lowest

Total per capita meat consumption worldwide in 2014 (in kg)*



* 2014 is the latest year data is available. Excludes seafood.

Source: UN Food and Agriculture Organization via Our World in Data

Pros and Cons of Eating Meat

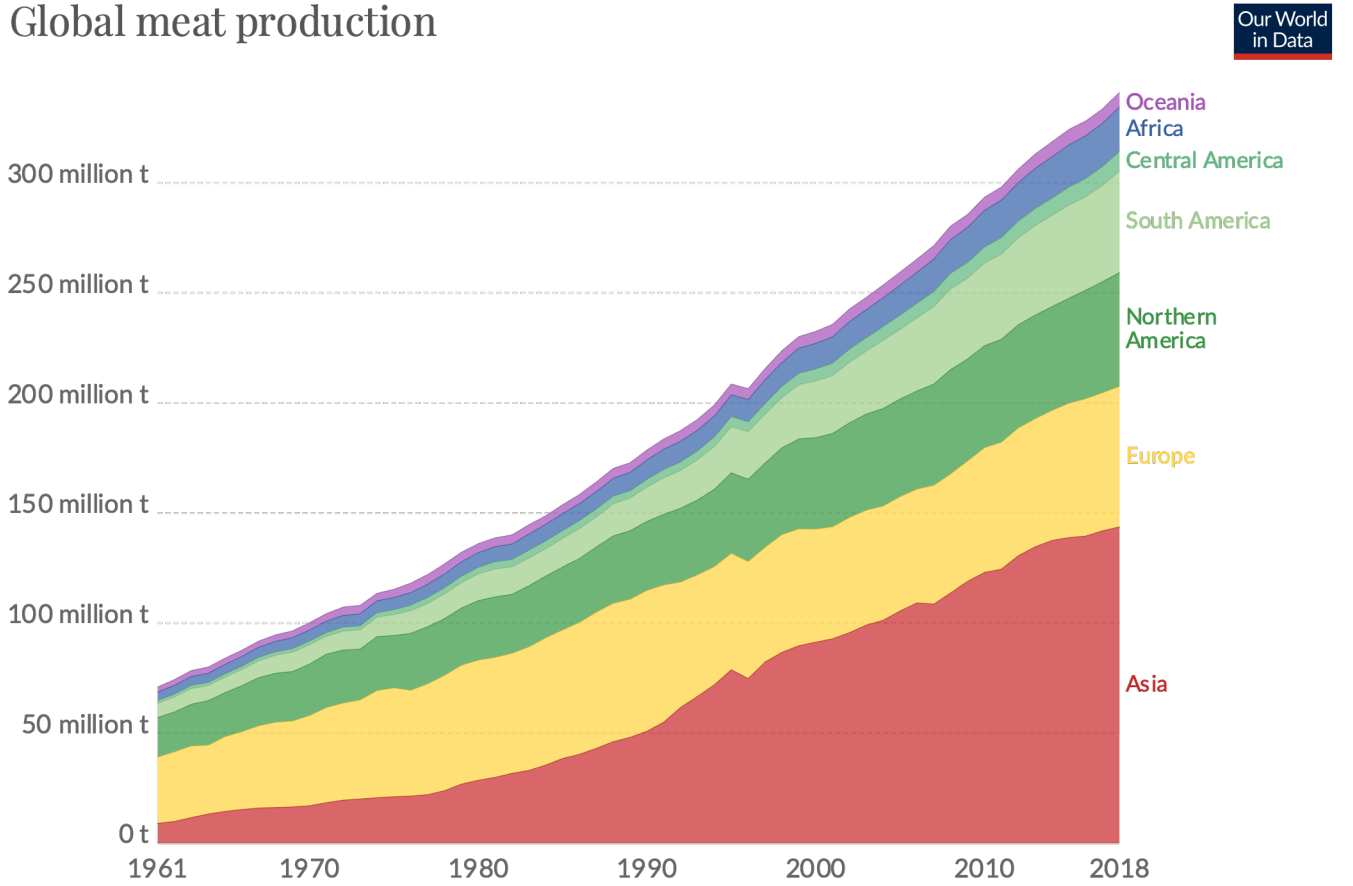
Pros

- Meat provides important micronutrients such as Vitamin B12 and iron.
- Evidence we evolved into modern humans because we hunted, cooked, and ate meat.
- Eating meat is an integral part of many religions and cultures.

Cons

- Meat is not essential if supplement diet with Vitamin B12 and other vitamins and minerals.
- Increases zoonotic spillover risks.
- Raising domesticated animals and/or hunting wild animals contaminates environments, ecosystems, and reduces biodiversity.

Global meat production

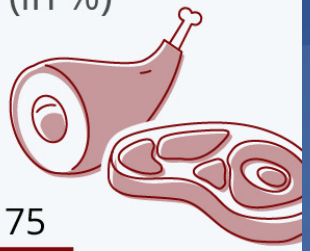


Source: UN Food and Agriculture Organization (FAO)

OurWorldInData.org/meat-production • CC BY

Eating Meat Is the Norm Almost Everywhere

Share of respondents who said they ate meat (in %)

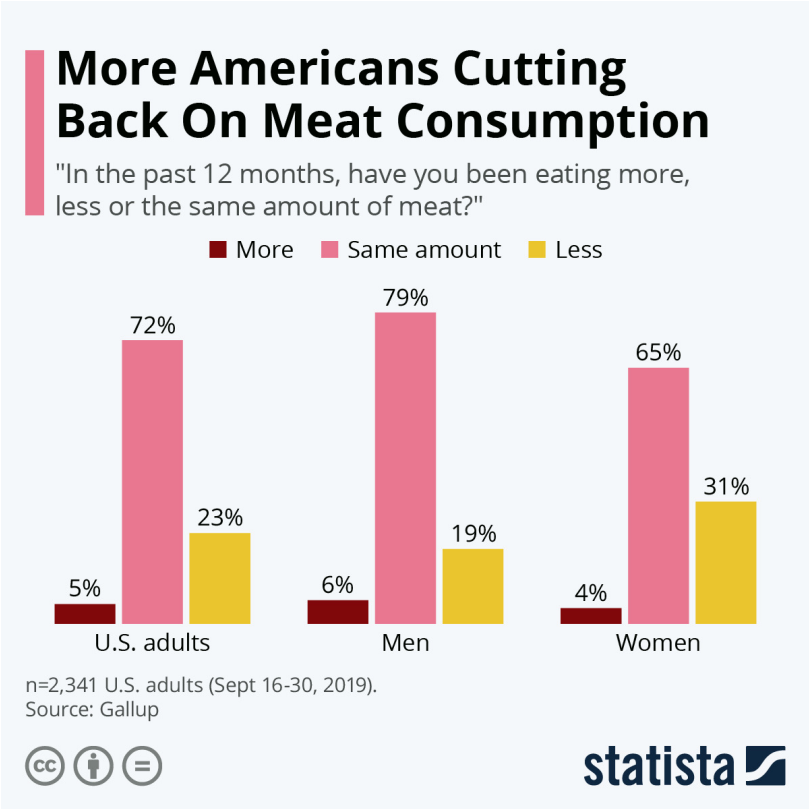


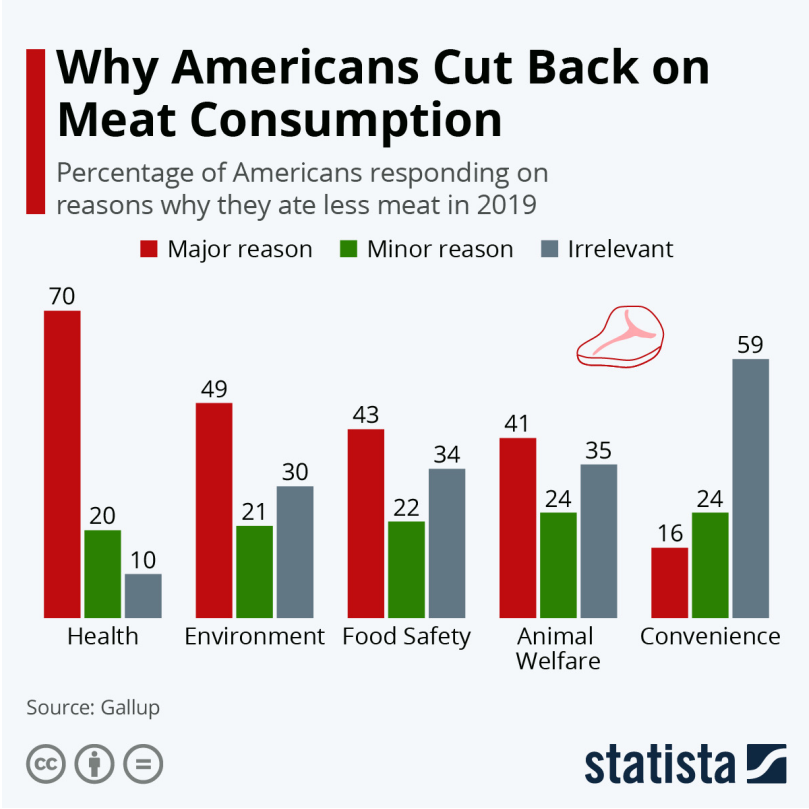
1,000-5,000 respondents 18-64 y/o per country surveyed Feb 2020 - March 2021

Source: Statista Global Consumer Survey

statista

Changing National Dietary Preferences is Possible





But Requires Cultural and Societal Change

Our One Health Analysis Findings

One Health Factors:

Humans
& Animals
(Fecal Wastes)

Complexity Factors:

Microbial & Populations

Plants
(Fertilizers)

Microbial & Populations

Environments &
Ecosystems
(Water, Soil, Air)
(Global Resistome)

Microbial & Populations

Political, Social, Economic Factors:
International/Global Food Security
Global Demand for Meat

Time Factor: Years

One Health Analysis Findings

- Human and domesticated animal populations are growing and producing increasing amounts of fecal matter each year.
- Animals produce 80 percent of global fecal matter, but it's generally ignored.
- Human and animal fecal matter contain many pathogens, but sanitation systems are designed to process human waste.
- Little oversight of manure management in many middle- and low- income countries. Little oversight of CAFO manure management in the U.S.
- Plants need nitrogen, phosphorus, and potassium—which are contained in manure, but synthetic fertilizer use predominates.
- Manure management and agricultural soil management emit methane and nitrous oxide, potent greenhouse gases into the atmosphere worsening climate change.
- Manure risks contaminating the 'Global Resistome' which worsens AMR.
- These findings impact food safety and the practice of medicine as well as food security and the continuation of agriculture.

What can be done?

"One Health"

Recognizing that the main impact of antimicrobial resistance is on human health, but that both the contributing factors and the consequences, including economic and others, go beyond health, and that there is a need for a coherent, comprehensive and integrated approach at global, regional and national levels, in a "One Health" approach and beyond, involving different actors and sectors such as human and veterinary medicine, agriculture, finance, environment and consumers.[6]

Alignment with AMR global action plan

The goal of the AMR global action plan is: "To ensure, for as long as possible, continuity of successful treatment and prevention of infectious diseases with effective and safe medicines that are quality-assured, used in a responsible way, and accessible to all who need them".

Its five strategic objectives are:

- Objective 1: Improve awareness and understanding of antimicrobial resistance through effective communication, education and training.
- Objective 2: Strengthen the knowledge and evidence base through surveillance and research.
- Objective 3: Reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures.
- Objective 4: Optimize the use of antimicrobial medicines in human and animal health.
- Objective 5: Develop the economic case for sustainable investment that takes account of the needs of all countries, and increase investment in new medicines, diagnostic tools, vaccines and other interventions.

No Mention of Manure Management and Ecosystem Impact.

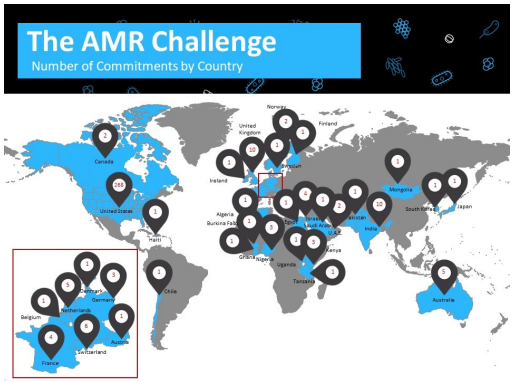
Antimicrobial Resistance

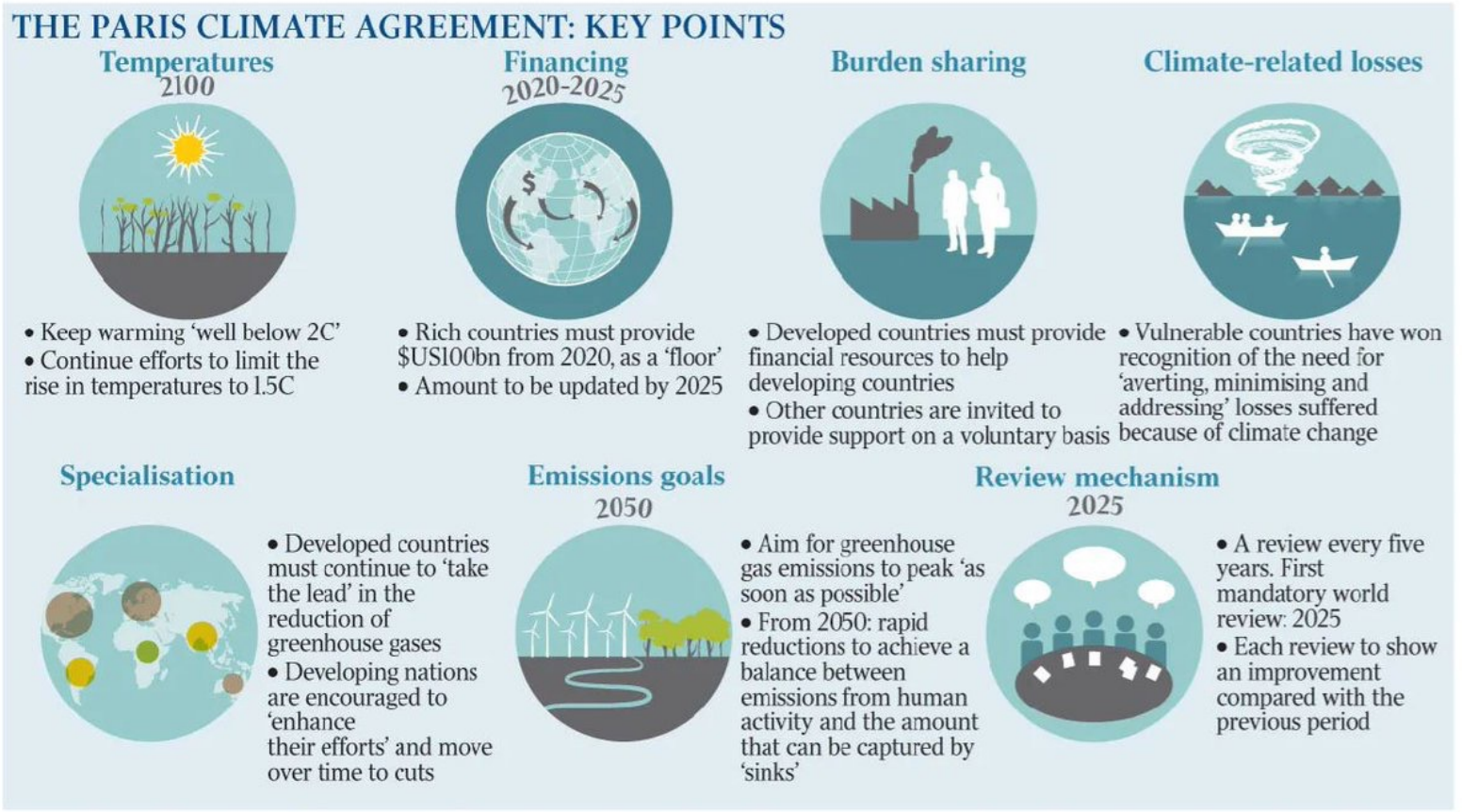
A MANUAL FOR DEVELOPING NATIONAL ACTION PLANS

Version 1
February 2016

Food and Agriculture Organization of the United Nations · OIE World Organisation for Animal Health · World Health Organization

UN General Assembly



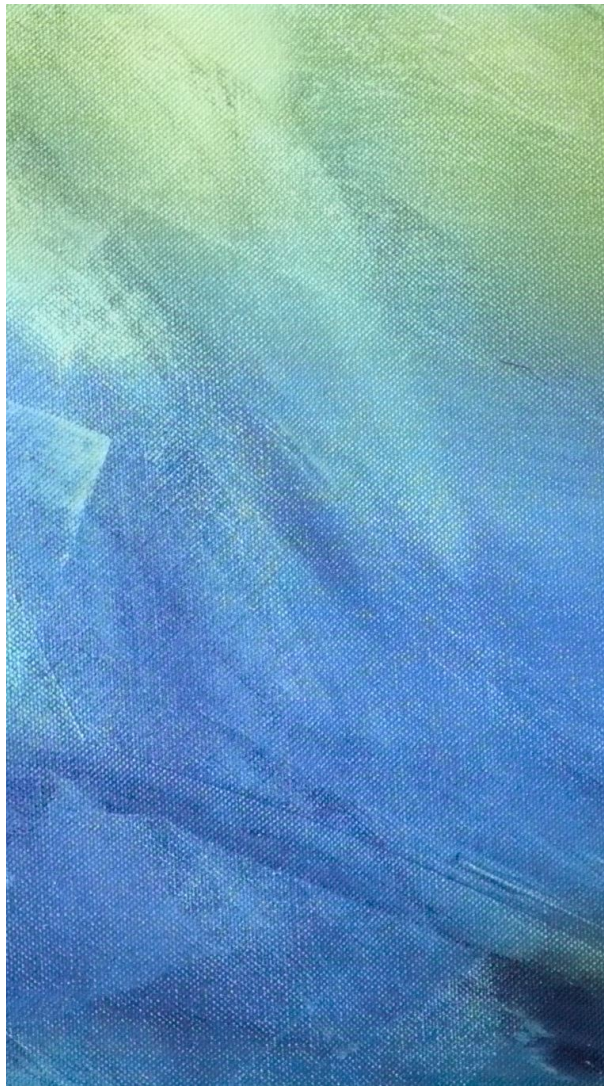


No mention of curtailing agriculture's greenhouse gas emissions

Strategies to Reduce CH4 & N2O Emissions

Manure Management: Change the way manure is stored and handled; methane digesters capture and convert emissions into renewable energy.

Agricultural Soil Management: Avoid over-fertilization of soils, urea-based (low N) fertilizer use, subsurface drip irrigation, nitrification inhibitors, monitoring soil N, cover crops, no-till farming.



https://www.edf.org/media/report-changing-manure-management-would-significantly-reduce-dairy-methane-emissions

https://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Nitrous_Oxide__In_focus/

https://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Nitrous_Oxide__In_focus/#N2O%20management%20practices

California Senate Bill 605, Chapter 523 Short-lived Climate Pollutant Reduction Strategies, 2014

Ricardo Lara, Democrat
Calif. Senate 2012-2019
Currently, Calif. Insurance Commissioner

Senate Bill 605 (Lara, Chapter 523, Statutes of 2014) and Senate Bill 1383 (Lara, Chapter 295, Statutes of 2016) direct California Air Resources Board (CARB) to reduce dairy methane emissions by 40 percent by 2030.

Budget Act of 2014 allocated $12 million to support dairy methane reduction projects such as the Dairy Digester Research and Development Program—captures methane from manure to use as energy source.

https://ww3.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf
https://en.wikipedia.org/wiki/Ricardo_Lara

We must restore our beautiful planet.

One Health recognizes that life is interconnected.

- What can you do?
- Learn about One Health
- Spread the word
- Interdisciplinary colleagues
- Organize and be change agents

Browse > Health > Public Health

Bats, Ducks, and Pandemics: An Introduction to One Health Policy

4.7 272 ratings

Laura Kahn

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Already enrolled

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About this Course

6,271 recent views

Welcome to "Bats, Ducks, and Pandemics: An Introduction to One Health Policy".

One Health is the concept that human, animal, and environmental/ecosystem health are linked. The concept provides a useful framework for examining complex health issues such as food safety and security, emerging and vector-borne diseases, and antimicrobial resistance. It can be used to analyze government policies to determine if they are effective in improving health and well-being.

SHOW ALL

WHAT YOU WILL LEARN

- Define One Health and provide examples where the concept can be used
- Identify the components of an effective organization
- Investigate the politics of disease outbreaks—leadership, communication, health care access, and corruption

Flexible deadlines
Reset deadlines in accordance to your schedule

100% online
Start instantly and learn at your own schedule.

Beginner Level

Approx. 11 hours to complete

English
Subtitles: French, Portuguese (European), Russi

- Co-Founded in 2006; Website in 2008
- The OHI Team:
  - Bruce Kaplan DVM, Dipl. AVES (Hon)
  - Laura Kahn, MD, MPH, MPP, Dipl. AVES (Hon)
  - Tom Monath MD, Dipl. AVES (Hon)
  - Thomas M. Yuill PhD
  - Helena Chapman MD, MPH, PhD
  - Craig Carter DVM, PhD, Dipl. ACVPM
  - Becky Barrentine, MBA

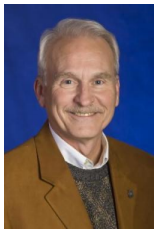
Bruce Kaplan

Laura Kahn

Tom Monath

Tom Yuill

Helena Chapman



Craig Carter

Becky Barrentine

http://www.onehealthinitiative.com

Thank you! Questions?

Follow on Twitter: @LauraKahn1