

Zoonoses

Coupled to a highly connected complex world

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Michigan State University

September 23, 2010



- I. Introduction
- II. Zoonoses- Background & Trends
- III. Connecting disease to the world of today
- IV. Zoonoses skyline



I. Introduction

Rabies Highly Pathogenic Avian Influenza
Severe Acute Respiratory Syndrome Malaria
Lyme disease Nipah virus Monkey pox Arbovirus Rickettsial Dengue
Bovine spongiform encephalitis E.Coli 0157:H7
West Nile virus Plague
Salmonella Swine flu



I. Introduction

New terms



I. Introduction

Pathogens cross political borders



I. Introduction

Globalized world and sanitary infrastructure



I. Introduction

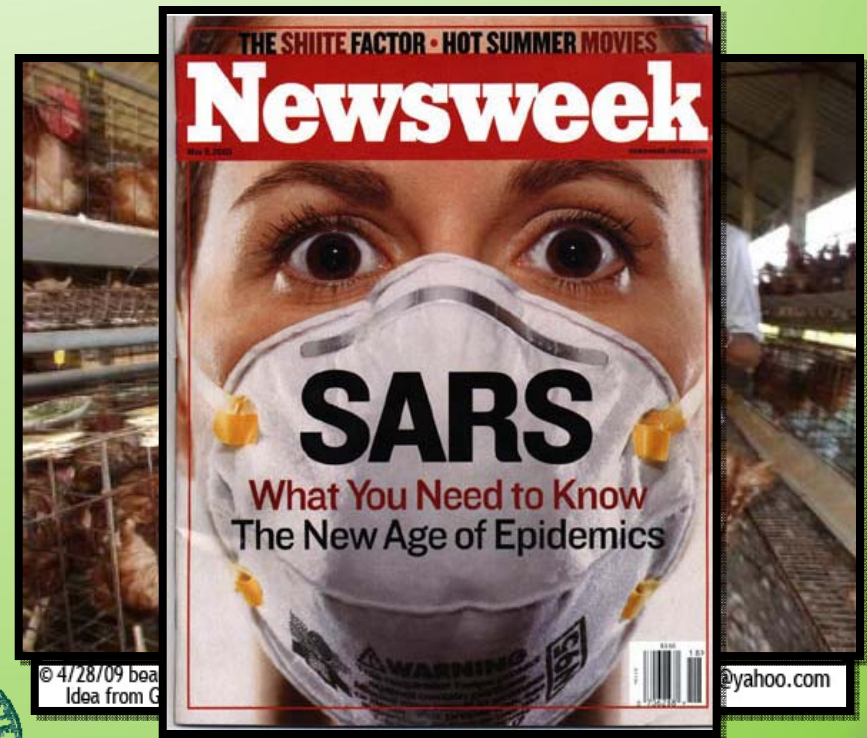
Changing institutions, laws, and governments



I. Introduction

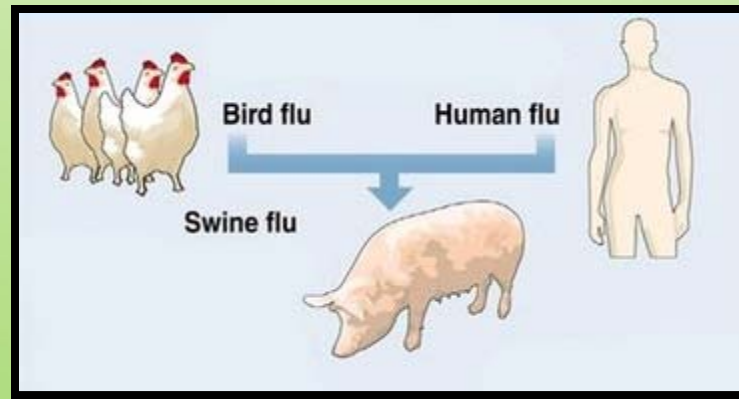
International spread of disease

- Asian avian flu virus
- Severe acute respiratory syndrome
- Swine flu

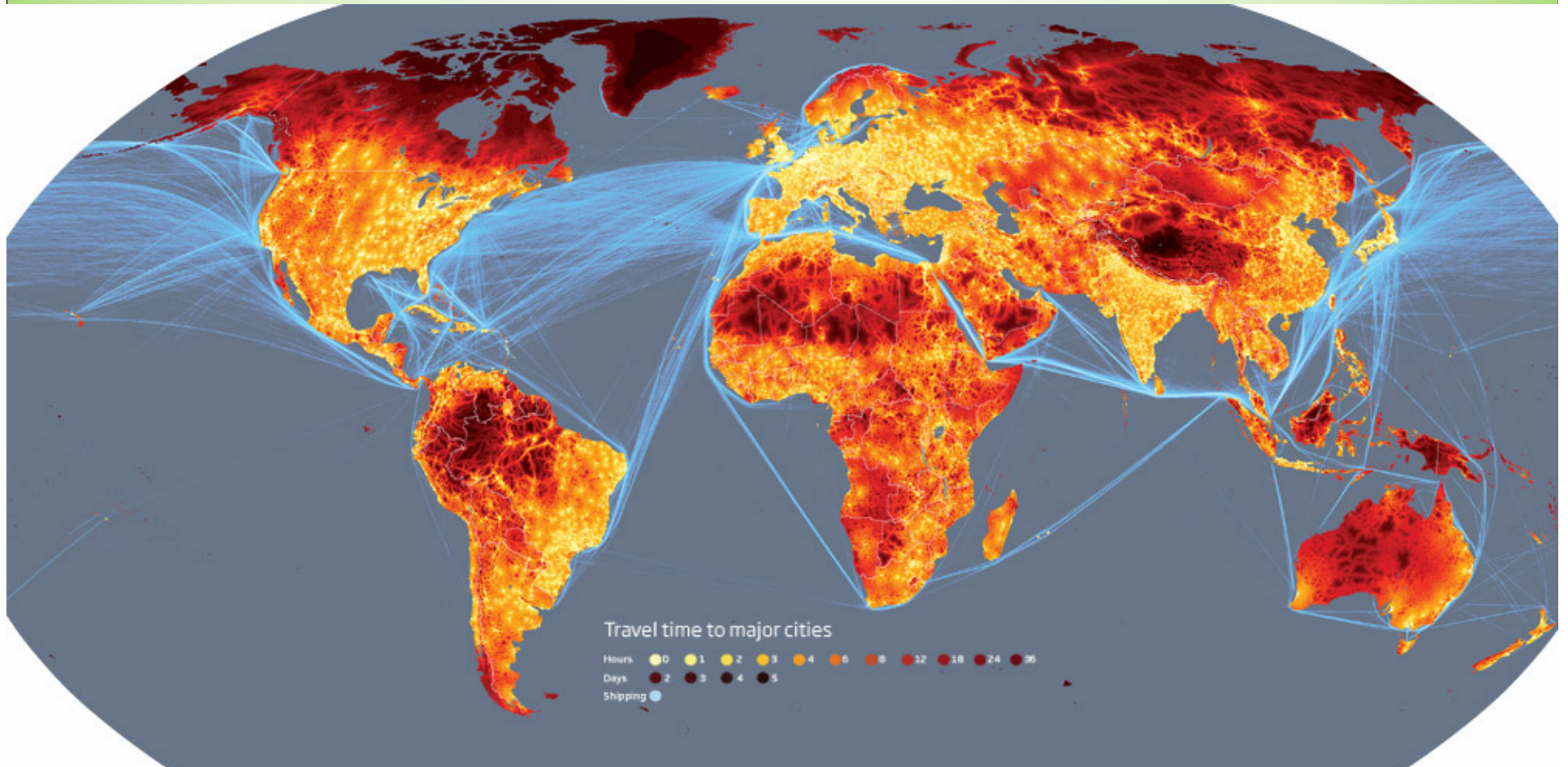


II. Background & Trends

- *Zoonoses*: Any infection or infectious disease transmissible under natural conditions to humans or those shared between humans and animals.
- 1,400 species of human pathogens are now recognized, and over 800 (nearly 60%) are known to be zoonotic.

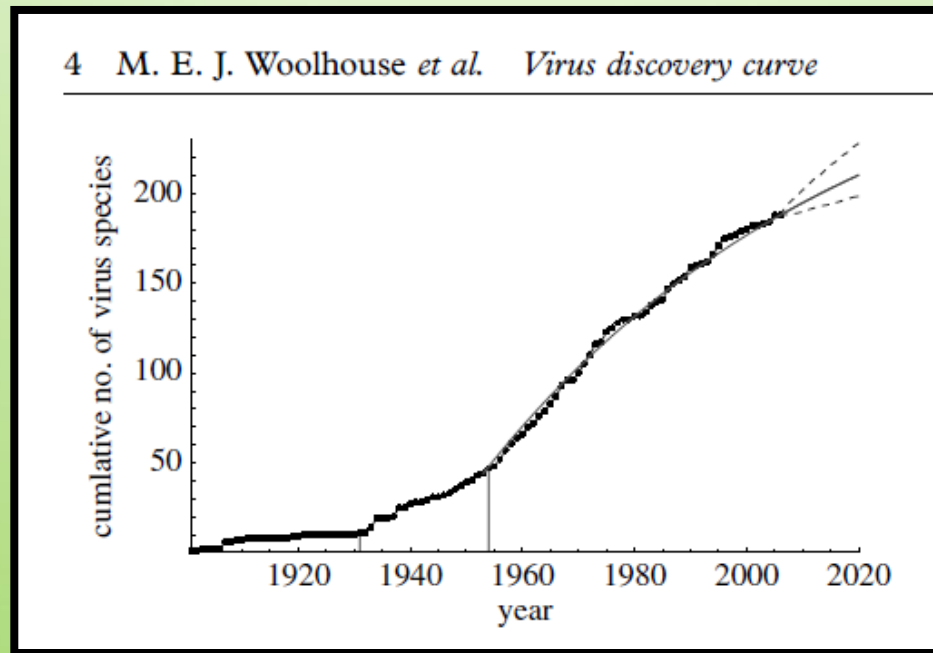


II. Background & Trends



II. Background & Trends

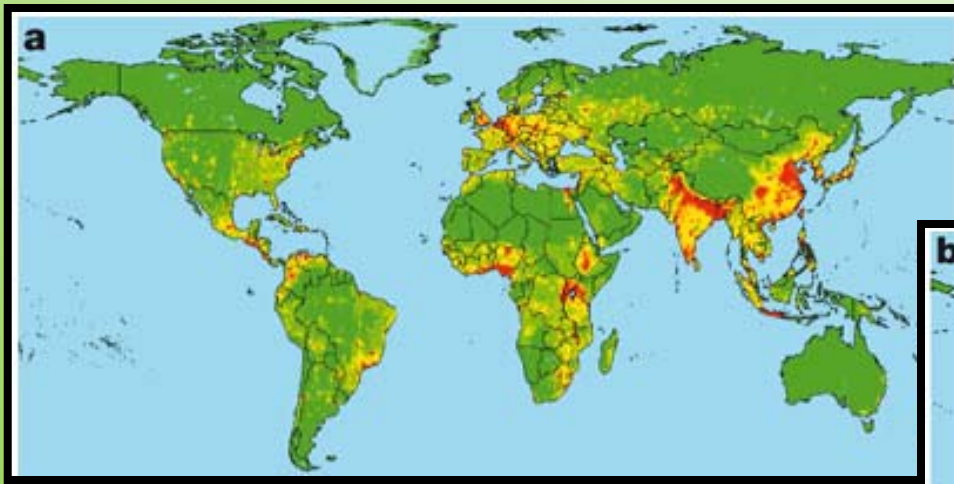
- The discovery of new human pathogen species continues at a rate of 3-4 species per year.



II. Background & Trends

Wildlife plays an important role

Zoonotic pathogens from wildlife



Zoonotic pathogens from non-wildlife



Source: Nature, 2008



II. Background & Trends

- 75% of emerging diseases are zoonotic
- Zoonotic agents comprise more than 80% of the CDC-listed biothreat agents of concern:

- Anthrax (*Bacillus anthracis*)
- Arenaviruses
- Botulism (*Clostridium botulinum* toxin)
- *Brucella* species (brucellosis)
- *Chlamydia psittaci* (psittacosis)
- Cholera (*Vibrio cholerae*)
- Ebola virus hemorrhagic fever
- *E. coli* O157:H7 (*Escherichia coli*)
- Emerging infectious diseases: Nipah virus and hantavirus
- Epsilon toxin of *Clostridium perfringens*
- Food safety threats (e.g., *Salmonella* species, *Escherichia coli* O157:H7, *Shigella*)
- Glanders (*Burkholderia mallei*)
- Lassa fever
- Marburg virus hemorrhagic fever
- Melioidosis (*Burkholderia pseudomallei*)
- Plague (*Yersinia pestis*)
- Q fever (*Coxiella burnetii*)
- Ricin toxin from *Ricinus communis* (castor beans)
- *Salmonella* species (salmonellosis)
- Salmonellosis (*Salmonella* species)
- *Shigella* (shigellosis)
- Smallpox (variola major)
- Staphylococcal enterotoxin B
- Tularemia (*Francisella tularensis*)
- Typhoid fever (*Salmonella* Typhi)
- Typhus fever (*Rickettsia prowazekii*)
- *Vibrio cholerae* (cholera)
- Viral encephalitis
- Viral hemorrhagic fevers (filoviruses [e.g., Ebola, Marburg] and arenaviruses [e.g., Lassa, Machupo])
- Water safety threats (e.g., *Vibrio cholerae*, *Cryptosporidium parvum*)



II. Background & Trends

Significant global outbreaks since 1993

- | | |
|-------------------------------|----------------------------|
| 1993- Hanta virus | 2000- Rift valley fever |
| 1994- Plague (India) | 2001- Anthrax |
| 1995- Ebola (Zaire) | 2002- Norwalk-like viruses |
| 1996- New variant of CJD (UK) | 2003- SARS |
| 1997- H5N1 (Hong Kong) | 2006- H5N1 |
| 1998- Nipah virus (Malaysia) | 2009- Pandemic H1N1 |
| 1999- West Nile | |



II. Background & Trends

- Preventative vaccination
- Culling animals
- Pasteurizing milk



II. Background & Trends

Size & scope

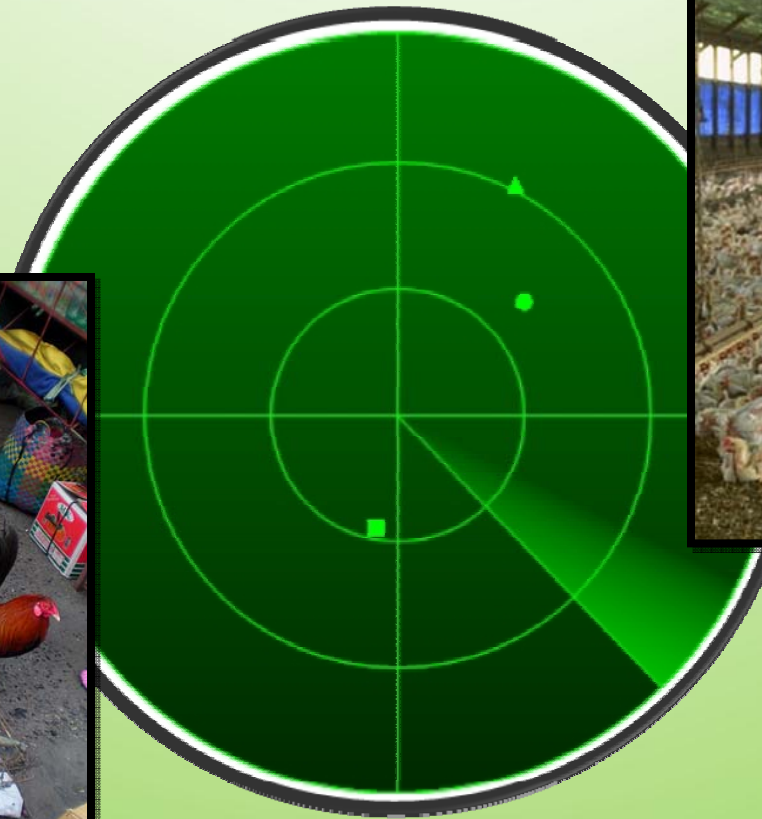


Source: UN World Tourism Organization,
UNFAO, World Bank



II. Background & Trends

H5N1 falling off radar



II. Background & Trends

Nations Pledge \$2 Billion to Combat Bird Flu

Wednesday, January 18, 2006
Associated Press

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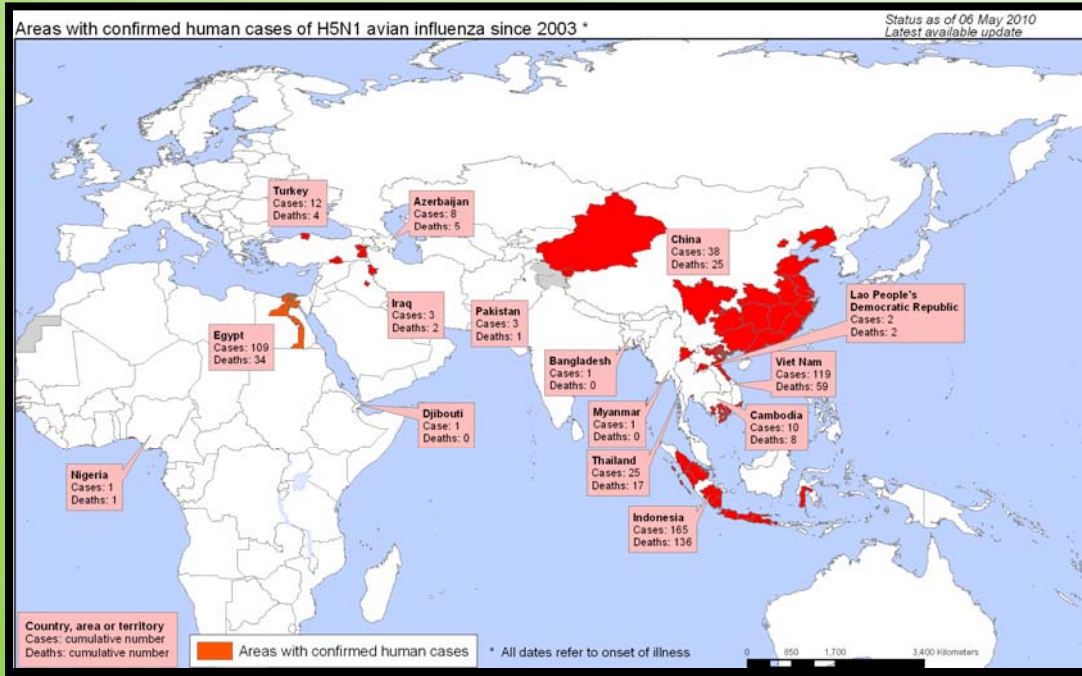
- 45% to be spent in Vietnam, Cambodia, Indonesia, Thailand and Laos
- EU pledged \$121 million
- US pledged \$334 million
- Japan donated \$159 million
- China said it would donate \$10 million



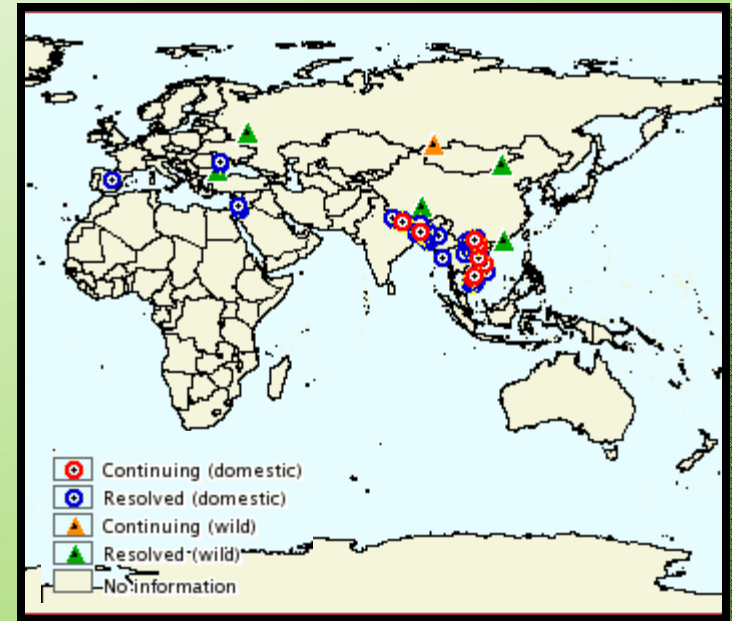
II. Background & Trends

H5N1

Confirmed human cases of H5N1 2003-2010



63 Countries Report H5N1 Avian Influenza in Domestic Poultry/Wildlife 2003-2010



Source: World Health Organization, 2010

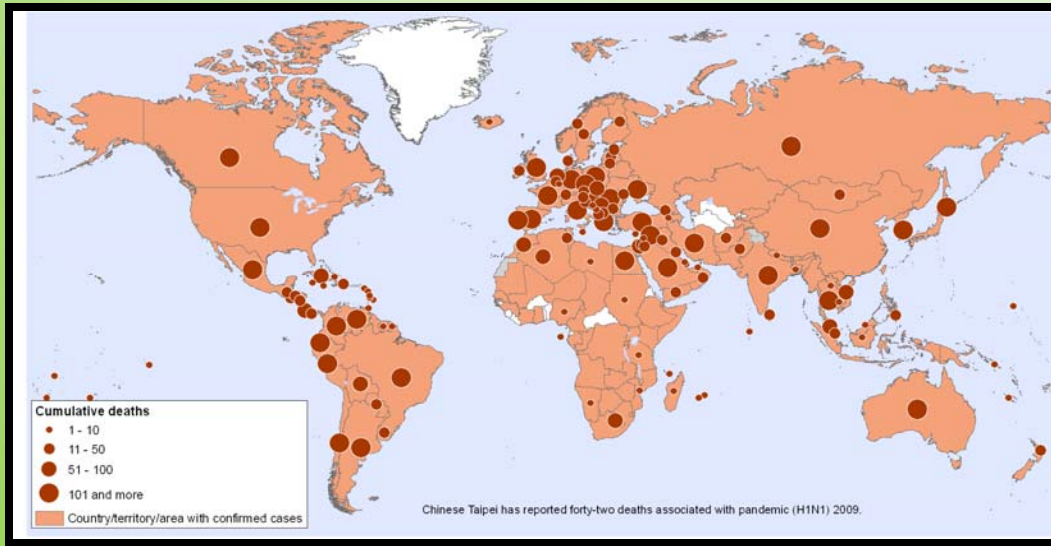


Source: OIE, WAHID, 2010

II. Background & Trends

Connecting disease to world of today

Confirmed human cases of Pandemic H1N1
in humans, 2010



Reported cases of H1N1 in swine,
2007-2009



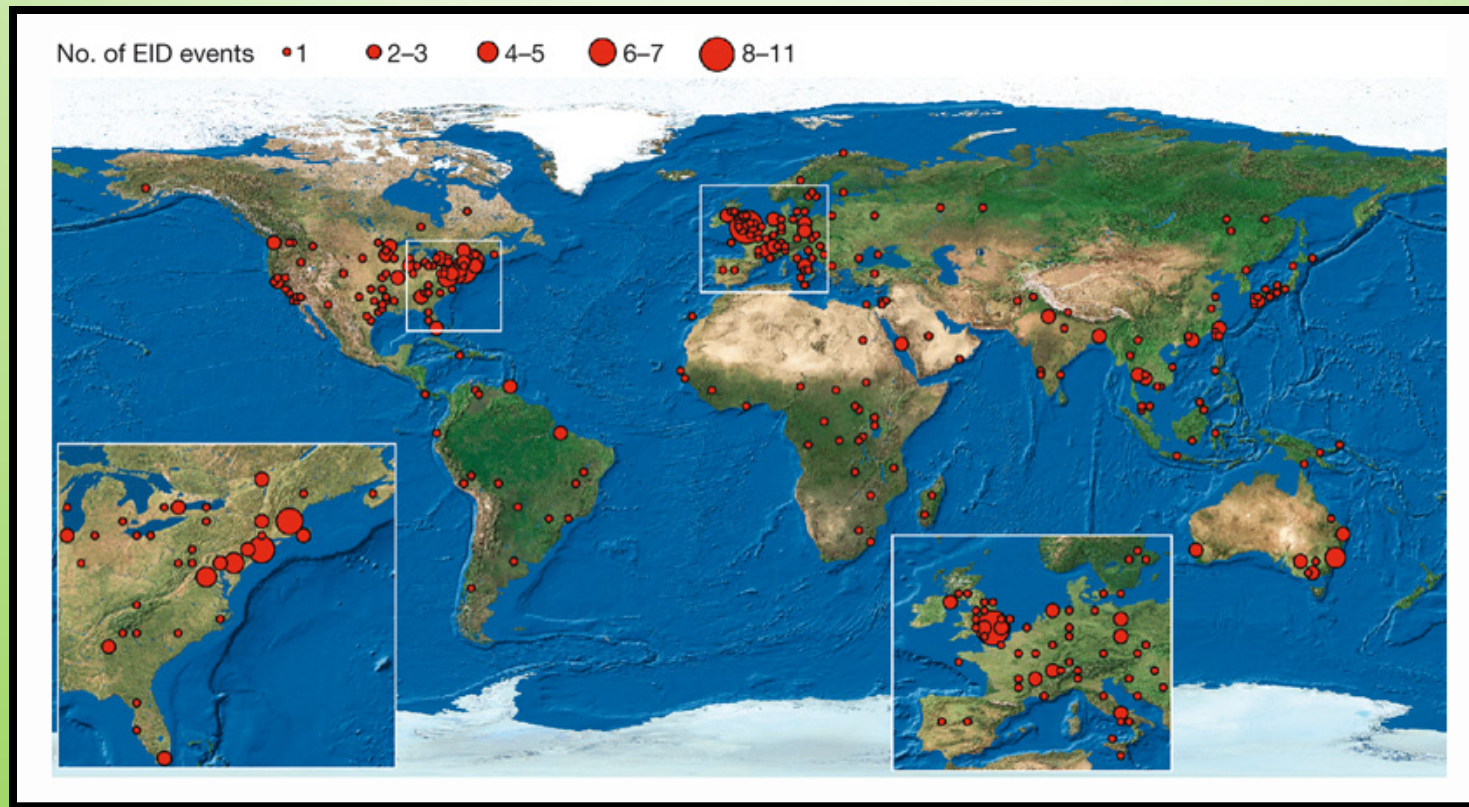
● 2007 – Philippines outbreak
● 2009 – Mexico, Canada, US

Source: World Health Organization, 2010, The Canadian Food
Inspection Agency



II. Background & Trends

Origins of emerging infectious disease (EID) events from 1940-2004



Source: Nature, 2008



II. Background & Trends

- Large gaps exist in disease surveillance networks, including coverage across species and across geographic space.
- 90% of the cause of human infectious disease could not be identified, even in developed countries.

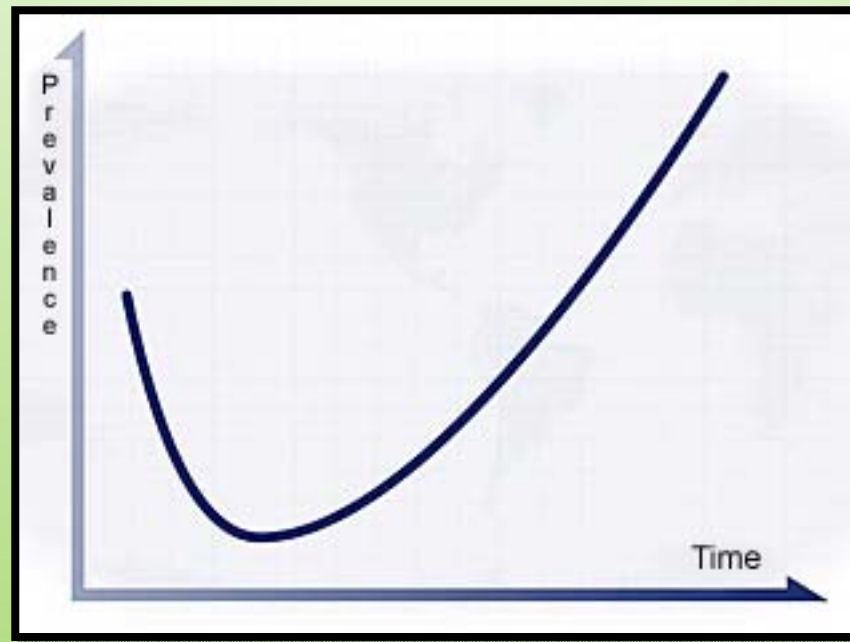


Source: Sustaining global surveillance and response to emerging zoonotic diseases, National Academies Press



II. Background & Trends

The J-curve



Animal Public Health Map



Animal Public Health Map

Animal Public Health MAP OF THE DECADE

PUBLIC HEALTH

INFECTIOUS DISEASE ECOLOGY

- Animal & public health continuum
- From morbidity/mortality to prevention/intervention
- Holistic and systemic approaches

BIO-DIVERSITY FROM RAPID URBANIZATION

- Peri-urban settlements
- Re-emerging diseases
- Population-induced climate variability

Rapid urbanization

Source: United Nations

ANIMAL HEALTH

INCREASE OF TRANSBOUNDARY DISEASES

- Rift Valley fever
- Avian flu
- Foot-and-mouth disease

DISEASE MIGRATION

- West Nile Virus: Egypt → New York → California
- Marburg hemorrhagic fever: Congo → Angola
- HIV: African jungle → worldwide

INCREASED SUSCEPTIBILITY

- Ecological changes
- Reduced gene pools

THREAT OF ZOOONOTIC DISEASES

- 80% of all human pathogens are zoonotic
- 75% of emerging infectious diseases are of animal origin

LOCAL ↔ GLOBAL DISCONNECTS BETWEEN STAKEHOLDERS

- Farms
- Health
- Food industry
- Tourism

CONTESTED TRADE AGREEMENTS OVER FOOD/HEALTH STANDARDS

- WTO Sanitary and phytosanitary measures
- OIE international animal health code
- Bi- and multi-lateral trade agreements

COMMERCIALIZATION OF BUSHMEAT/WILDLIFE

- Bushmeat trade
- Urban wildlife
- International trade of exotic pets

MOBILE NETWORKS

- Smart mobs

CHEAP, PORTABLE DIAGNOSTICS

- Lab-on-a-card
- BioLED technology
- ISTAT

GOODS

VULNERABILITY OF COMPLEX GLOBALIZED FOOD CHAIN

EXTREME WATER EVENTS

- Drought
- Floods
- Food insecurity

Global supermarket risks & opportunities
(Share of supermarket retail sales)

Region	1992 (%)	2002 (%)
Central America	~10	~15
South America	~15	~20
Southeast Asia	~20	~25
East Asia	~25	~30
Central Europe	~30	~35

Source: Pearson et al.

Global movement

Source: Airports Council Intl

WEAK POLITICAL LEADERSHIP

FOOD WARS

- Trade
- Natural/artificial
- Media

FOOD SAFETY REGULATORY BOTTLENECKS

COMPETITION FOR FOOD RESOURCES

- Biofuels
- Agrochemicals
- Bio-based products (e.g. clothes, packaging)

FOOD TRANSPARENCY

- iBuyRight
- Dole bananas' farm codes
- Substitute uses for food

LOCAL GOES GLOBAL

Local outbreaks quickly become global concerns as a result of international interdependence.

NEW PRODUCTS SERVICES FOR TH

- Famine insurance
- Micro-credit
- mBanking

AGRO-ECOLOGICAL LINKS TO INFECTIOUS DISEASES

- Climate change and dengue fever
- Deforestation and yellow fever
- Maize production and malaria

EARLY WARNING AND PREPAREDNESS

- Models of Infectious Disease Agent Study (MIDAS)
- Booz Allen influenza pandemic simulations (World Economic Forum)
- Macro-epidemiologic risk assessments of BSE

TELE-MEDICINE

- iviva.net
- Satelife (healthnet.org)
- Narayana Hrudayala hospitals

AED * SATELLIFE
Center for Health Information and Technology

ECOSYSTEM INSULTS

- Land use slash and burn
- Exploitation of fragile environments
- Biofuels risk resource degradation

OPEN SOURCE BIOTECHNOLOGY

- Public-private partnerships
- Cambia

ECOLOGICAL HEALTH AS BUSINESS PLATFORM

- Sustainline.com
- FiveLimes.com
- Dotheightthing.com

REMOTE SENSING AND TRACKING

- Movement tracking
- Early warning
- Temperature sensors

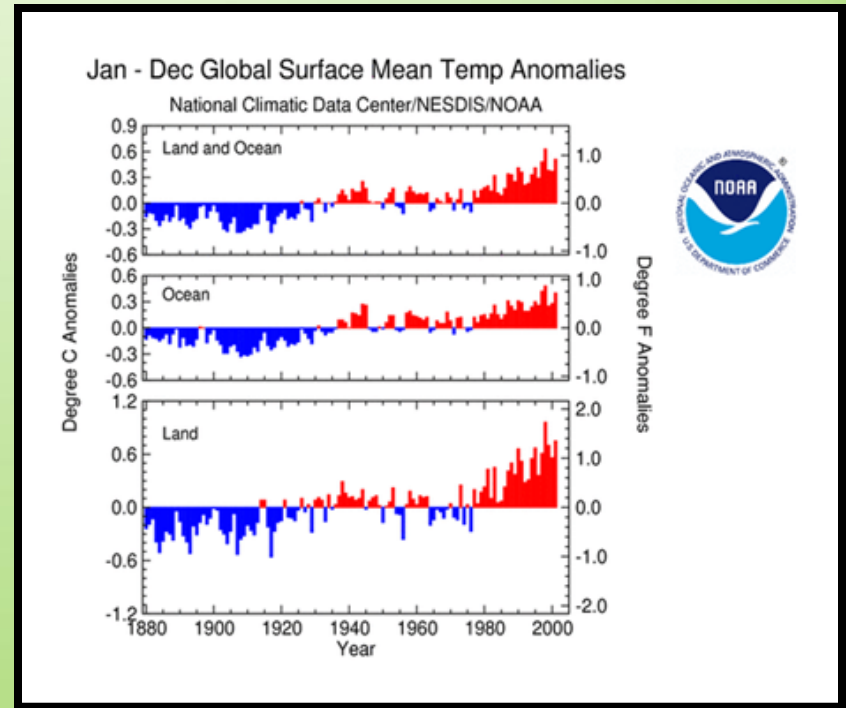
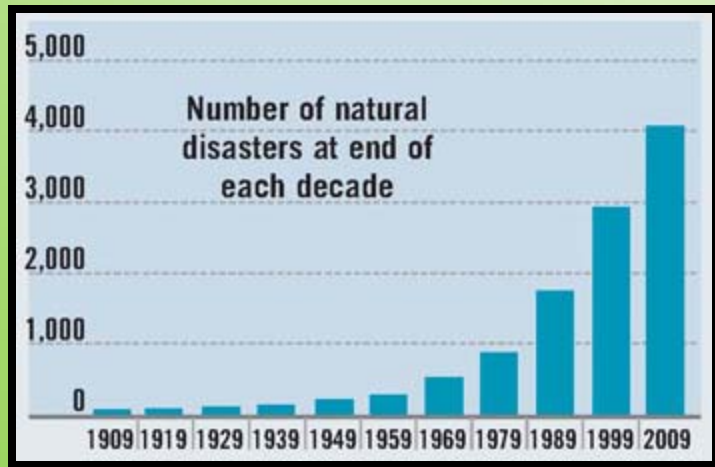
GOOGLE

Who is Sick?

III. Connecting disease to world of today

Ecological risk and climate change

“Ecosystem services...have been estimated to be equivalent to the world gross domestic product, roughly \$30 trillion. “ -E.O. Wilson



Source: Goldman Sachs analysis of WHO Data, NOAA



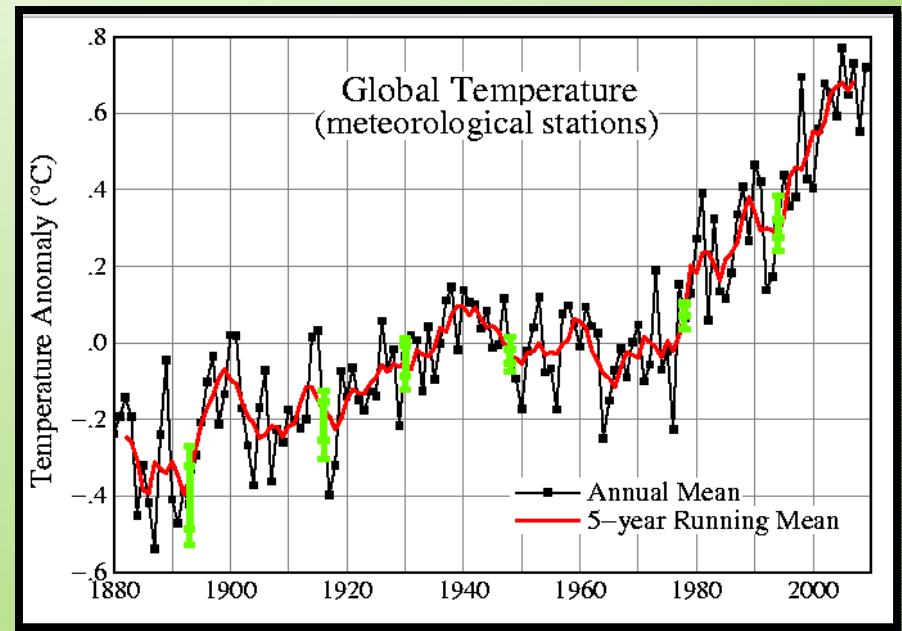
III. Connecting disease to world of today

Ecological risk and climate change

- Geographic changes will take place in water-borne and vector-borne disease.
- Increases in precipitation will lead to favorable habitats for vectors, intermediate and reservoir hosts, or warming that leads to expansion or ranges in low latitudes, oceans, or mountain regions.

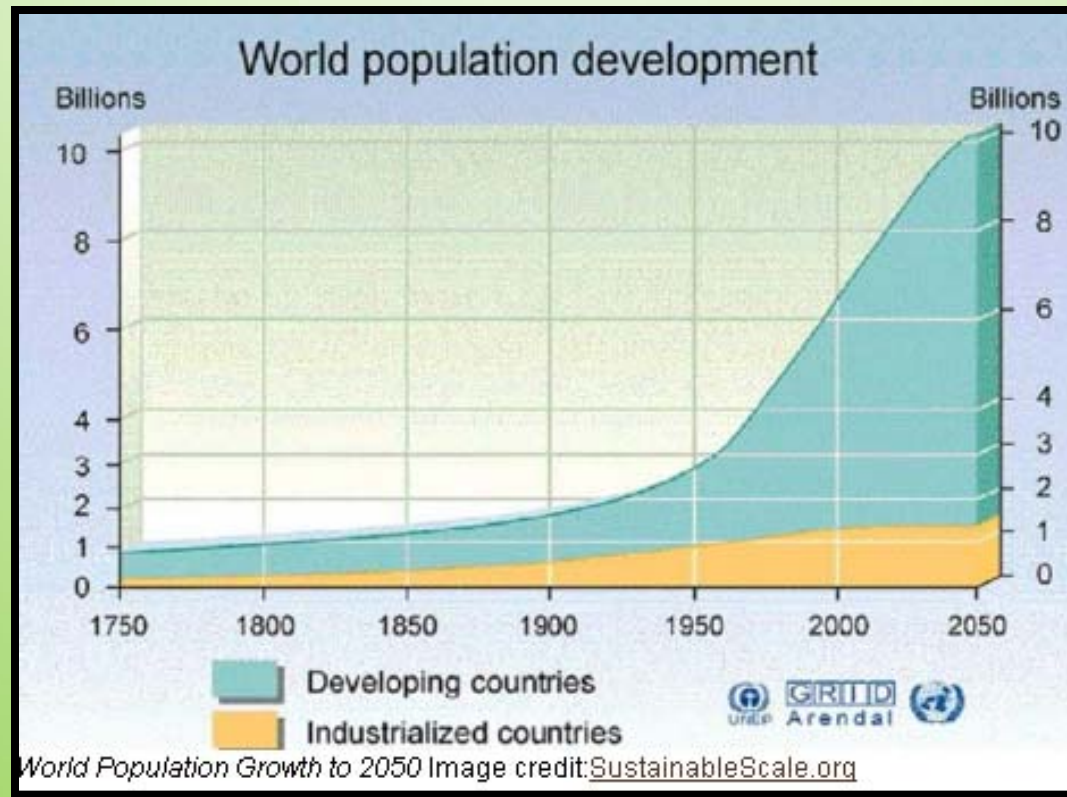


Hanta virus



III. Connecting disease to world of today

Population dynamics



Source: UNEP/GRID



III. Connecting disease to world of today

Population Dynamics

- In 2000, emerging market economies accounted for 56% of the global middle class
- By 2030, that figure is expected to reach 93%
- China and India alone will account for 2/3 of this expansion



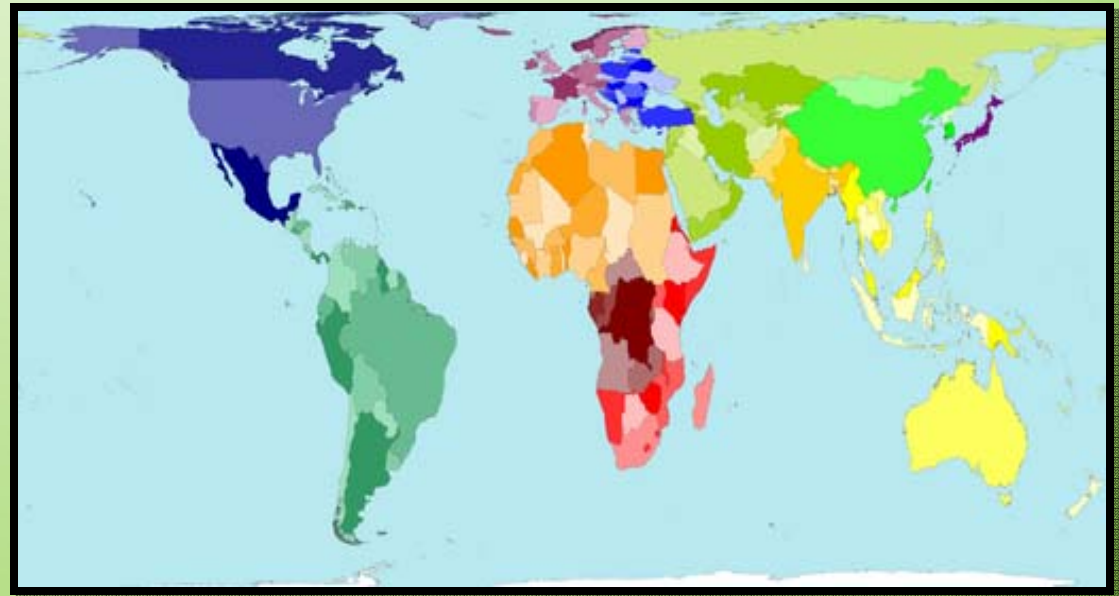
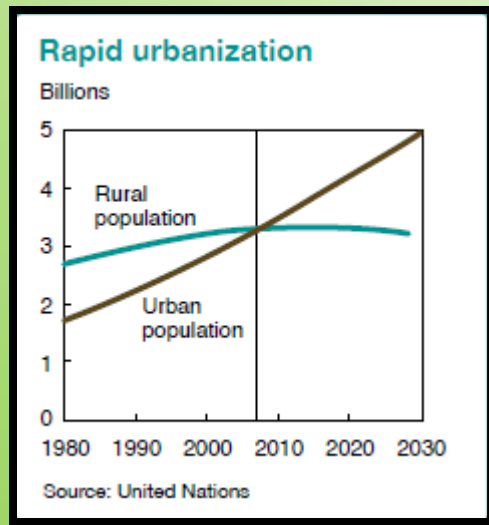
Source: Sustaining global surveillance and response to emerging zoonotic diseases, National Academies Press



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Population Dynamics

Slum growth, 1990-2001



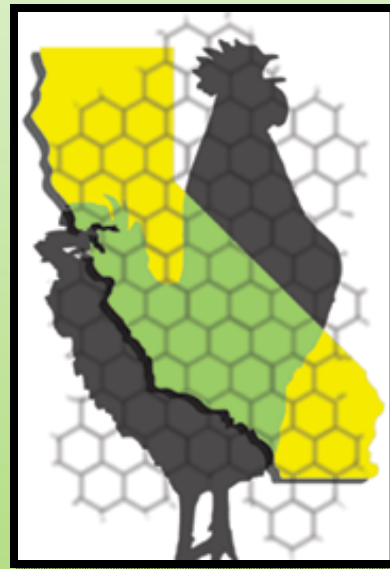
Source: United Nations



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Population dynamics

The smuggling of roosters into the country for cockfighting was responsible for a 2002 exotic Newcastle disease epidemic in California.

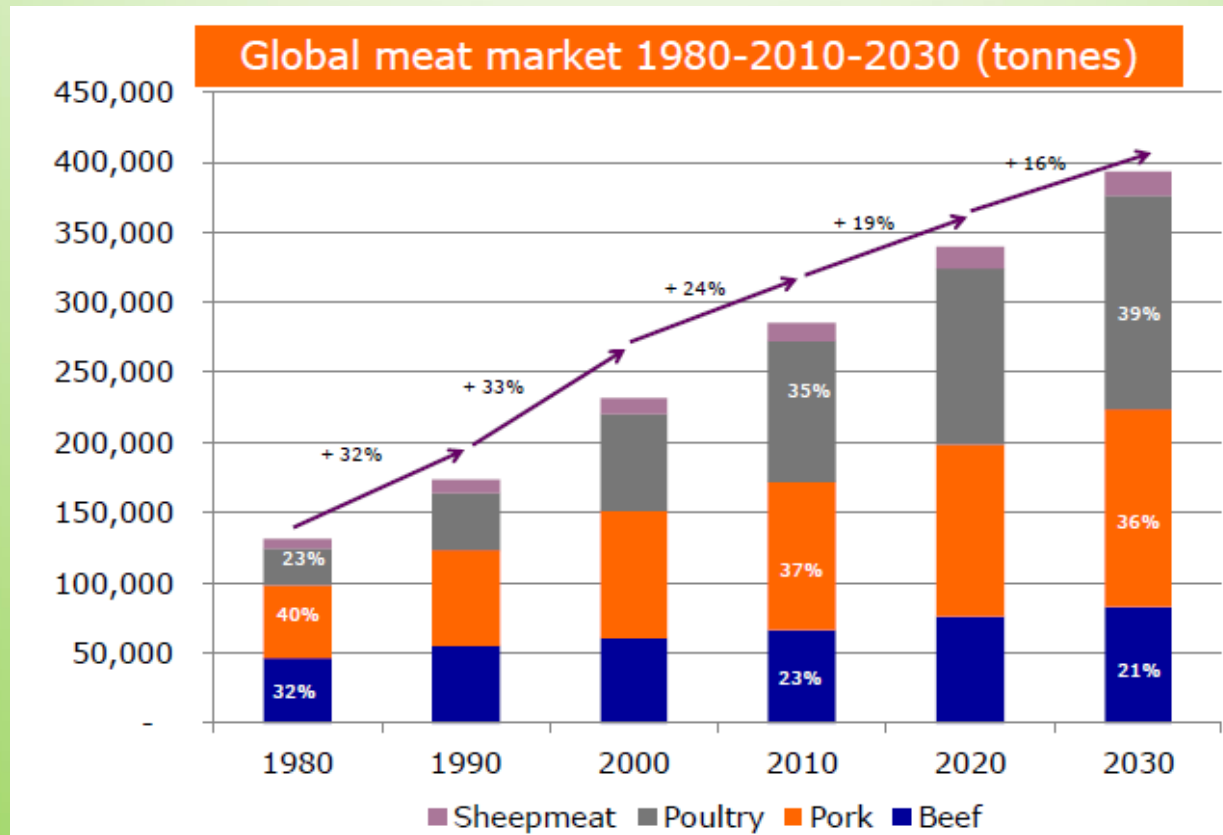


Source: AVMA



III. Connecting disease to world of today

World Population Growth



Source: A dynamic meat market towards 2020,
Kennes, 2010



III. Connecting disease to world of today

World Population Growth

In 2008 , an estimated 21 billion food animals were produced for a global population of 6.5 billion people

In 2007, the Chinese consumer who ate 44 lbs of meat in 1985, consumed 110 lbs



Source: FAO , GLiPHA,
The Economist: The end of cheap food, 2007



III. Connecting disease to world of today

Growing governance gap

- What governments can do and are expected to do
- Demands on social services vs. infrastructure projects

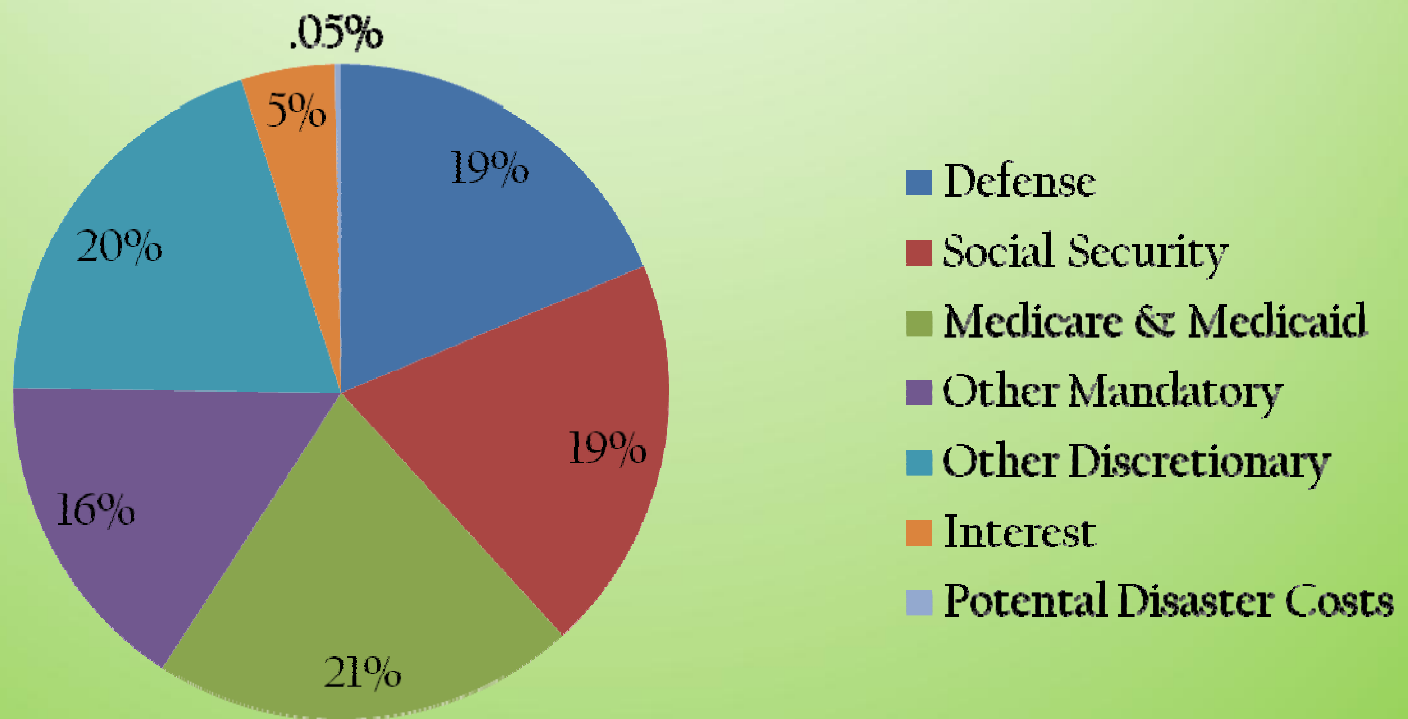


III. Connecting disease to world of today

Growing governance gap

- US 2010 Federal Budget

Total: \$3.55 trillion



III. Connecting disease to world of today

Growing governance gap

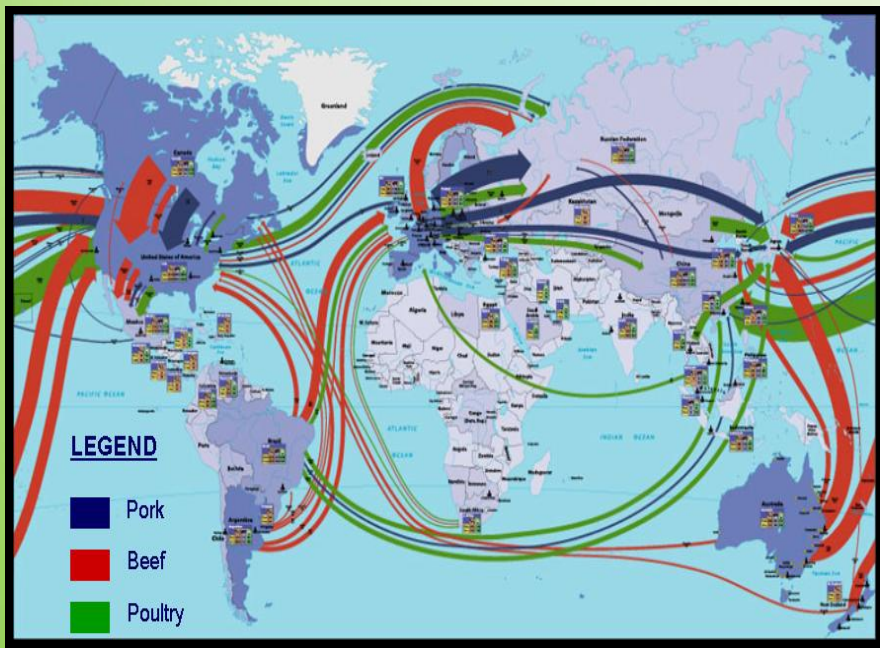
- Turnover in Ministries and leadership positions
- Limited expenditures for animal health, plant health and food safety
- Participation within the World Organization for Animal Health (OIE)
- Emerging growth of 3rd parties



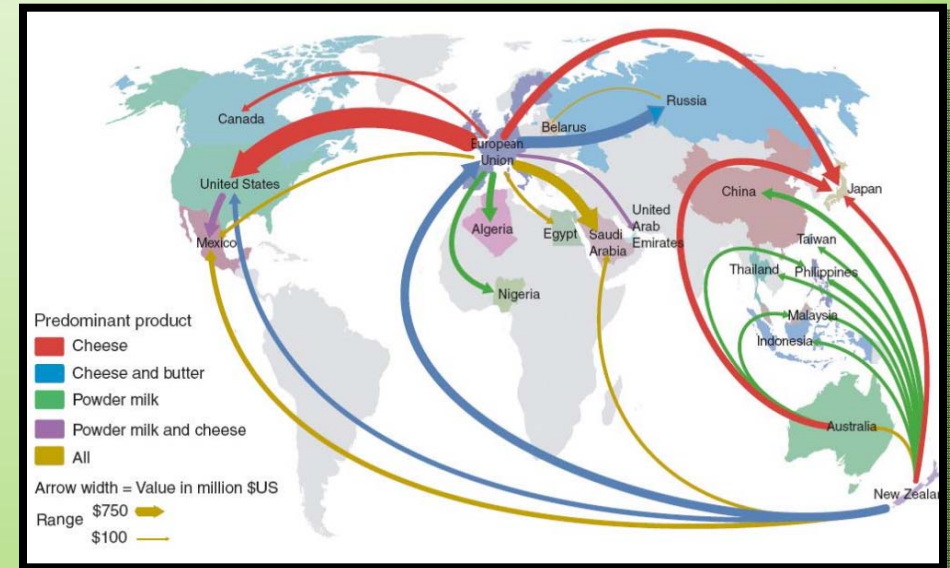
III. Connecting disease to world of today

Global foodscapes

Global Meat Trade



Major global trade flows of dairy products, 2003



Source: GIRA

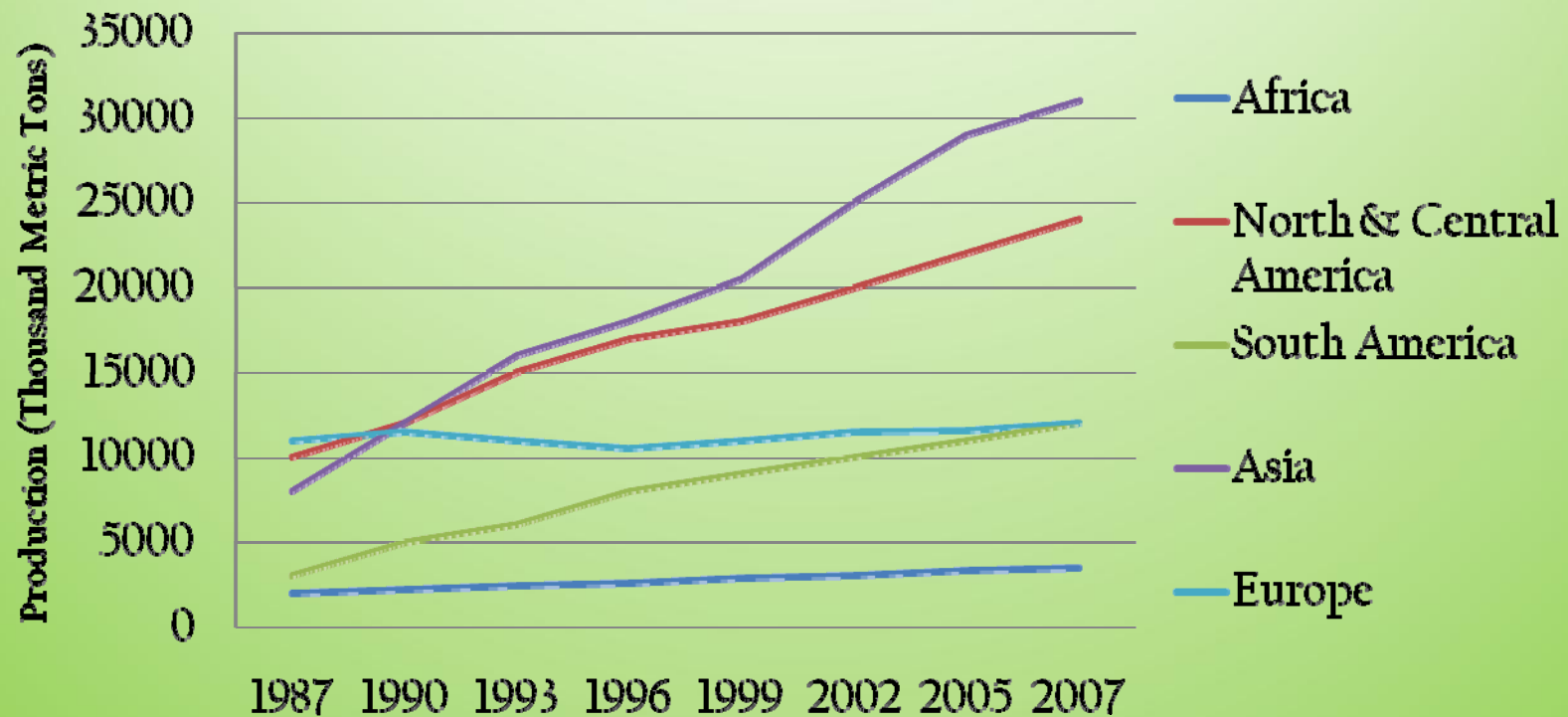


Source: ERS, USDA, 2005

III. Connecting disease to world of today

Global foodscapes

Trends in Poultry Production

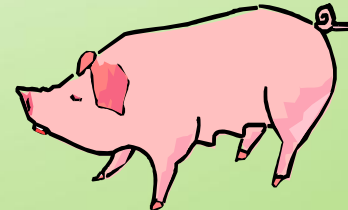
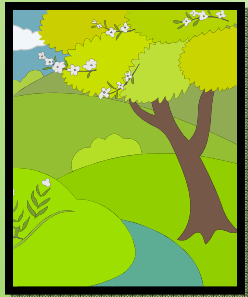


III. Connecting disease to world of today

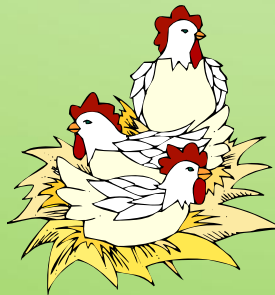
Microbial networks

- Networks of microbes, humans, animals and technologies form to create new environments

NIPAH virus



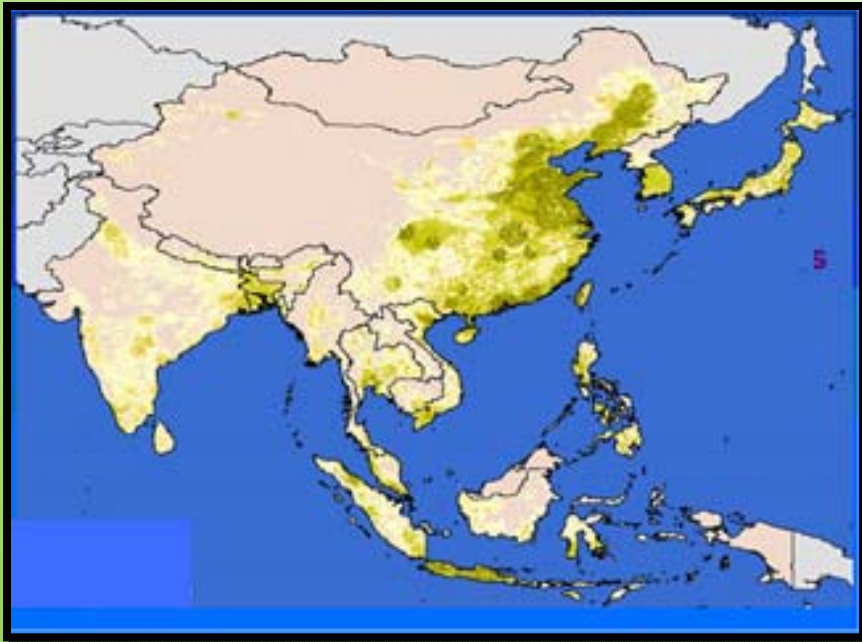
SARS virus



III. Connecting disease to world of today

Microbial networks

Poultry population density



Human population density



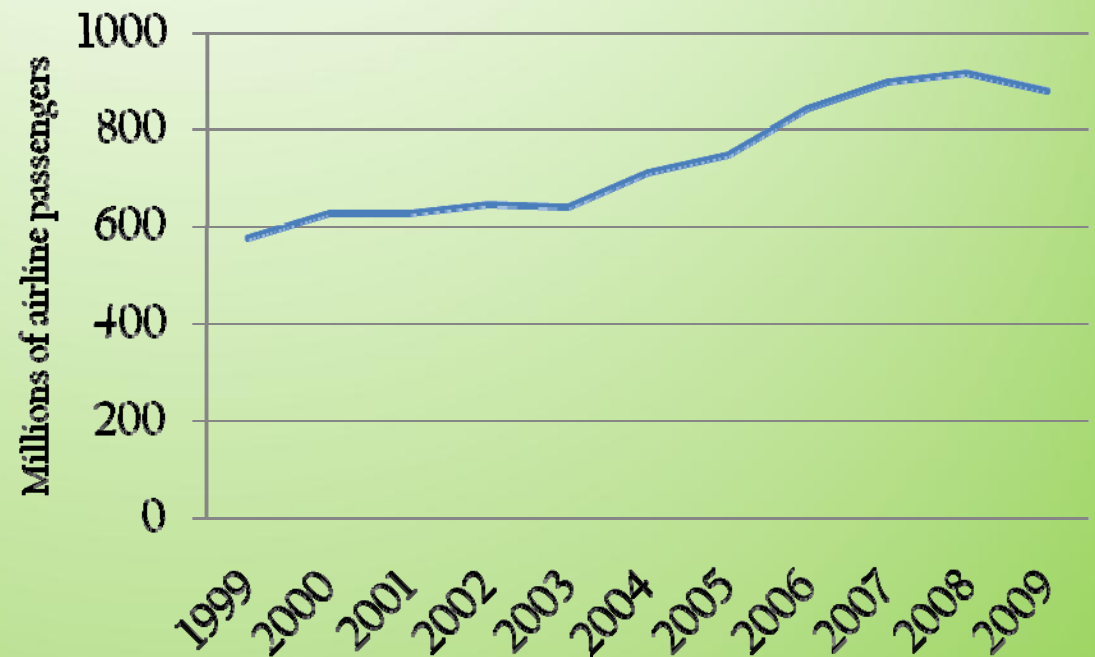
Source: FAO, WHO, Rimsa, Mexico City April 2005

III. Connecting disease to world of today

Microbial networks



International Tourist arrivals



Source: UNWTO World Tourism Barometer, 2010



III. Connecting disease to world of today

Technology & social action

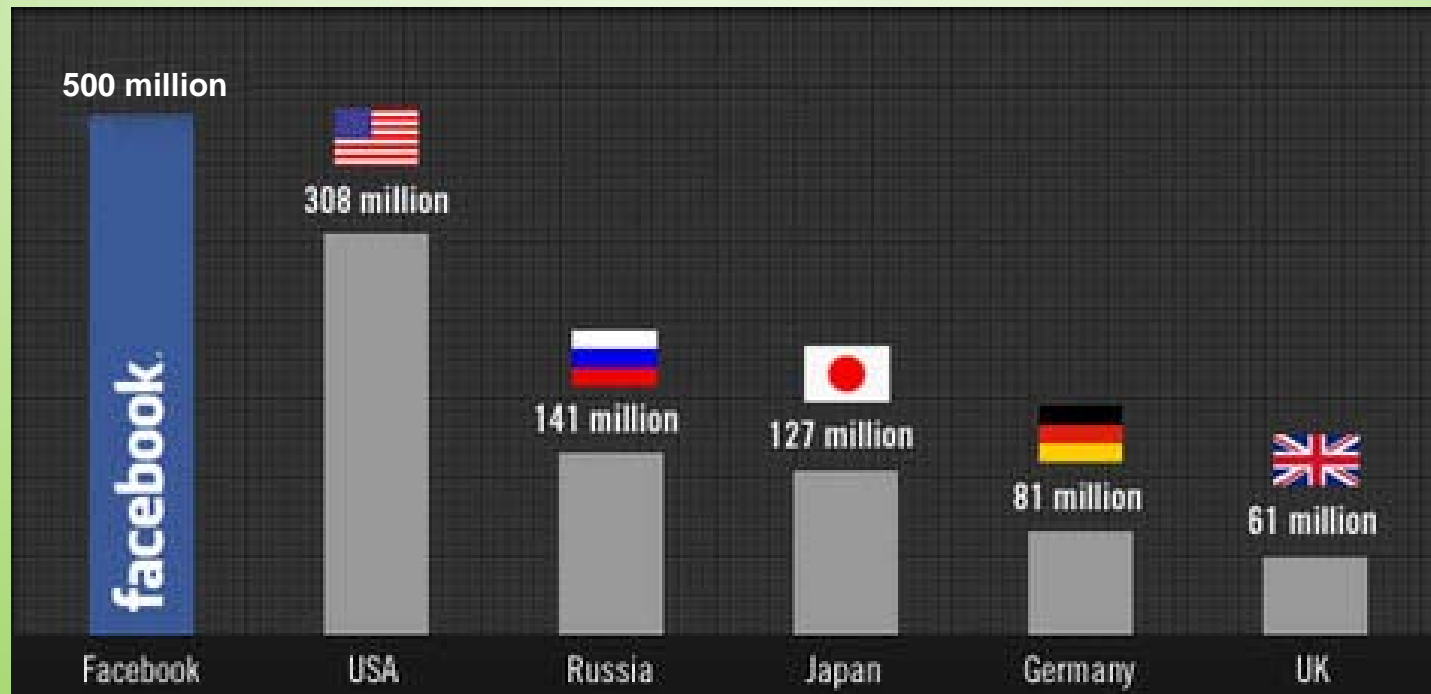
- People can organize around issues without being limited by geographic distance



III. Connecting disease to world of today

Technology & social action

Only India & China have larger populations than Facebook



We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run - Amara's Law



III. Connecting disease to world of today

- Affected sectors:
 - Public health
 - Animal health
 - Goods
 - Services
 - Civil society
 - Education

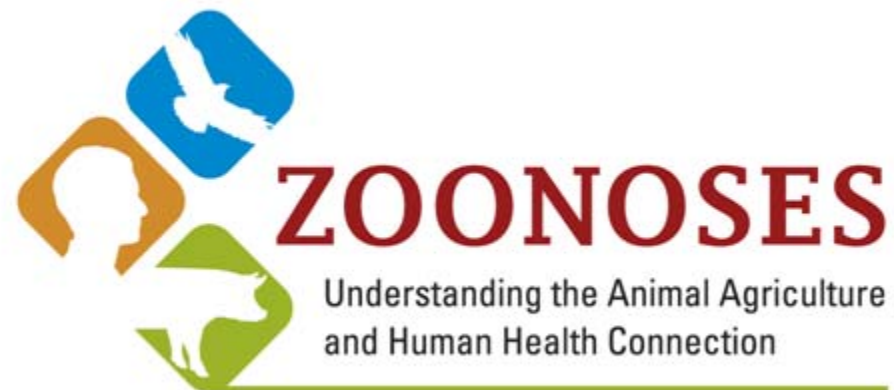


III. Connecting disease to world of today

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IV. Zoonoses skyline

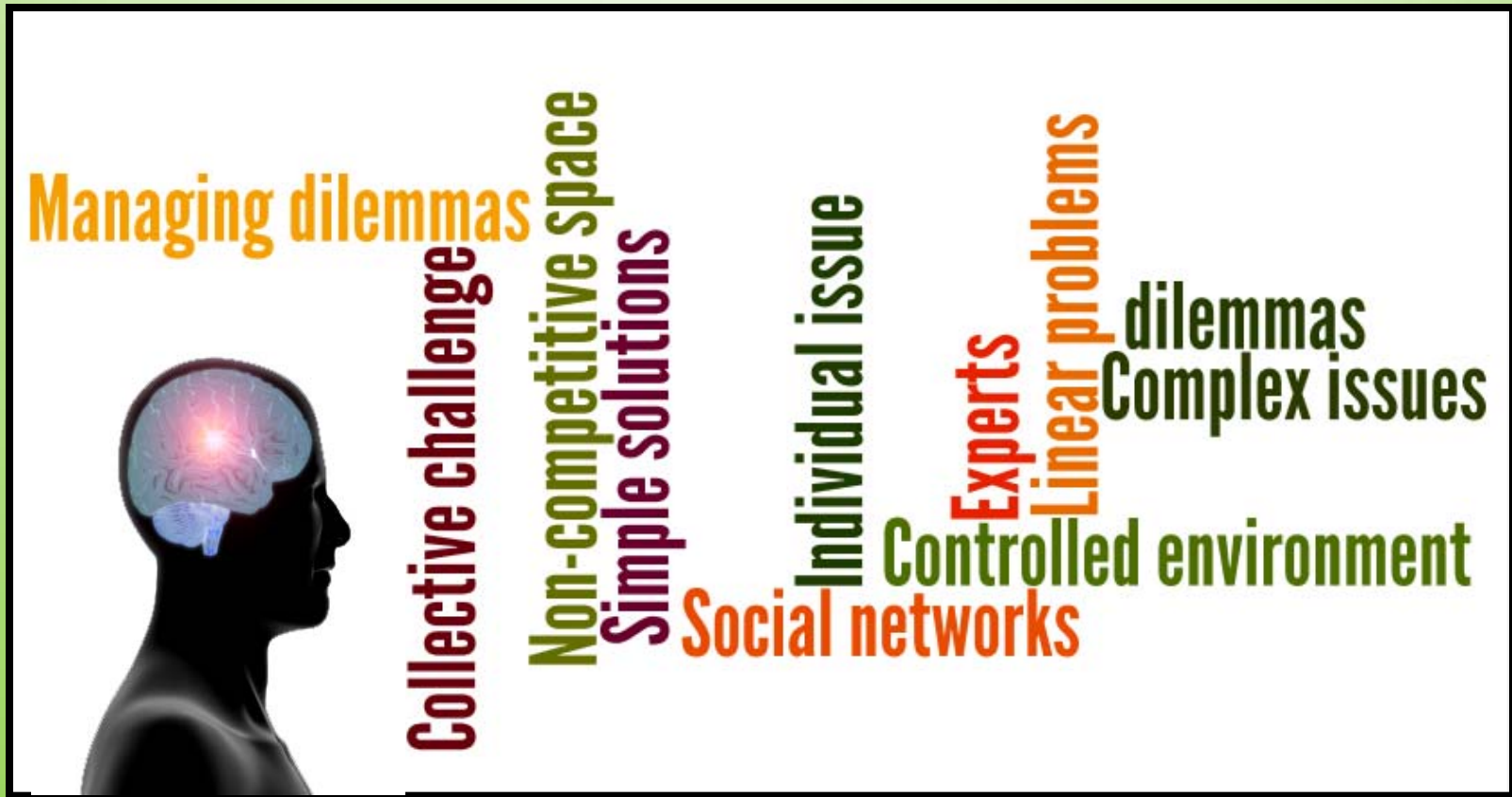


IV. Zoonoses skyline



IV. Zoonoses skyline

Language



IV. Zoonoses skyline

Language

Linear problems

Controlled environment

Experts

Individual issue

Simple solutions



Complex issues

Non-competitive space

Network platforms

Collective challenge

Managing dilemmas



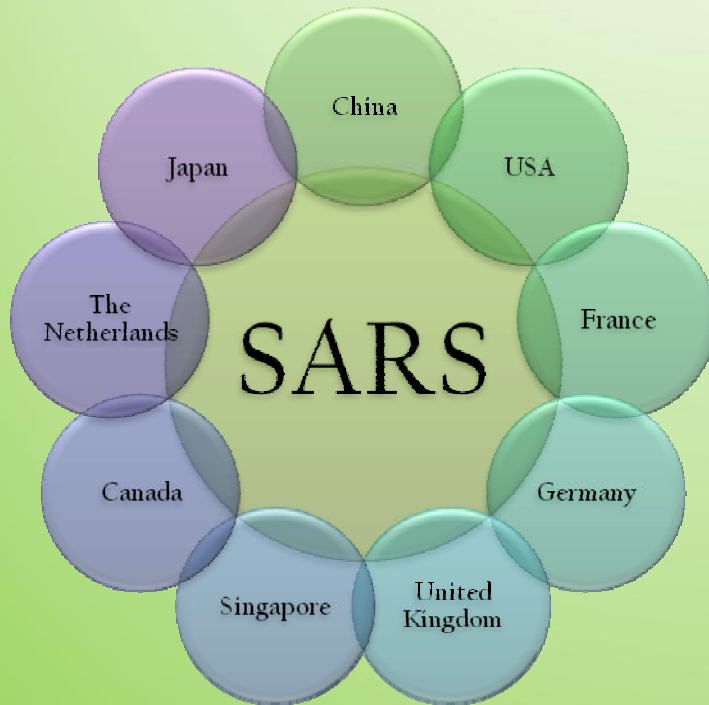
IV. Zoonoses skyline

Issue Framing



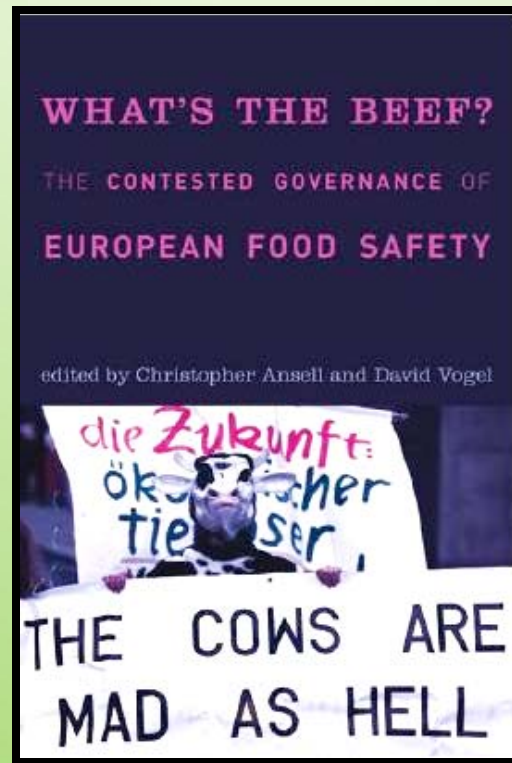
IV. Zoonoses skyline

Shared Cooperation



IV. Zoonoses skyline

Governance Gap



IV. Zoonoses skyline

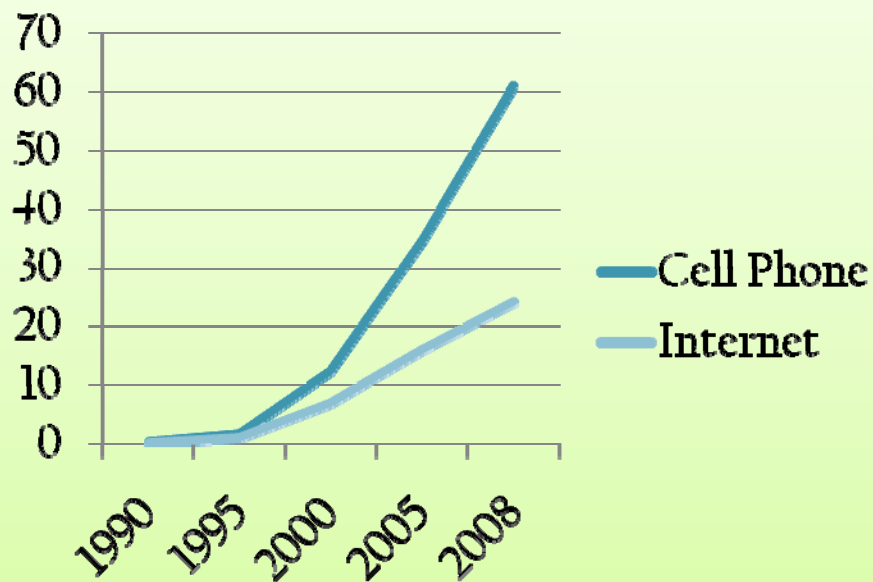
Pre-competitive space



IV. Zoonoses skyline

Societal engagement

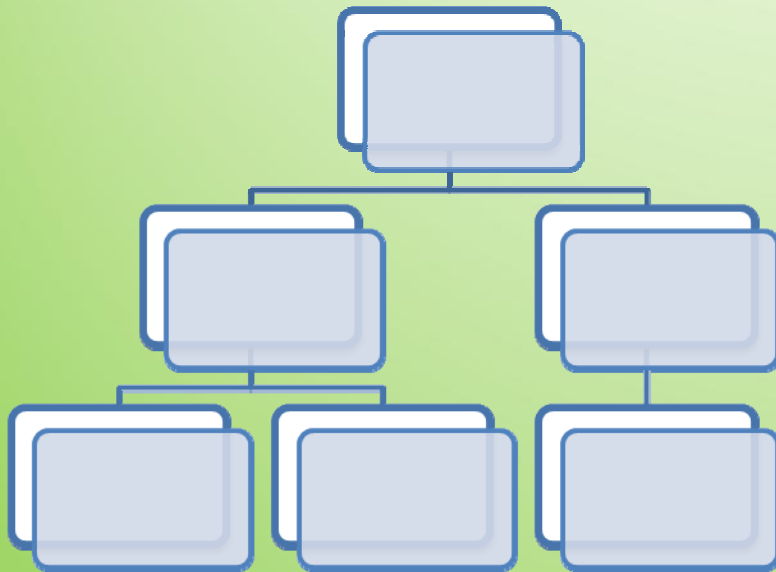
World Cell Phone & Internet use per 100 people



IV. Zoonoses skyline

Academic engagement

Current



Potential



IV. Zoonoses skyline

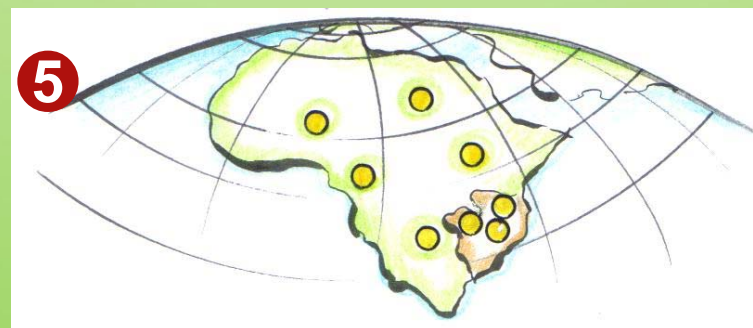
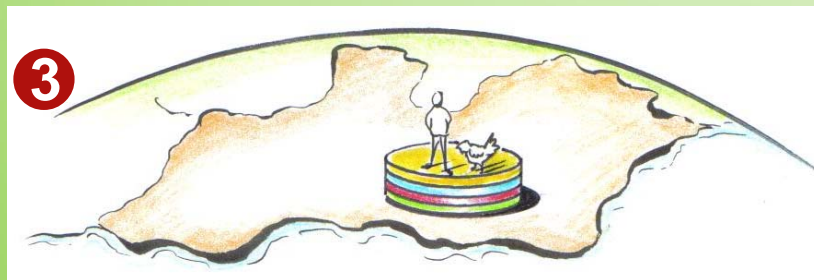
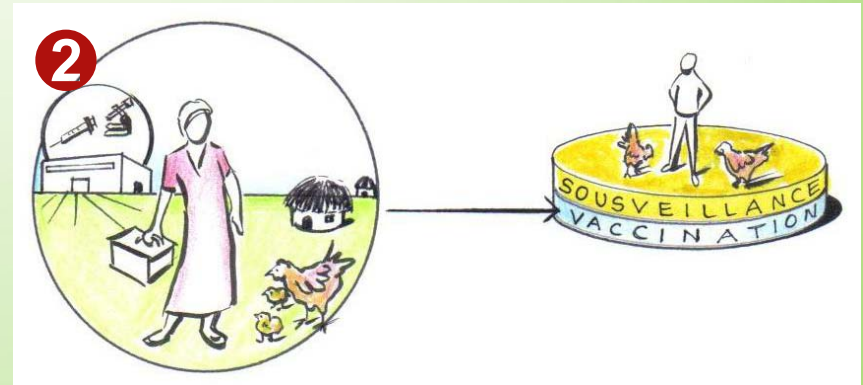
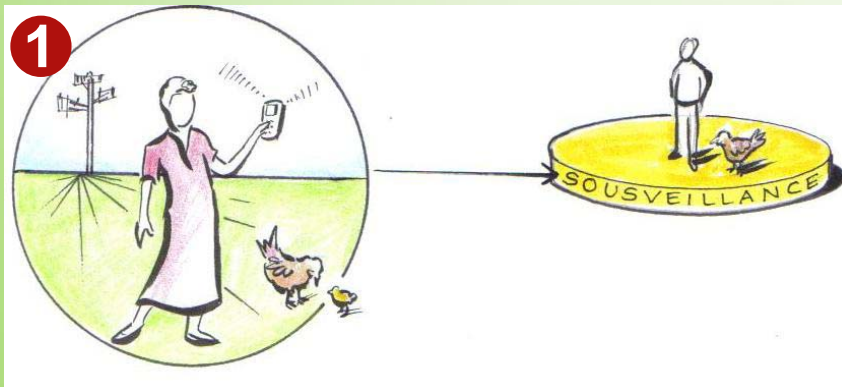
Learning platforms



A screenshot of the 'Who Is Sick?' website. The title is 'Who Is Sick?' in large red letters, with 'BETA' underneath. To the right, it says 'LA Times article' and 'Who Is Sick Video Contest'. Below the title is a search bar with 'City or Zip Code' and '93105' entered. There are buttons for 'Search' and 'Discussion Forum'. A legend on the left lists symptoms with colored squares: Runny nose (red), Cough (green), Fever (yellow), Head ache (black), Muscle ache (orange), and Stomach ache (blue). A 'Post' button is at the bottom. On the right, a map of Southern California shows various cities with colored circular markers indicating sickness reports.



IV. Zoonoses skyline



IV. Zoonoses skyline

Incentives & sustainability

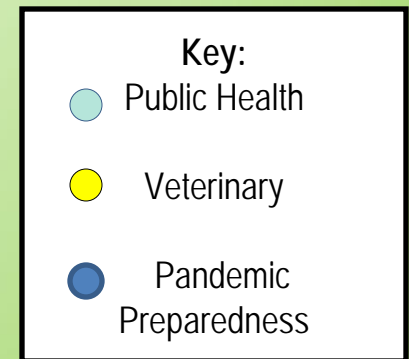
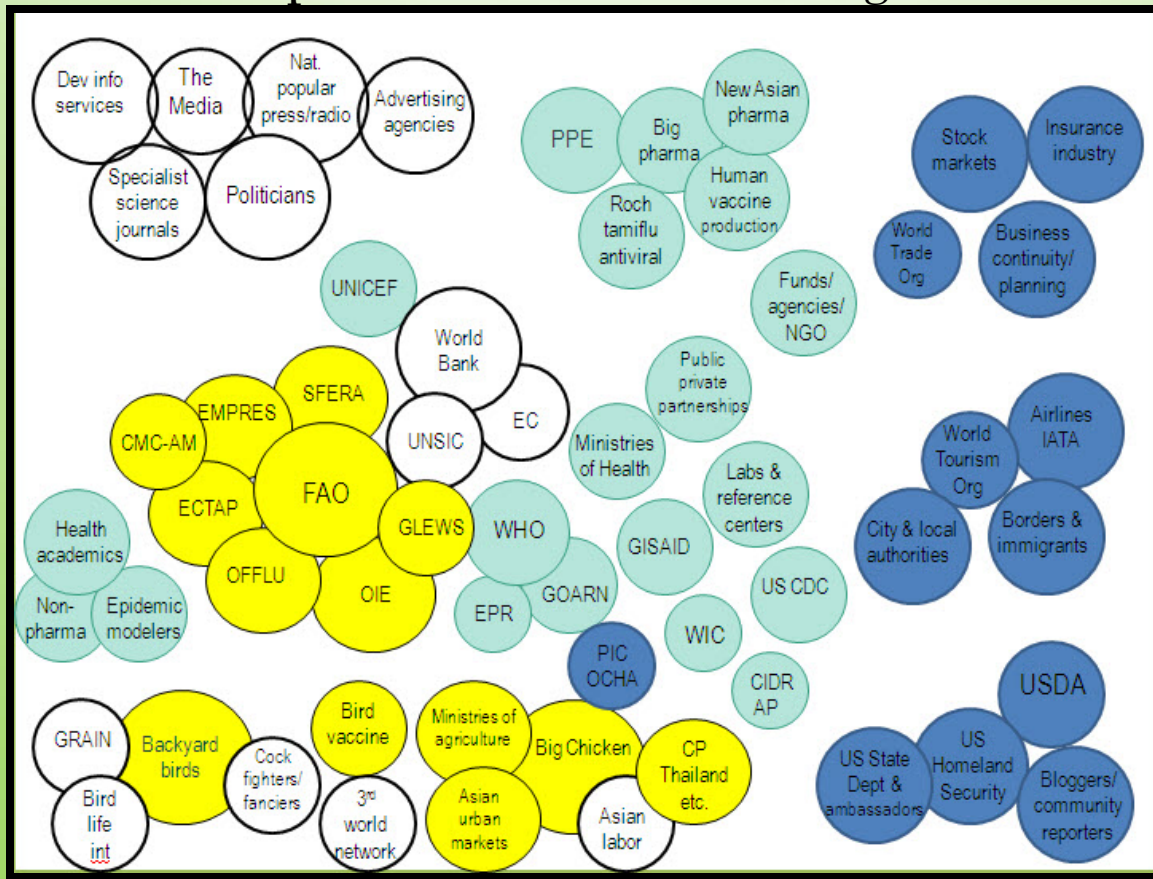


Bangladesh Rural Action Committee- the world's largest
non-governmental development organization



IV. Zoonoses skyline Incentives & sustainability

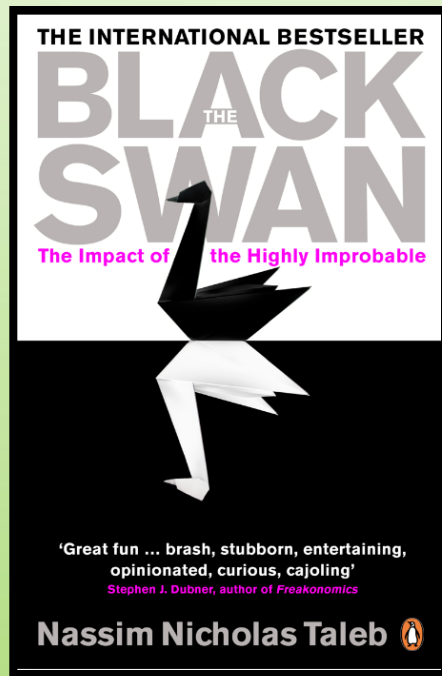
The international avian influenza response: an actor-network diagram



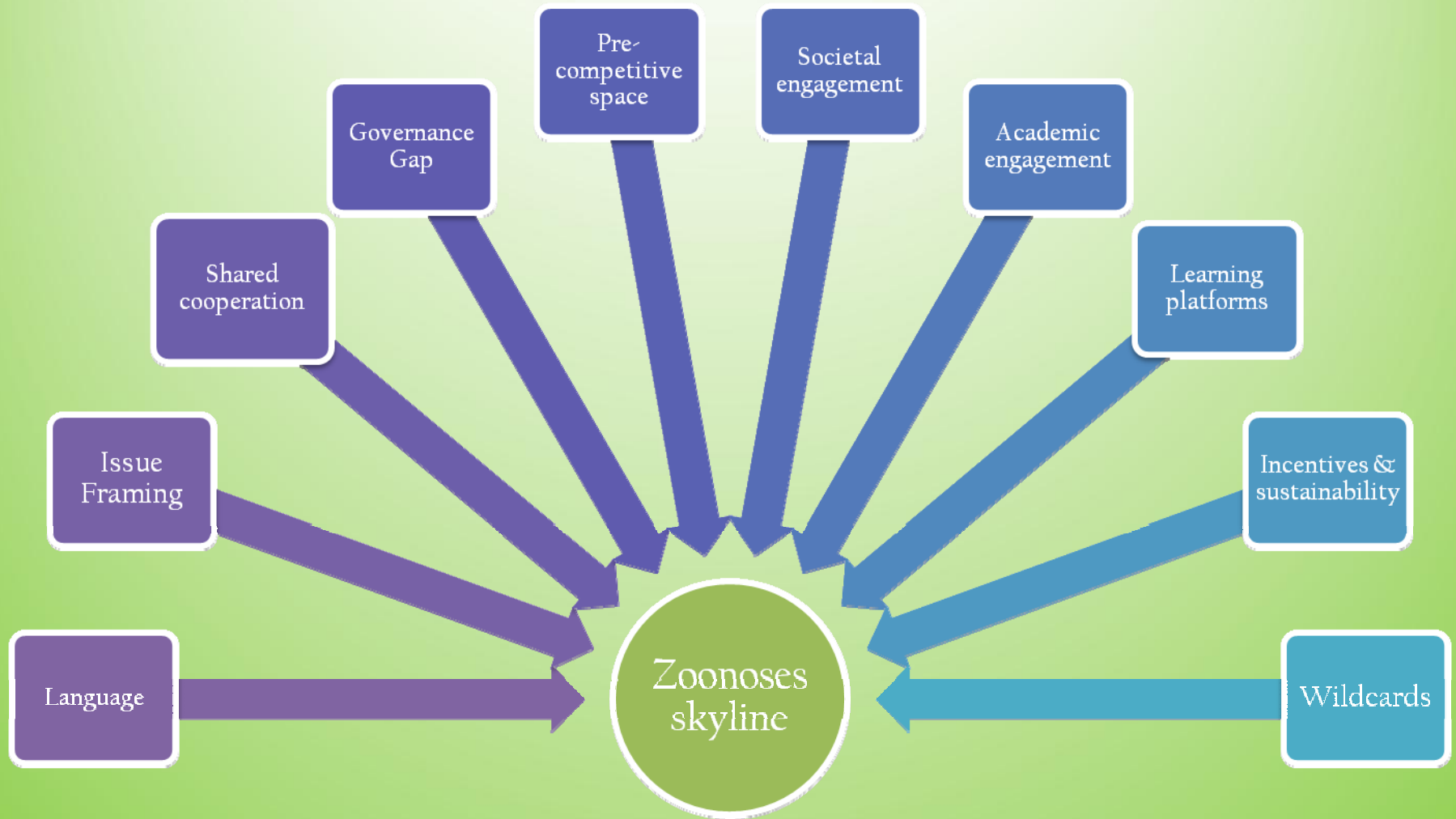
IV. Zoonoses skyline

Wildcards

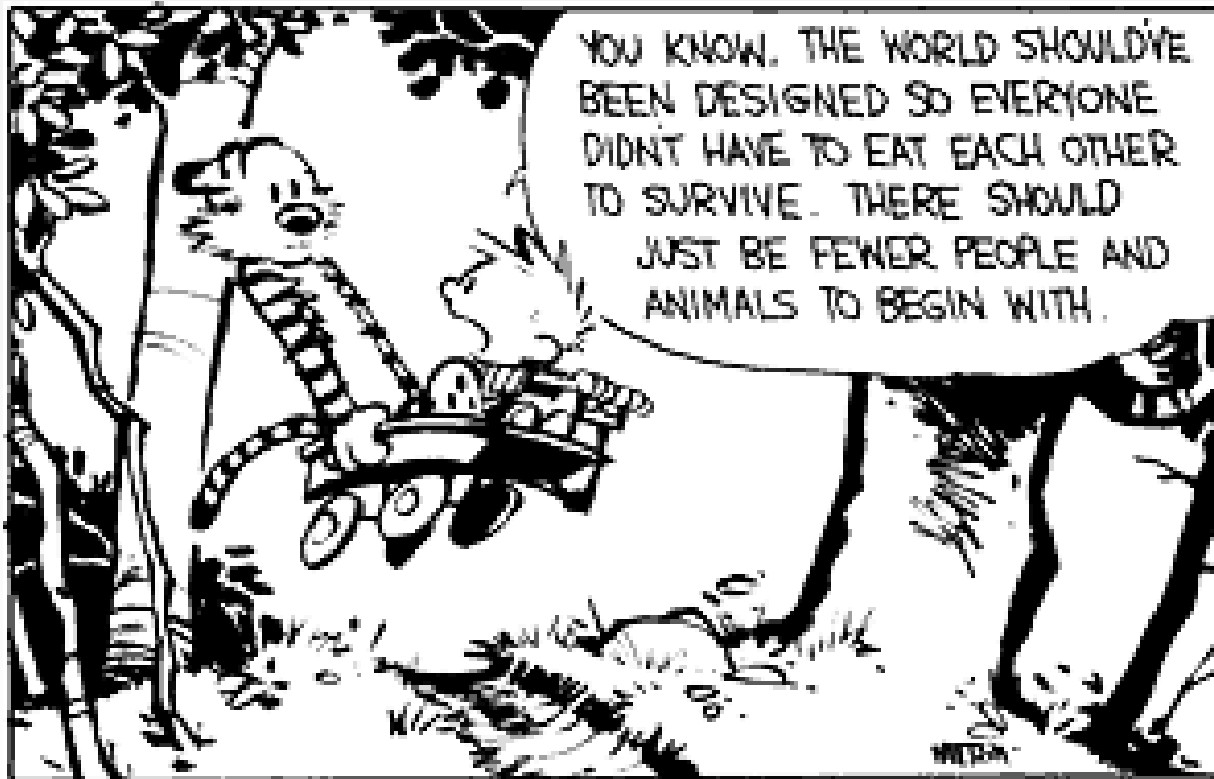
Absence of evidence is not the same as the evidence of absence.



IV. Zoonoses skyline



Calvin and Hobbes by Bill Watterson



AND THE WORLD CERTAINLY
COULD'VE USED A MORE EVEN
DISTRIBUTION OF ITS RESOURCES,
THAT'S FOR SURE.



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Calvin and Hobbes by Bill Watterson



Calvin and Hobbes by Bill Watterson