uOttawa | Faculté de médecine
Faculty of Medicine

Climate change and One Health: tackling vector-borne disease risks in an era of global change

Manisha Kulkarni, PhD

Professor & University Research Chair in Climate Change and Emerging Diseases

School of Epidemiology & Public Health | University of Ottawa

CAHS Forum, Montreal | May 8, 2026

CIHR IRSC | NSERC CRSNG | wellcome | Public Health Agency of Canada | GLOBAL 1 HEALTH NETWORK / RÉSEAU SEULE SANTÉ | INNOVATION.CA Canada Foundation for Innovation / Fondation canadienne pour l'innovation | INSIGHT Research Lab

Key messages

1. Global change is altering patterns of vector-borne disease transmission and risk

2. One Health approaches are needed to understand and address increasing risks posed by climate-sensitive diseases

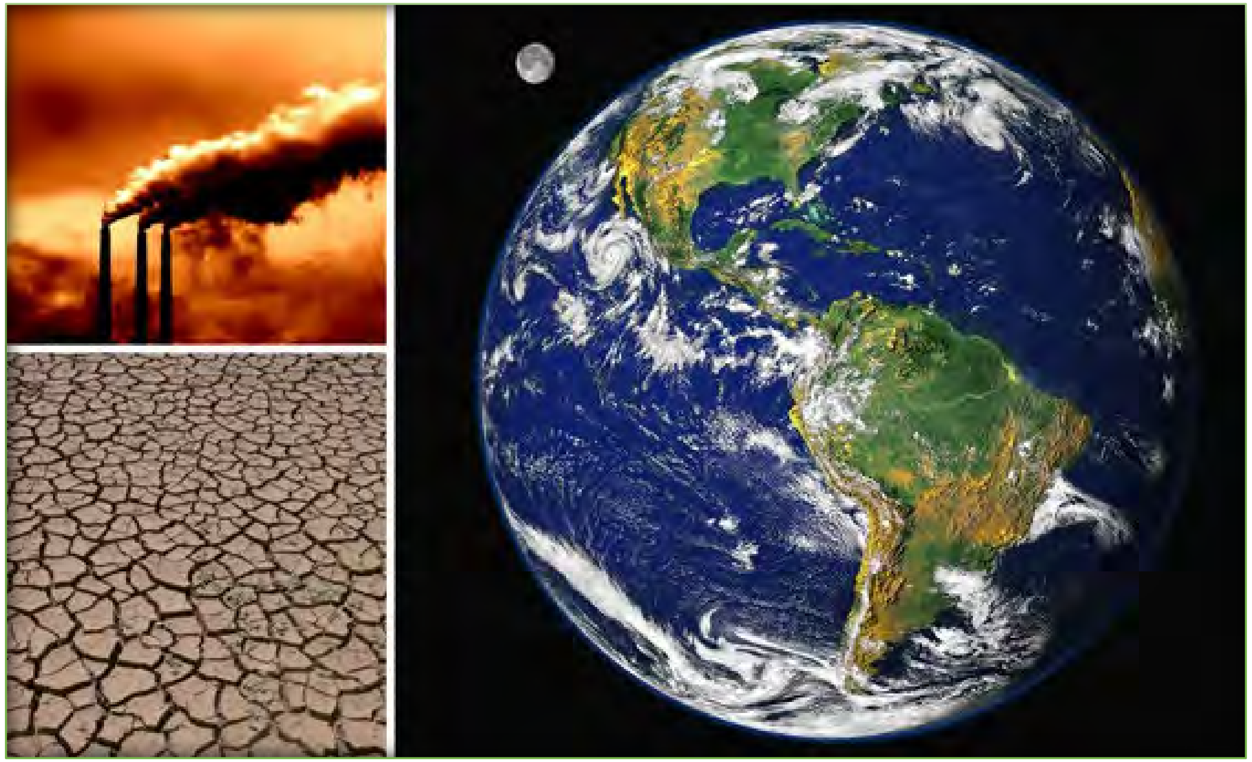
3. A novel One Health research framework can help to generate meaningful evidence and solutions

Global change is altering patterns of vector-borne disease transmission and risk

We're in an era of global change

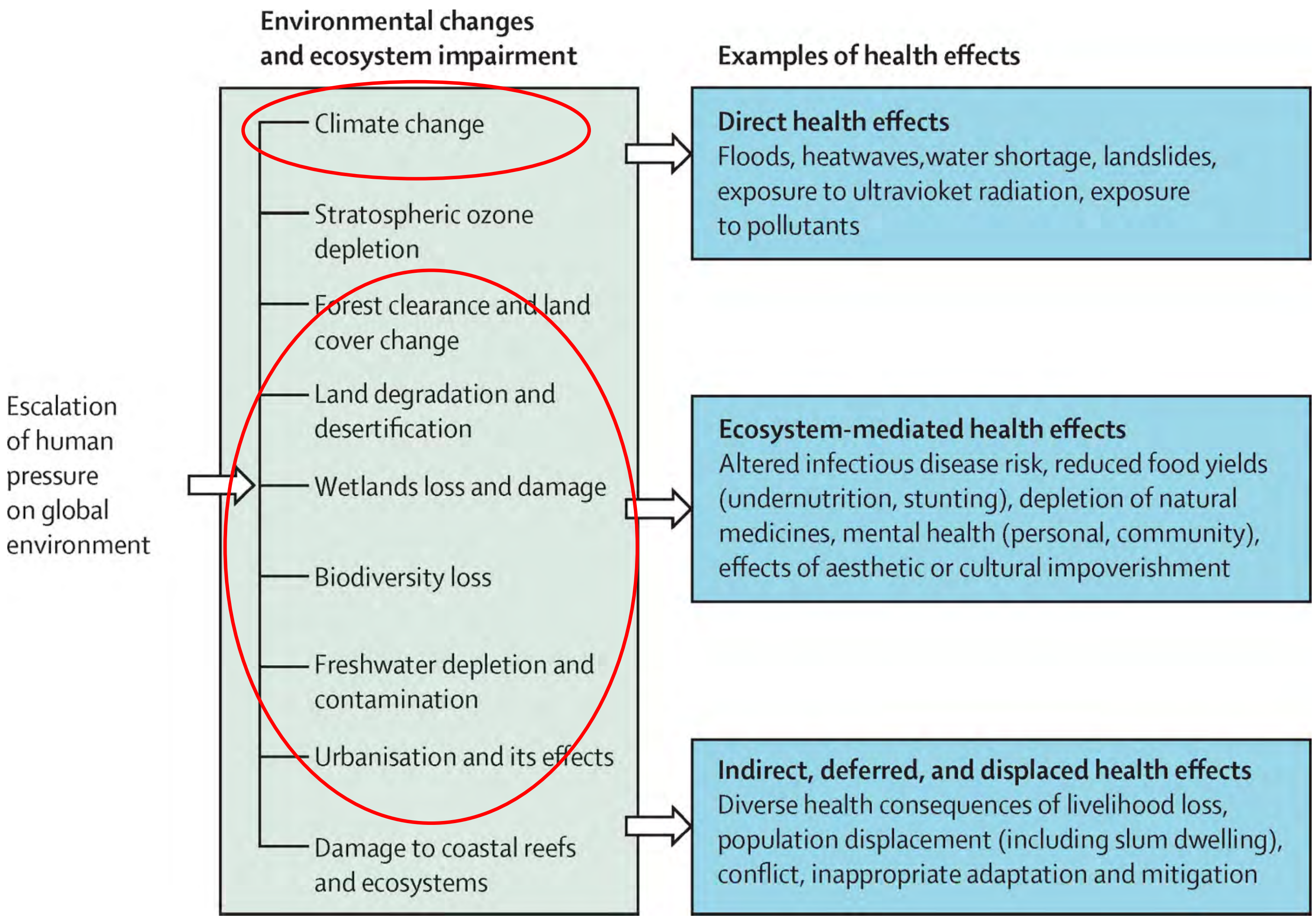
Global change encompasses change in a wide range of global scale phenomena, including climate change:

- Population, the economy, resource use,
- Land use, land cover, and urbanization
- Coastal ecosystems, the physical climate, and marine food chains
- Biological diversity



Steffen et al. 2004

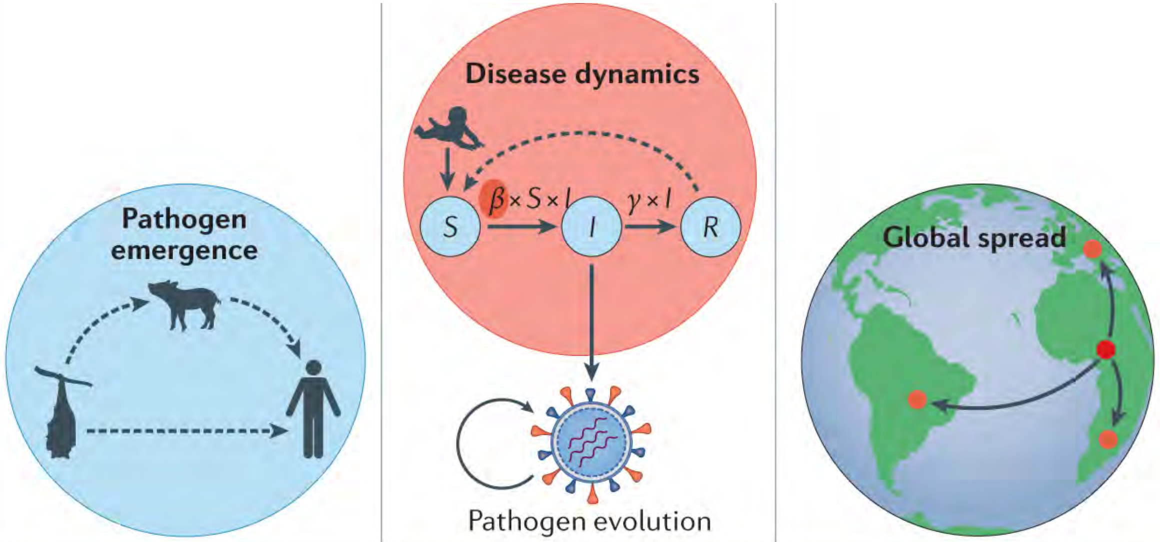
Climate change and other anthropogenic ecosystem disruptions affect human health



Whitmee et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. The Lancet 2015 386, 1973-2028

Climate change interacts with other global changes to affect infectious disease emergence, dynamics and spread

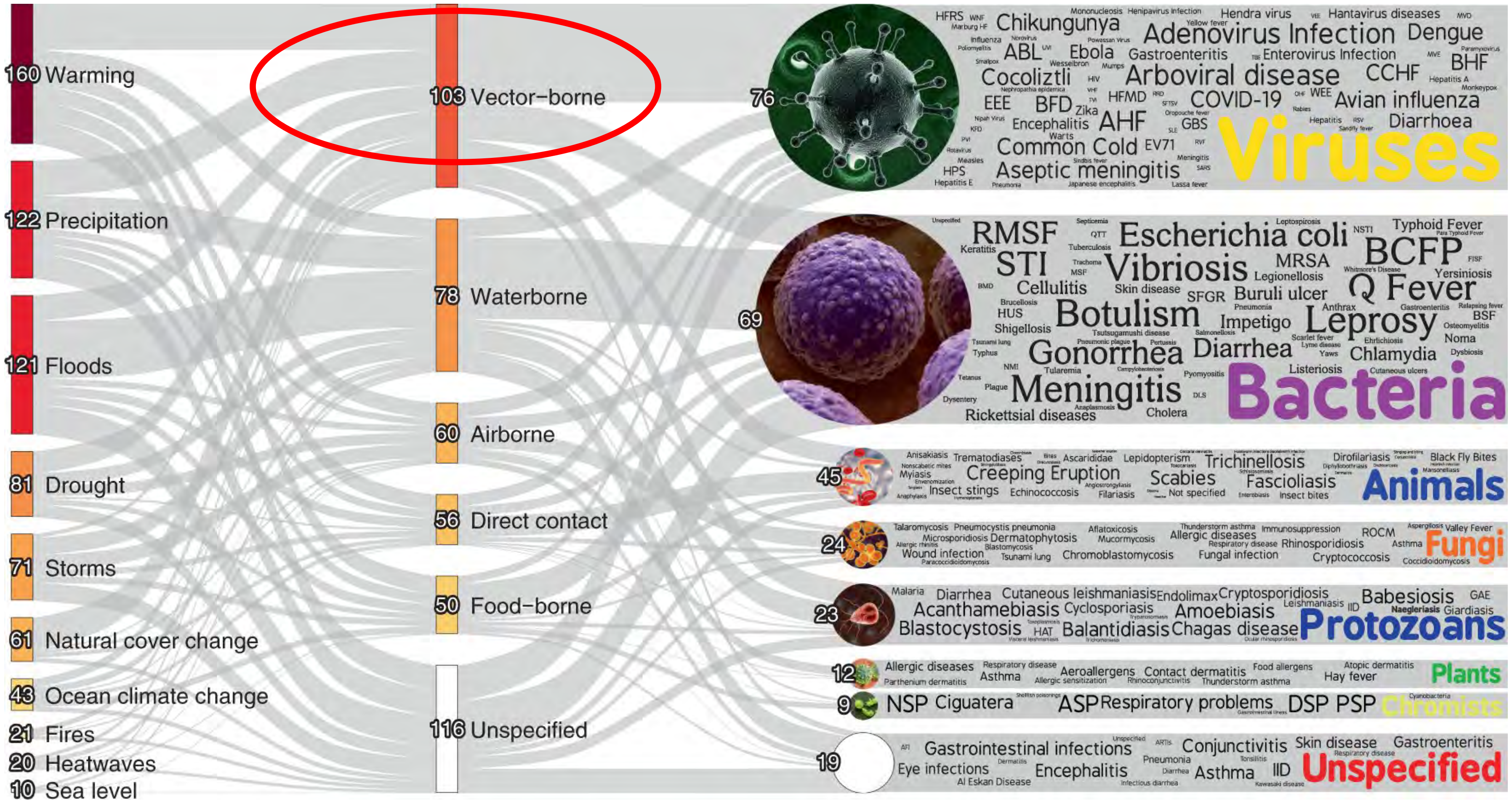
Baker et al Infectious disease in an era of global change. Nature Reviews Microbiology volume 20, pages193–205 (2022).https://www.nature.com/articles/s41579-021-00639-z



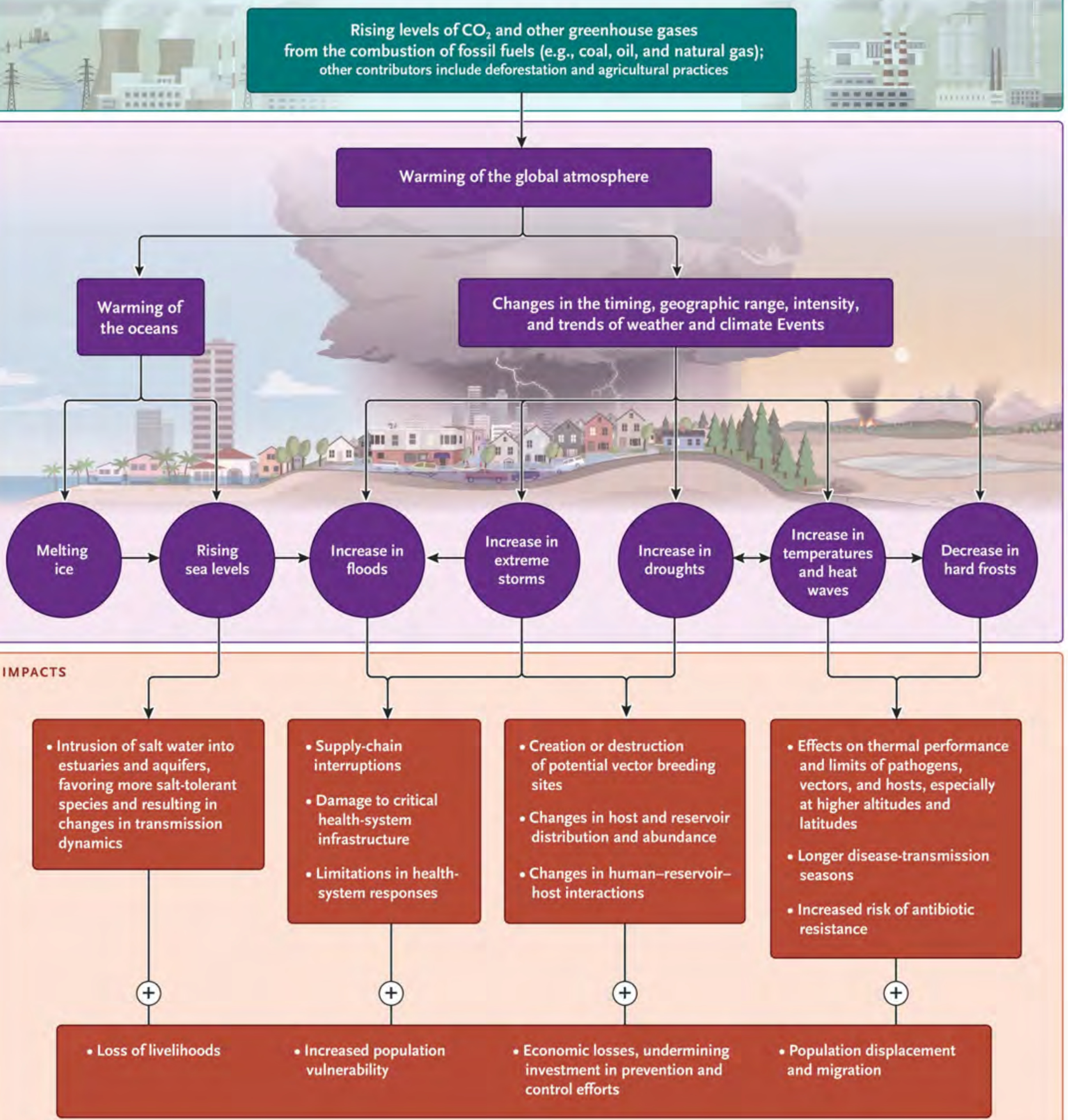
Climatic change	Drives range shifts for reservoir species	Affects transmission and susceptibility	Affects the geographical range of vectors
Technological change			
Transportation	Improved global surveillance		Air transit and high-speed rail affect pace and range of spread
Health care		Vaccination affects dynamics	Improved care reduces burden
Demographic change			
Population growth and land use	Increased contact with reservoir species	Population numbers affect evolution, birth rates affect dynamics	Larger population travelling
Urbanization	Depends on species	Density affects contact rate	Urban population more connected
Ageing	Imunosenescence affects spillover risk	Ageing population increases transmission	Possible larger burden

Over half of known human infectious diseases can be aggravated by climate change

Large number of climate-sensitive diseases are *vector-borne* – impacted by a wide range of climate hazards



Mora et al. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change* **volume 12**, 869–875 (2022)

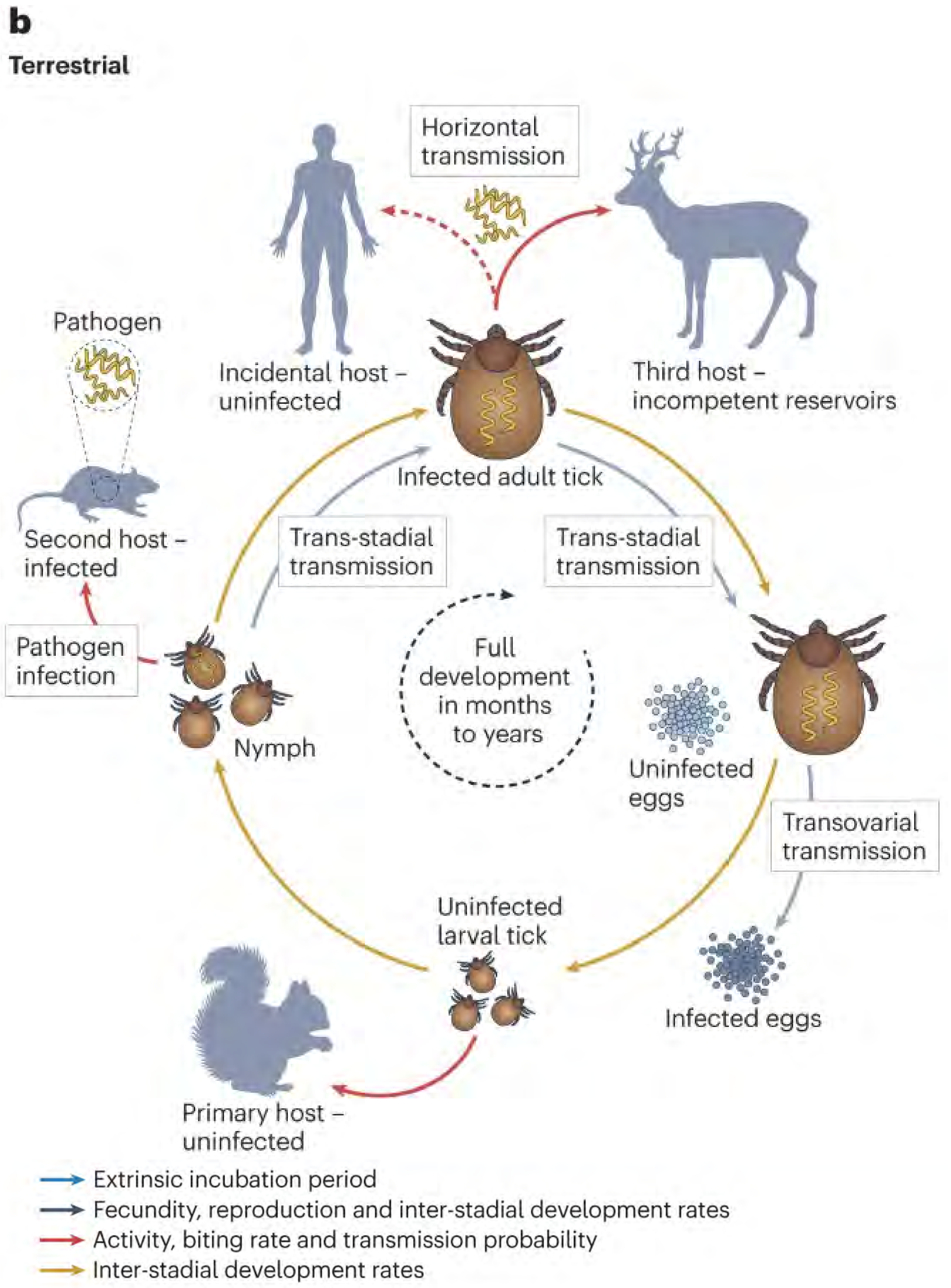


- Rising temperatures, changing precipitation patterns and extreme weather events alter:
  - vector and wildlife reservoir habitat and distributions
  - vector and pathogen survival and development rates
  - length of transmission seasons
  - human-vector contact rates
  - population vulnerability and response efforts

- Environmental dependencies of key vector and pathogen processes make vector-borne diseases highly sensitive to climate and ecological changes

Pathways between Fossil Fuels and Rising Greenhouse Gases and Vector-borne Diseases. Thomson & Stanberry 2022 N Engl J Med 2022;387:1969-1978

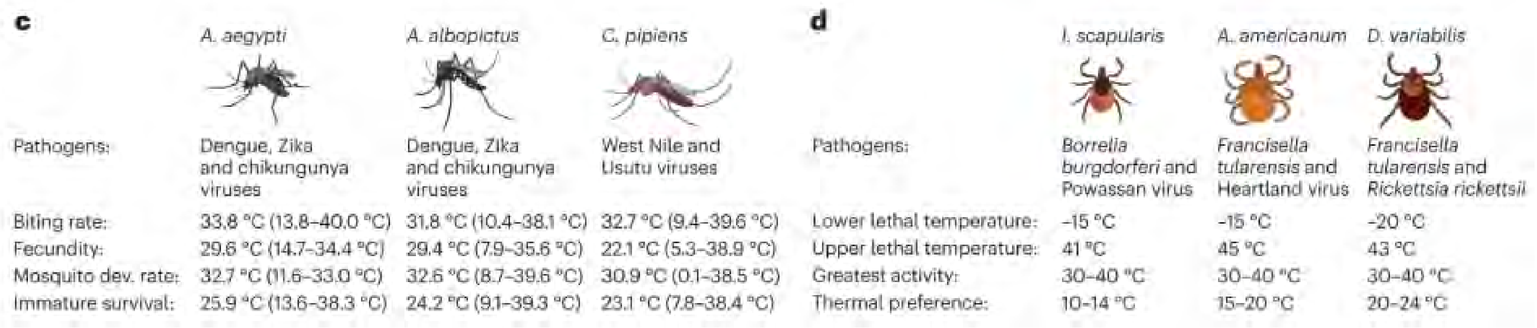
Some vector-borne pathogens have cycles involving multiple wild and domestic animals (enzootic and epizootic cycles), and others such as *Plasmodium falciparum* and dengue virus (DENV) are maintained in a single vertebrate host (human-amplified cycles).



Temperature-dependent processes

Temperature effects on vector life cycle and pathogen transmission routes for arboviral illness and tick-borne diseases

de Souza, W.M., Weaver, S.C. Effects of climate change and human activities on vector-borne diseases. *Nat Rev Microbiol* **22**, 476–491 (2024).



c

	A. aegypti	*A. albopictus*	*C. pipiens*
Pathogens:	Dengue, Zika and chikungunya viruses	Dengue, Zika and chikungunya viruses	West Nile and Usutu viruses
Biting rate:	33.8 °C (13.8–40.0 °C)	31.8 °C (10.4–38.1 °C)	32.7 °C (9.4–39.6 °C)
Fecundity:	29.6 °C (14.7–34.4 °C)	29.4 °C (7.9–35.6 °C)	22.1 °C (5.3–38.9 °C)
Mosquito dev. rate:	32.7 °C (11.6–33.0 °C)	32.6 °C (8.7–39.6 °C)	30.9 °C (0.1–38.5 °C)
Immature survival:	25.9 °C (13.6–38.3 °C)	24.2 °C (9.1–39.3 °C)	23.1 °C (7.8–38.4 °C)

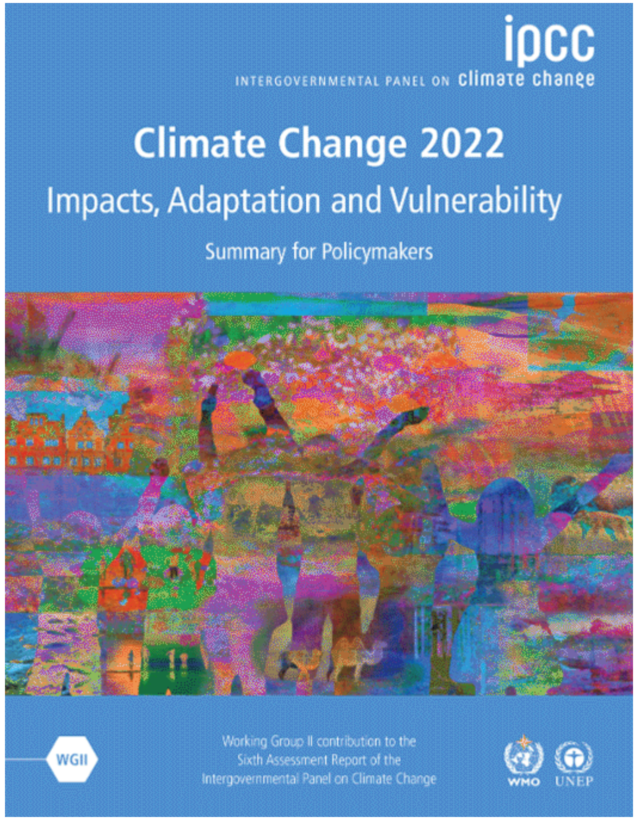
d

	I. scapularis	*A. americanum*	*D. variabilis*
Pathogens:	*Borrelia burgdorferi* and Powassan virus	*Francisella tularensis* and Heartland virus	*Francisella tularensis* and *Rickettsia rickettsii*
Lower lethal temperature:	−15 °C	−15 °C	−20 °C
Upper lethal temperature:	41 °C	45 °C	43 °C
Greatest activity:	30–40 °C	30–40 °C	30–40 °C
Thermal preference:	10–14 °C	15–20 °C	20–24 °C

- Temperature effects on key biological traits of vectors and pathogens are non-linear and differ by species
- New regions are becoming climatically suitable for vectors and pathogens, altering patterns of disease risks, globally and locally
- Vector habitat preferences also differ across species, complicating future predictions of global change effects

de Souza, W.M., Weaver, S.C. Effects of climate change and human activities on vector-borne diseases. *Nat Rev Microbiol* **22**, 476–491 (2024).

Photos: https://www.ifri.org/ (top), https://policyoptions.irpp.org/ (middle), https://africa-health.com/ (bottom)



Intergovernmental Panel on Climate Change AR6. Climate change 2022: Impacts, adaptation and vulnerability. (https://www.ipcc.ch/report/ar6/wg2/).

Climate change and vector-borne diseases

Vectorial capacity has increased for dengue fever, malaria and other mosquito-borne diseases and higher global average temperatures are making wider geographic areas more suitable for transmission (high confidence).

Climate change has contributed to the spread of the Lyme disease vector *Ixodes scapularis*, and a corresponding increase in cases of Lyme disease in North America (high confidence).

Transmission of many vector-borne diseases is expected to further increase during the next 80 years if measures are not taken to adapt and strengthen control strategies

One Health approaches are needed to understand and address increasing risks posed by climate-sensitive diseases

Public health and climate change adaptation strategies to address vector-borne diseases exist...

Risk modelling & early warning systems

predictive models incorporating weather/climate data and vector and/or disease surveillance data

Prioritization

prioritize diseases based on public health importance & risk of (re-)emergence due to climate change

Surveillance

surveillance of vectors and/or sentinel animals

genomic surveillance

Interventions

vector control measures

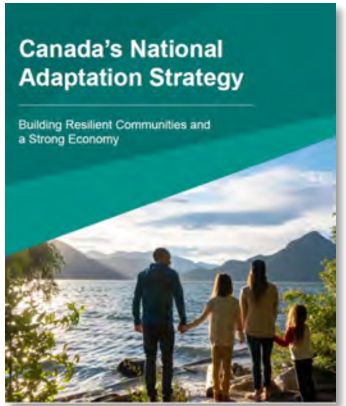
vaccines and therapeutics

personal protection

risk communications

Health of Canadians in a Changing Climate 2022; Thomson & Stanberry 2022 N Engl J Med 2022;387:1969-1978

Public health and climate change adaptation strategies to address vector-borne diseases exist…

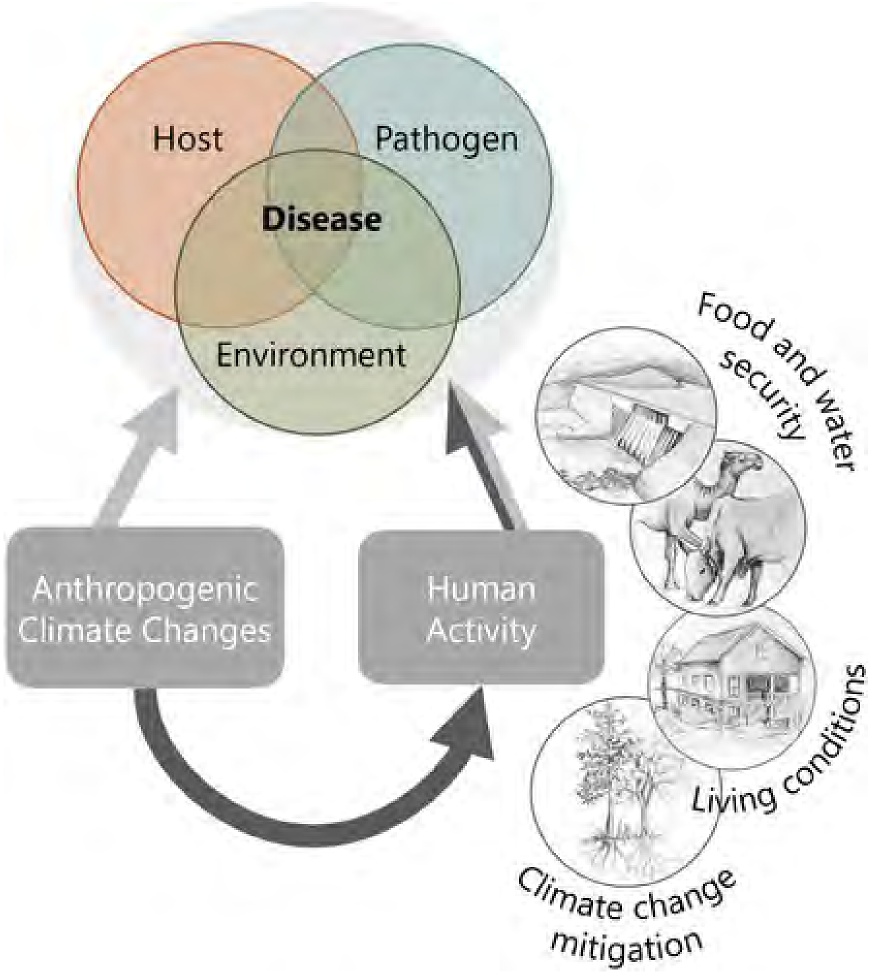


- BUT….adaptation and response efforts are constrained by existing research gaps:
    - limited knowledge of ecology in emerging regions
    - little surveillance data for calibration and validation of predictive models
    - lack of long-term monitoring that is required to attribute changes in disease risk to climate change

- Need for One Health research and One Health approaches to guide risk prediction and public health response

Vector-borne disease risk prediction and public health response must consider….

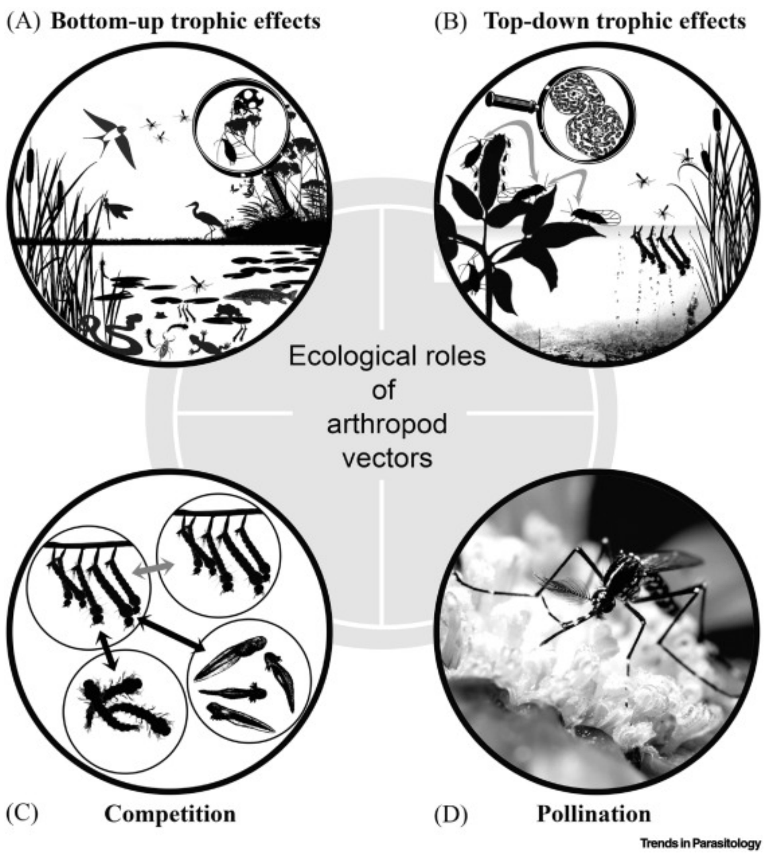
- Direct climate change impacts on host, pathogen and vector
- Indirect climate change impacts via pathways mediated by human actions:
    - climate change mitigation (actions to reduce GHG emissions, e.g. urban greening)
    - climate change adaptation (actions to enhance resilience, e.g. irrigation and water storage)



Titcomb et al. Infectious disease responses to human climate change adaptations. Global Change Biology, Volume: 30, Issue: 8, 2024

Vector-borne disease risk prediction and public health response must consider....

- Ecological importance of arthropods in ecosystems:
  - Foundation of the food web
  - Pollinators
  - Nutrient cycling and water quality
  - Ecological indicators
- One Health approaches needed to balance sometimes conflicting goals in vector management & ecosystem health



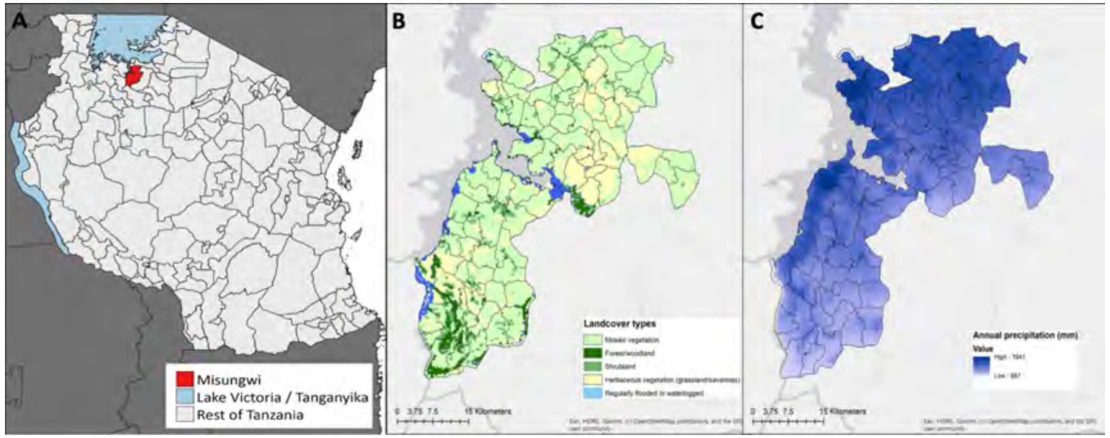
Lefèvre T, et al. The ecological significance of arthropod vectors of plant, animal, and human pathogens. Trends Parasitol. 2022 May;38(5):404-418.

Example 1 – Lake Victoria, Tanzania

- Climate change impacts on seasonal flooding & droughts
  - Food and water insecurity (human & livestock)
  - Wildlife habitat loss and human-wildlife conflict
  - Increased zoonotic disease risks (Rift Valley Fever virus, trypanosomiasis)

- Co-endemicity of malaria and schistosomiasis: 14-38% co-infection in children 5-15 yrs (Duguay et al., 2024)

- Role of temporary ponds as mosquito/snail breeding sites and water supply for livestock and humans

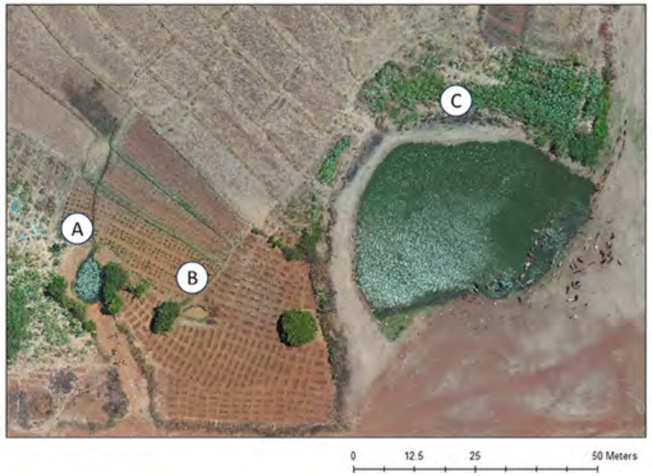


Matowo, N.S., Martin, J., Kulkarni, M.A. et al. (2021) An increasing role of pyrethroid-resistant *Anopheles funestus* in malaria transmission in Lake Zone, Tanzania. Sci Rep 11, 13457

Example 1 – Lake Victoria, Tanzania

- Participatory mapping and community walkthrough to understand water usage and disease exposure risks
- Vector habitat sampling and ecological niche modelling
- Drone mapping of water sources in communities
- Cross-sectional measures of disease exposure and risk factors
- Inform integrated malaria-NTD prevention and control approaches

One Health Research



Duguay et al. (2025) Fine scale mapping of water sources in low-income settings: A comparative study in Misungwi, Tanzania. PLoS ONE 20(3): e0319603; *Photos courtesy of Claudia Duguay (uOttawa)*

Example 2 – Maruwa Hills, South Sudan

- Murle nomadic pastoralists migrate seasonally to cattle camps
- Central importance of livestock for livelihoods, culture, identity and social relations
- Climate change + conflict
  - Altered migration routes/timing
  - Increased livestock diseases, ~30% prevalence of malaria (MSF, 2025)
  - Challenges to implement human/animal health services

Photos courtesy of Natacha Protopopoff (Swiss TPH), and Eliud Lukole (LSHTM)

Example 2 – Maruwa Hills, South Sudan

Examine changes in water resource availability, mobility patterns, and their link to malaria risk

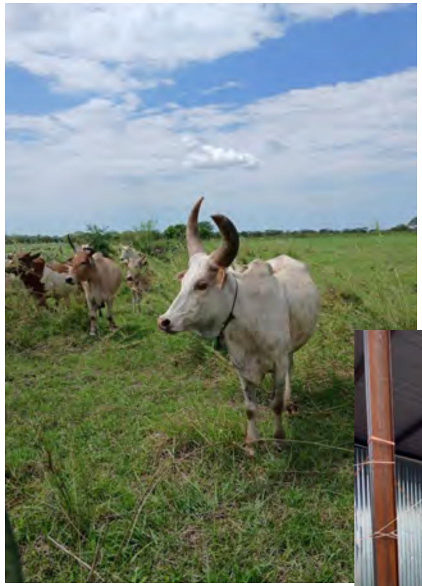
Integration of environment-vector-animal-human data and local knowledge

Engagement with local NGO and community leaders

Mixed-methods observational and implementation research study to evaluate PermaNet® Dumuria for malaria control

One Health research

Inform culturally-tailored approaches to malaria control for hard-to-reach populations



Photos courtesy of Corey Leclair (MSF) and Eliud Lukole (LSHTM)

Example 3 – Ottawa, Canada

- Climate and landscape changes driving northward expansion of blacklegged tick populations and tick-borne diseases
- Urbanization → biodiversity loss & human encroachment into woodland habitats → increased spillover risk
- 5-fold increase in Lyme disease incidence in Ottawa since 2015

Photos courtesy of Roman McKay and Benoit Talbot (uOttawa)

Example 3 – Ottawa, Canada

Mixed methods approach to assess population knowledge, behaviours and perceptions towards disease risk and preventive measures

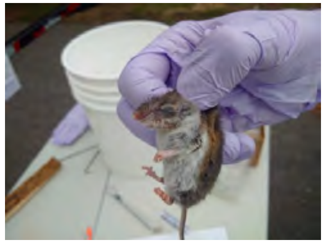
Mapping forest connectivity along landscape gradient

Integration of community and stakeholder perspectives

Characterize tick-borne disease environmental risk in peri-urban settings

One Health research

Inform land management practices, climate change adaptation, and public health strategies to reduce risk



Photos courtesy of Roman McKay and Benoit Talbot (uOttawa)

One Health approaches to address climate-sensitive diseases


PLOS Climate

RESEARCH ARTICLE

Investigating the recommendations and governmental actions to address the emerging risks of vector-borne diseases in Canada's changing climate: A scoping review

Abstract

Recent scoping review:

- Compared recommended strategies to address emerging vector-borne disease risks with actions in ~90 Canadian climate change adaptation plans
- Only 9% of plans explicitly mentioned One Health, with majority at the national level

More One Health strategies needed:

- Integrated surveillance & early warning systems for human & animal diseases
- Integrated vector management approaches that protect ecosystem services
- Integrated distribution of human medicines/interventions during livestock vaccination campaigns
- Insecticide-treated livestock to address residual malaria transmission by exophilic vectors
- Repurposing of veterinary drugs for malaria and dengue control (e.g. isoxazolines)

Schryer R, Norman M, Kulkarni MA (2025) Investigating the recommendations and governmental actions to address the emerging risks of vector-borne diseases in Canada's changing climate: A scoping review. PLOS Clim 4(9): e0000546.

A novel One Health research framework can help to generate meaningful evidence and solutions

A novel framework for One Health research

- Draws on elements from existing One Health and Ecohealth frameworks, OHHLEP **foundational principles**, and practical aspects of transdisciplinary research

- Traces the research process through **four phases** and reflects **five guiding principles**

    - systems thinking,
    - Indigenous and local knowledge,
    - gender and inclusion,
    - stakeholder participation, and
    - optimal ecosystem-animal-plant-human health outcomes.

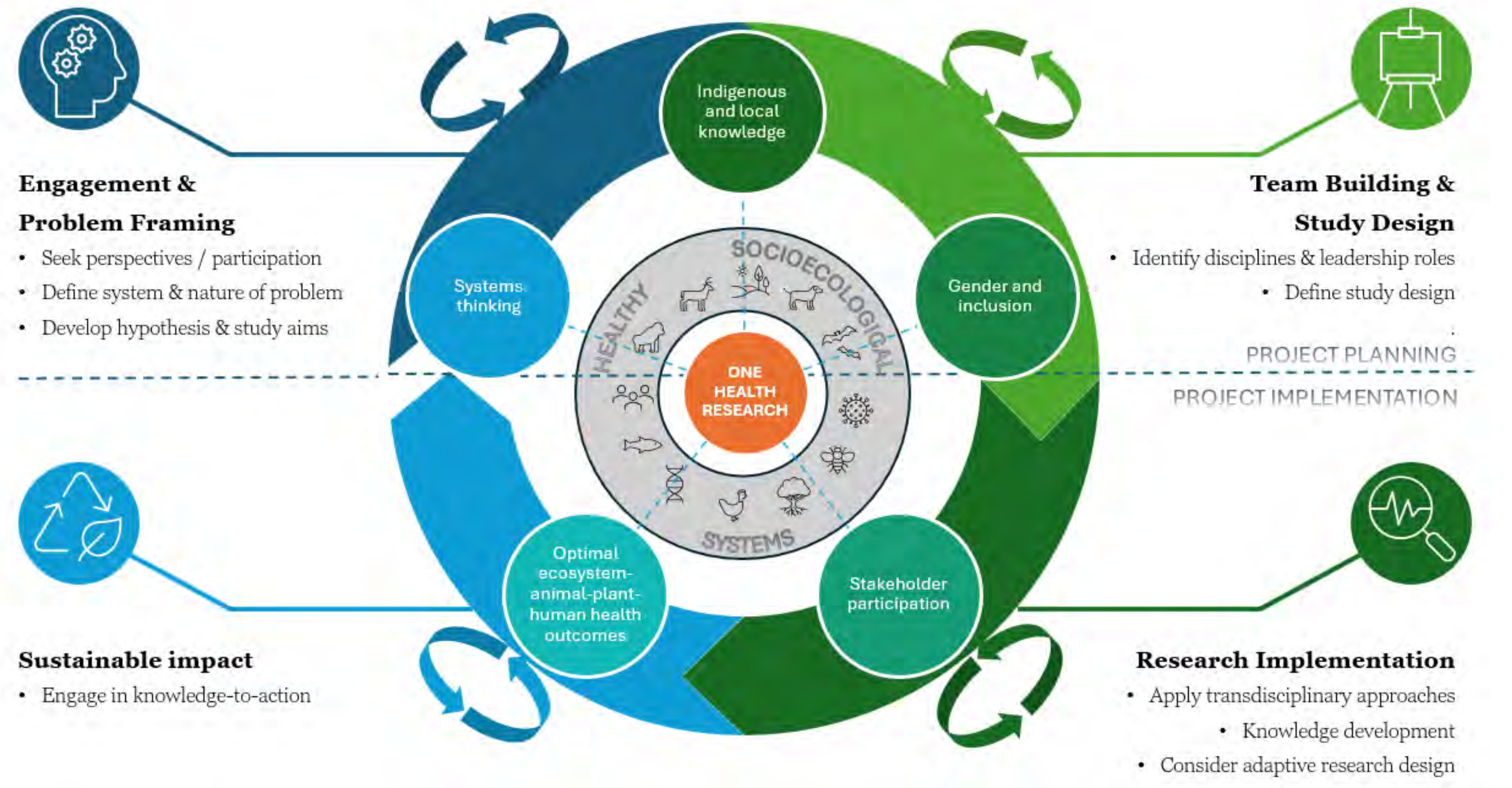


Figure 1. Framework to guide One Health research.

(M. Kulkarni, C. Jardine, H. Carabin, S. Mubareka, M. King, J. Parmley, N. Ogden, D. Charron , under review)

A novel framework for One Health research

- Recognizes the critical roles of **healthy socioecological systems** – comprised of healthy environments, healthy humans, and healthy animals, and their interdependencies – in achieving optimal health for all

- Recognizes that One Health research encompasses approaches from the **natural, social and health sciences** that are applied at **multiple scales**, from molecules and cells to populations and ecosystems

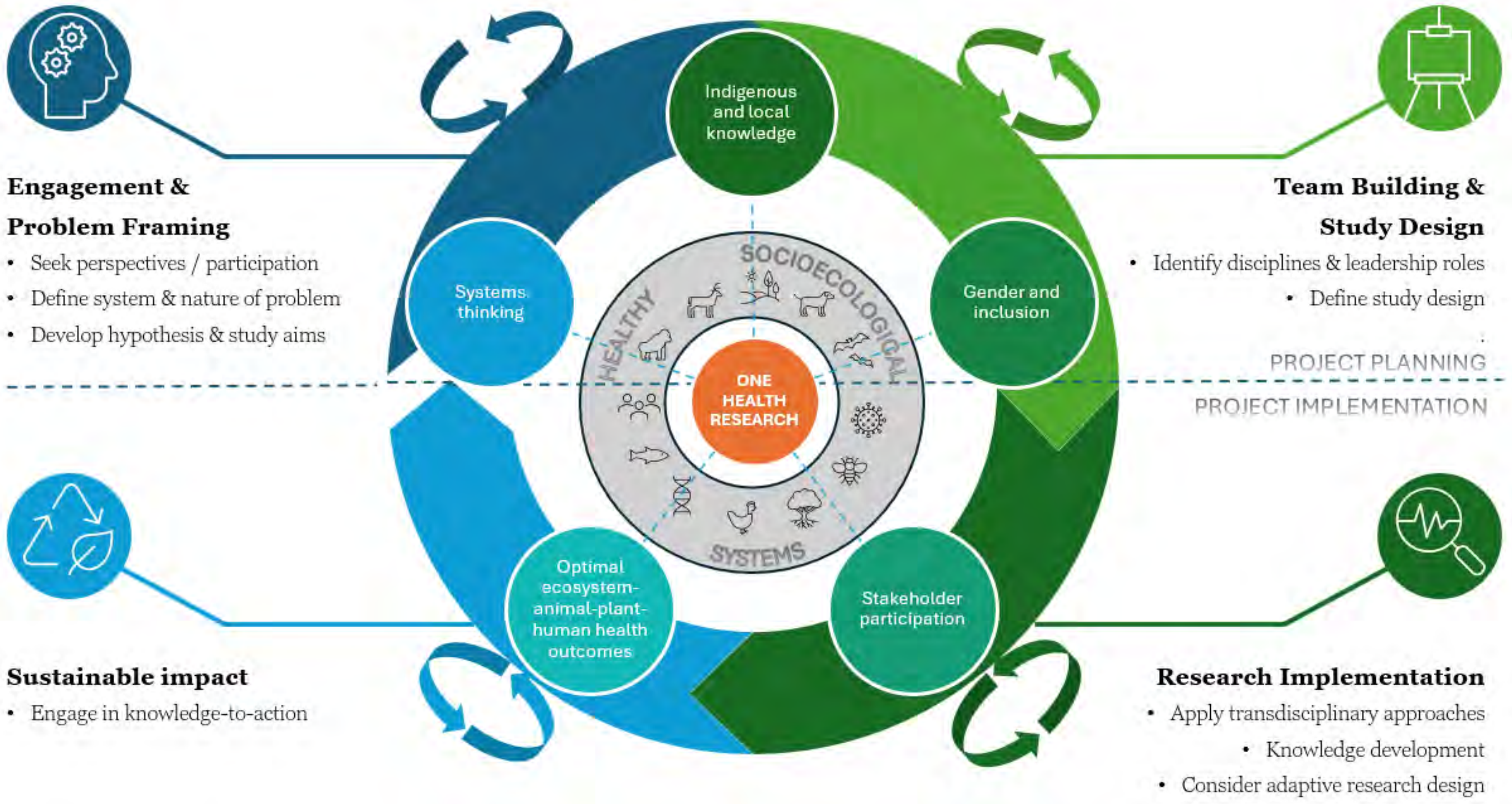
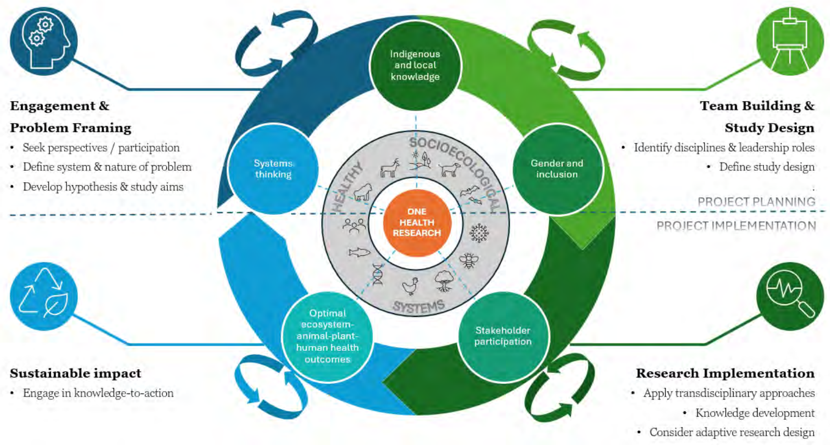


Figure 1. Framework to guide One Health research.

(M. Kulkarni, C. Jardine, H. Carabin, S. Mubareka, M. King, J. Parmley, N. Ogden, D. Charron , under review)

A novel framework for One Health research

- This framework may be applied to **address One Health problems** that include (but are not limited to):
  - the intersecting human, animal, plant and ecosystem health implications of **climate change**, air pollution, biodiversity loss, and environmental contaminants;
  - the complex challenges of **vector-borne and zoonotic disease control**, emerging pathogens, and antimicrobial resistance;
  - more local but not less complex problems such as beach or fishery closures due to local water quality problems.



Key messages

1. Global change is altering patterns of vector-borne disease transmission and risk

2. One Health approaches are needed to understand and address increasing risks posed by climate-sensitive diseases

3. A novel One Health research framework can help to generate meaningful evidence and solutions

Acknowledgements

Pan-African Malaria Vector Research Consortium, Tanzania
- Prof Frank Mosha
- Dr Debora Kajeguka
- Dr Robert Kaaya
- Dr Jacklin Mosha
- Dr Alphaxard Manjurano
- Dr Jackline Martin

London School of Hygiene & Tropical Medicine, UK
- Prof Mark Rowland
- Dr Nancy Matowo
- Dr Eliud Lukole
- Dr Louisa Messenger
- Prof Jackie Cook

Swiss TPH, Switzerland
- Dr Natacha Protopopoff

Medecins Sans Frontieres, Belgium
- Dr Corey Leclair

University of Montreal
- Prof Patrick Leighton

City of Ottawa & Ottawa Public Health
- Dr. Monir Taha
- Ann Stanton-Loucks
- Dr. Nick Stow

National Capital Commission
- Alex Stone
- Isabelle Hughes

University of Ottawa
- Dr Claudia Duguay
- Charles Thickstun
- Katarina Ost
- Dr Roman McKay
- Dr Benoit Talbot
- Dr Andreea Slatculescu
- Dr Jay Logan
- Dr Amber Gigi Hoi
- Michala Norman
- Renee Schryer
- Prof Anders Knudby

INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION

CIHR IRSC

Public Health Agency of Canada

wellcome

GLOBAL 1 HEALTH NETWORK
RÉSEAU 1 SEULE SANTÉ

NSERC CRSNG