Global Aquaculture Challenges

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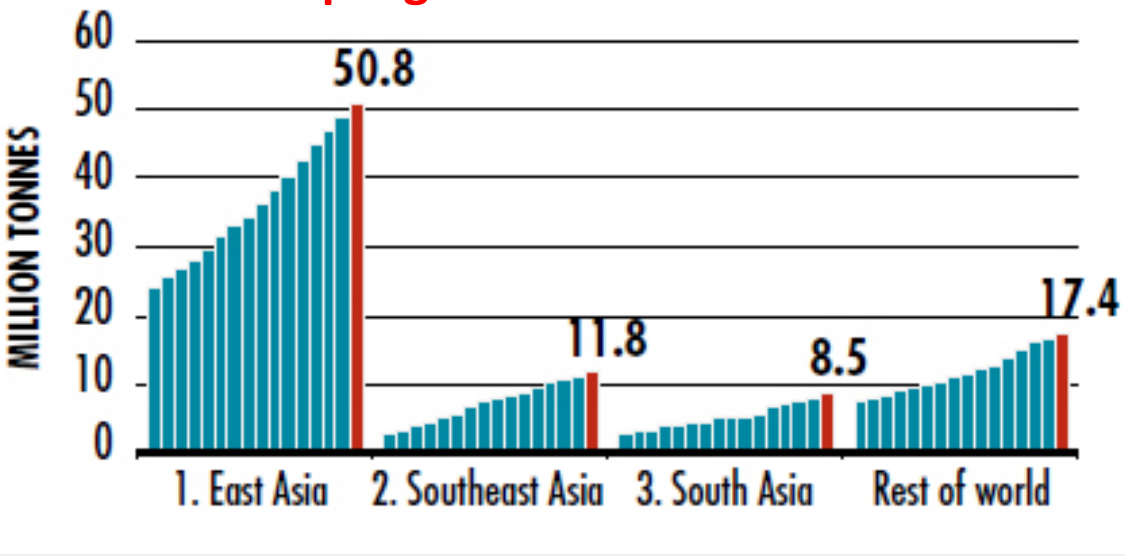
Seafood Production by Region – 2001 to 2016

Rapid growth in much of Asia



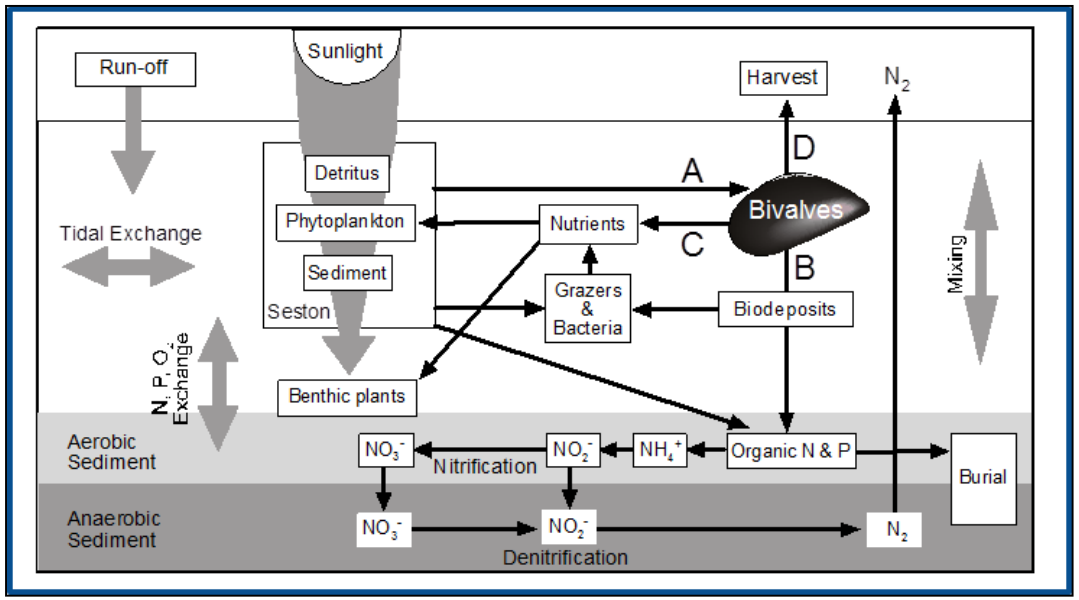
Slow or declining growth in many other regions

Source: FAO (2018)

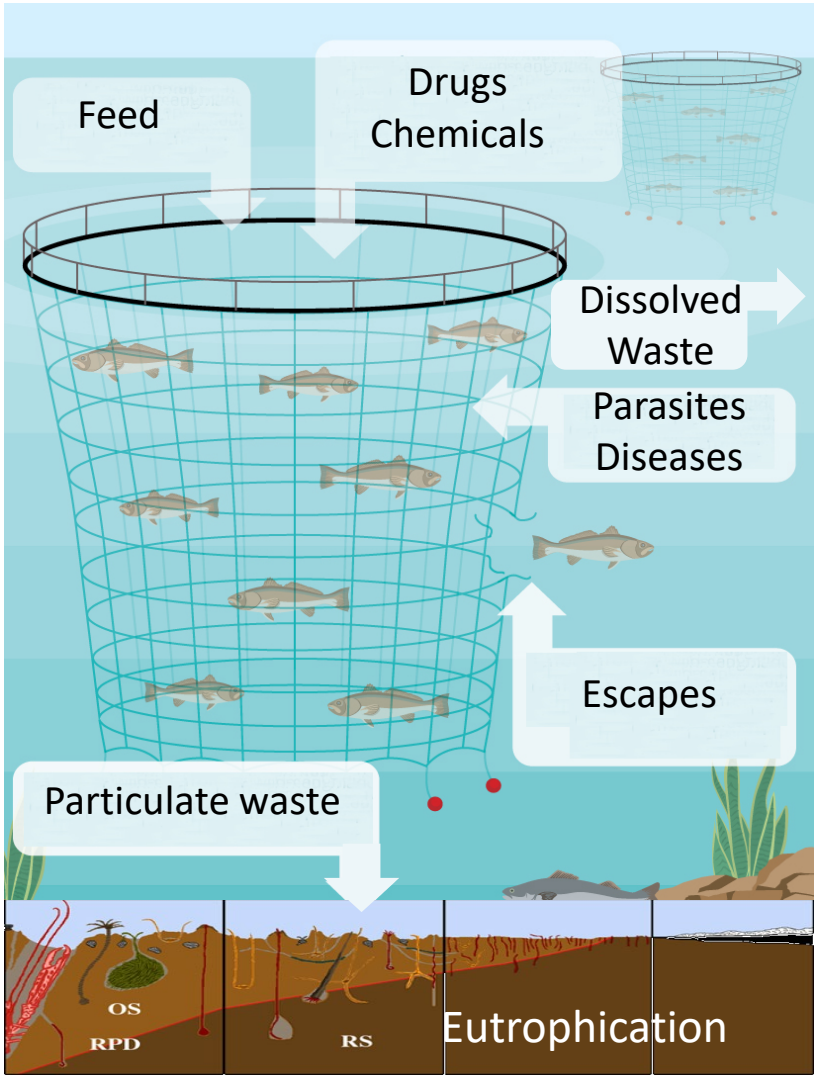
Environmental Sustainability Challenges

Aquaculture effluents / extractions

- Concerns regarding effects on wild fish, biodiversity, ecosystem structure and function.
- Conversion of wastes into a resource (Collection, IMTA, closed containment, …)



A) Depletion B) Biodeposition C) Excretion D) Extraction



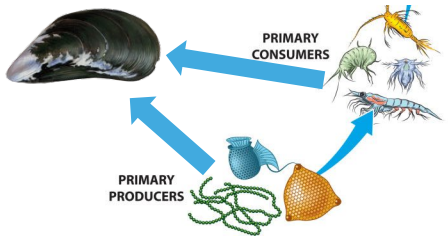
Environmental Sustainability Challenges

Fish Feed Sustainability:

- Most cultured fish production requires high-quality protein and oil-rich feeds sourced from capture fisheries and agriculture crops.
- Fishmeal replacement is required. Novel feeds are being developed that reduce competition with human food resources

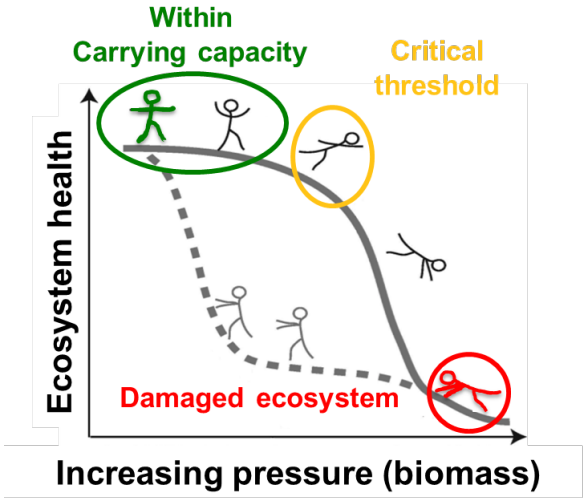
> *"Feed development will ultimately constrain whether any fed aquaculture can expand sustainably in the future"*
> - Troell et al. (2017)

- Low-trophic extractive aquaculture does not require outside source of feed (e.g bivalves and seaweed)
  - Potential marine feed source
  - Ecological services (e.g. mitigate eutrophication)
  - Maximizing the harvest competes with wild species for plankton resources



Environmental Sustainability Challenges

Ecological Carrying Capacity: *The level of culture that can be supported without leading to unacceptable changes to ecological processes, species, populations or communities in the growing environment.*



Identifying Ecological Carrying Capavity:

- Requires science knowledge on the physical environment, aquaculture environment interactions, ecosystem structure and function, and system resilience.
- Requires public input to help define “unacceptable”.
- Consider both environmental impacts and services of aquaculture

Animal Health Management Challenges

Disease: outbreaks of viral, bacterial and eukaryote pathogens

- Major constricting factor for expansion of the industry
- Yield-limiting effects on production estimated at US$6 billion/year
- Frequent emergence of previously unknown pathogens
- Export of live animals facilitates global transfer of pathogens

Disease Mitigation Challenges:

- Development of new therapeutics
- Remove barrier to organic certification
- Global deficit of trained aquaculture species health experts
- Increase biological knowledge on host-pathogen interactions
- Development of broadly resistant lines through selective breeding and genetic technologies
- Reduce the time between disease emergence and mitigation application
- Development of automated disease detection tools

Source: Stentiford et al. (2017)

Animal Health Management Challenges

Parasites as a barrier to production

Sea lice regarded as having the most commercially damaging effect on cultured salmon.

Norway: 3.6 to 16.6% of production lost per growth cycle. US$436 M in damages in 2011.
Chile: Disease outbreaks severe enough to halt industry growth

- Reduced efficacy of key chemotherapeutants in certain farming areas
- Strong negative media publicity:
  - Concern over impacts of treatments on non-target organisms
  - Transmission of sea lice between farmed and wild salmon along their migration routes.

Management challenge is to achieve a balance between the potential environmental and socio-economic risks:

Risk of environmental impacts from increased use of therapeutants
Risk to animal welfare and farm production
Risk to wild fish stocks
Risk to therapeutant efficacy
Risk of public opposition to aquaculture

Interactions between Wild and Captive Fish Stocks

1. Escape of hatchery-reared and genetically modified fish and shellfish;
   - interbreeding alters composition of local gene pools and fitness of wild fish
   - demonstrated as pervasive in several natural populations
2. Increased likelihood of exposure to pathogens, infection, and disease;
   - evidence for elevated levels of sea lice on wild salmonids in several areas
3. Introduction of antibiotics and other pharmaceuticals;
   - the spatial scale and significance of residues in wild species are unknown
4. Release of nutrients and organic matter;
   - localized benthic community effects

Source: ICES (2014)

Marine Harvest Chile reports massive salmon escape

TIMES COLONIST

Comment: The science is in — salmon farms need to be out

Salmar tightens procedures after Ocean Farm 1 escape

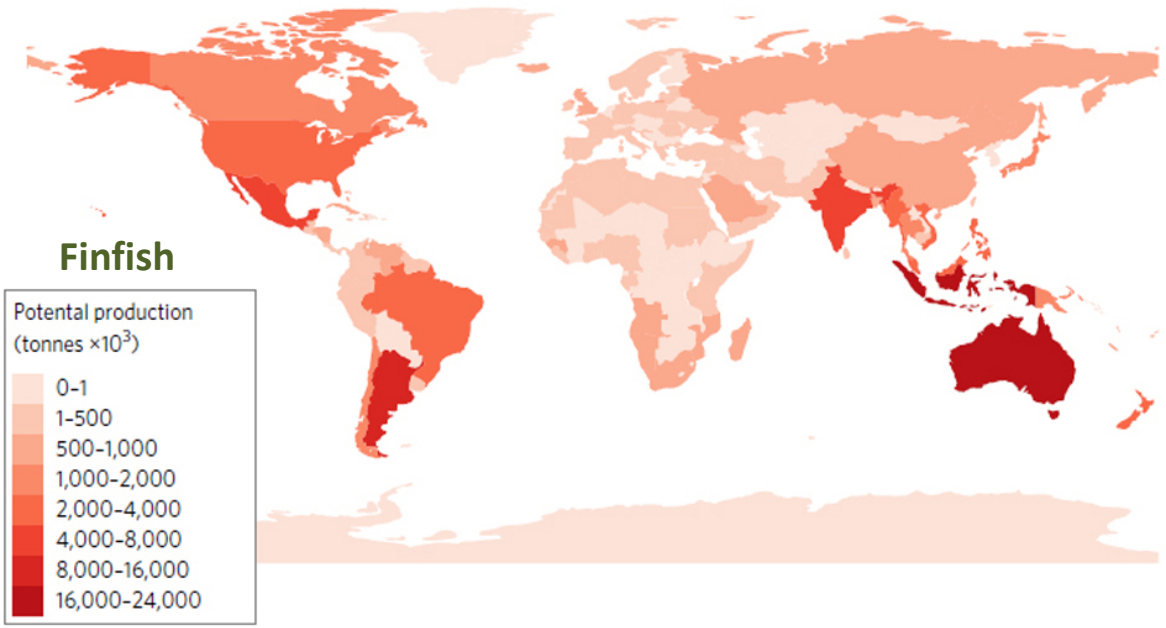
Growth Potential for Global Aquaculture

NATURE ECOLOGY & EVOLUTION ARTICLES

Gentry et al. (2017)

Potential Global Production:

- Suitable areas < 200 m depth
  - Thermal tolerance
  - Regional productivity
  - Oxygen concentration
  - User restrictions
- 11.4 M km^2 for fish
- 1.5 M km^2 for bivalves
- > 100 times current global seafood consumption



"… suitable space is unlikely to limit marine aquaculture development… "

Economic and Innovation Challenges

The future of aquaculture is in the open-oceans

Bremerhaven Declaration (2012):

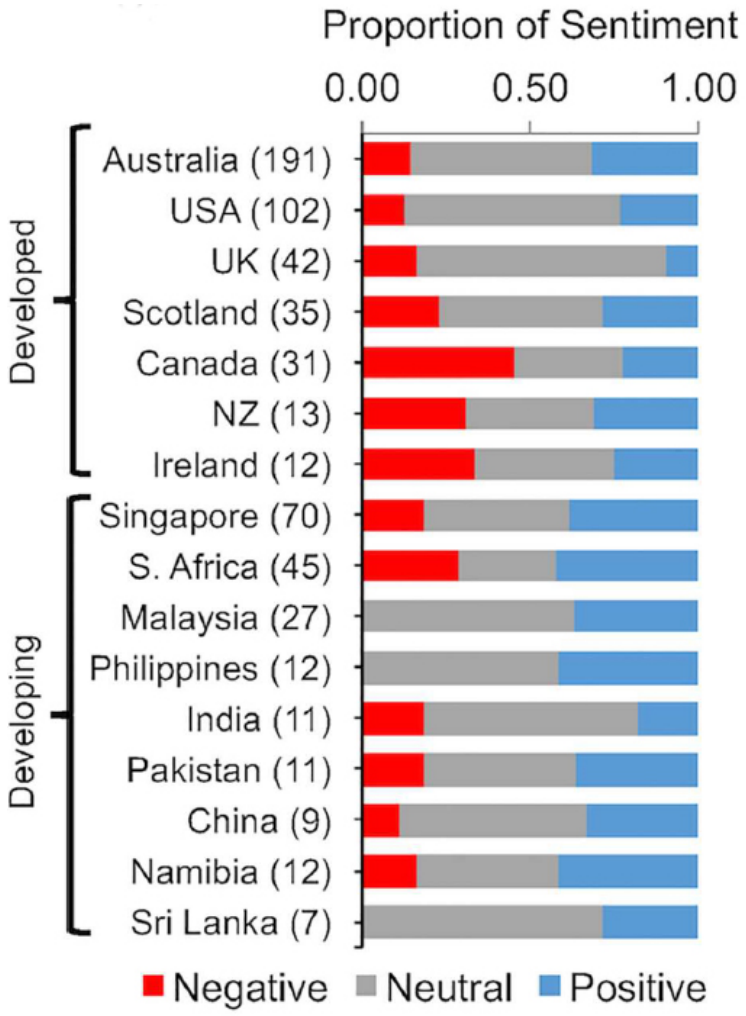
- Conventional coastal aquaculture will continue to grow but will not close the widening gap in seafood supply and demand.
- Modern technologies for offshore farming systems are required to significantly assist in closing this gap.

Capital and operating costs, and investment risks expected to be high for offshore aquaculture.

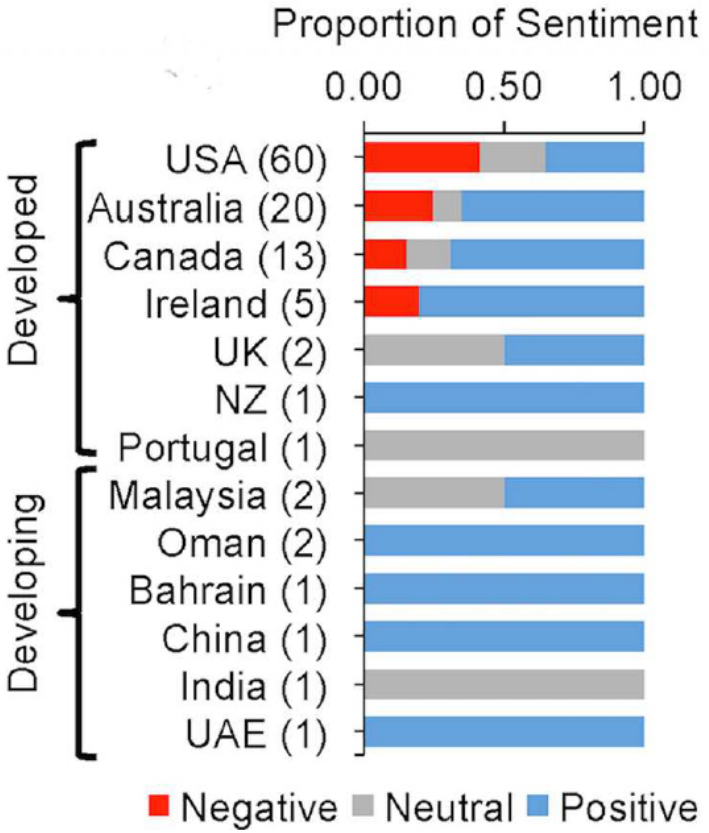
- Environment dictates need for sophisticated operations
- Advances in cage technologies needed to survive physical conditions and prevent escapes
- Intensification with high-value species needed to maximize profit
- Similar ecological and husbandry challenges as in coast
- Requires high level of cooperation from investors, government, NGOs, regulators, scientists and consumers

Public perceptions based on newspaper headlines

"Marine Aquaculture"



"Offshore Aquaculture"



Source: Froehlich et al. (2017)

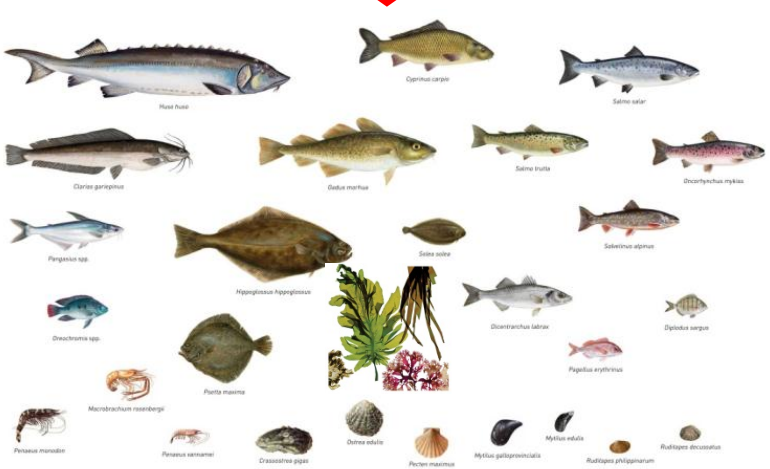
Challenges to Global Marine Aquaculture: Summary

Environment/Ecology

Wastes Disease Parasites Escapes Climate Water quality Sustainability Carrying capacity Suitability

Society

Culture Food preference Diet/health Conflicting use
Biosecurity Perceptions/Acceptability Politics/Governance



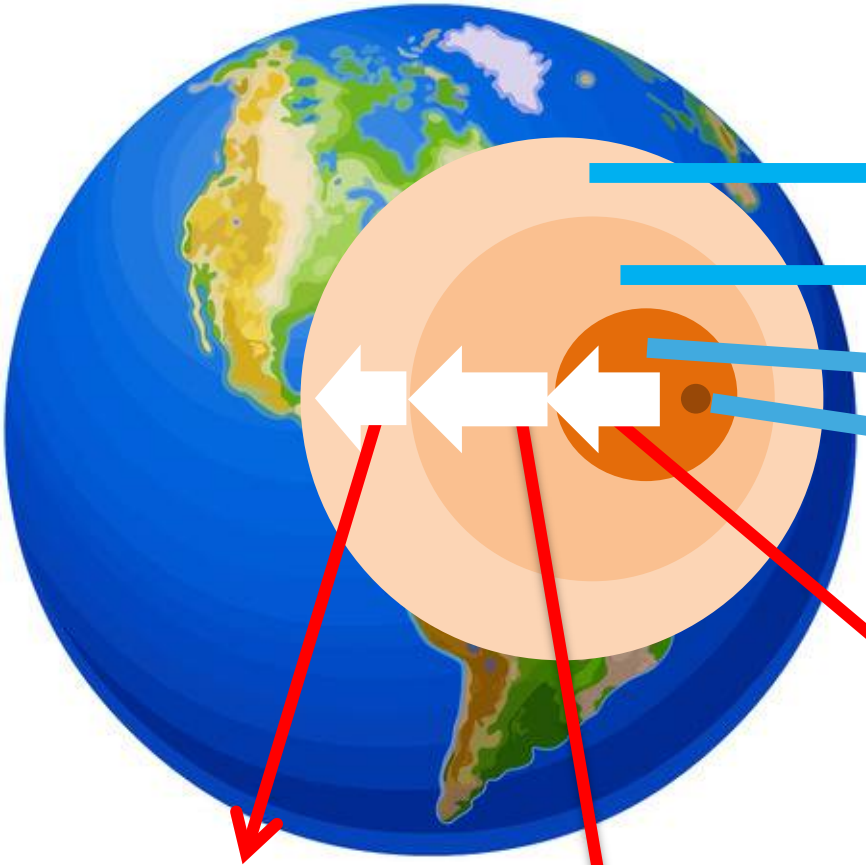
Economics

Jobs Profit Supply/Demand Market availability Cost Infrastructure Productivity Competition Uncertainty

Innovation

Engineering Biology /Genetics Feeds Treatments
Modelling Monitoring Technology transfer Investment

The Global Aquaculture Footprint Challenge



Physical CC (Suitable)

Production CC (Profitable)

Ecological CC (Sustainable)

Social CC (Agreeable)

Knowledge transfer; Transparency;
Stakeholder cooperation;
Integrated management

Innovation & Investment

Ecosystem Interactions; Best Practices;
Recycling; Experimental farms

Messages Towards Conference Action Points

Knowledge gaps:

The continued development of sustainable aquaculture is a global food security priority that requires the best available scientific knowledge. Research gaps include:

- alternative feeds to reduce dependence on capture fisheries for protein & oil
- an understanding of disease susceptibility, new diseases and prevention
- innovative approaches to reduce dependence on chemo-therapeutants
- far-field effects including interactions between multiple stressors
- indicators of social and ecological carrying capacity and decision thresholds

A "new" approach:

Academic and government research at industry farms limits the potential for addressing aquaculture challenges. A network of industry-scale experimental farms would permit controlled manipulative studies using novel approaches.

Knowledge transfer:

"Wealthy countries with a history of social conscience, in a rapidly expanding and globally-connected world, have a responsibility to develop and transfer relevant knowledge and sustainable food production practices to less developed regions." (Shawn Robinson, personal communication)