The role of strain development and improvement in tilapia aquaculture

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aquaculture provides nearly half of all food fish

mostly freshwater species farmed in Asia

many countries still demand continued growth

key constraints are lack of feed, seed and capacity

fish breeding has been a major issue

<10% is from genetically improved strains

enormous opportunity for improved strains

Genetic improvement approaches in fish

Several approaches to genetic improvement feasible with fish

hybridization
cross-breeding

chromosome manipulation

transgenesis

selective breeding

only approach where gains are cumulative and permanent

Several approaches to genetic improvement feasible with fish

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cross-breeding

chromosome manipulation

transgenesis

selective breeding

multiple selection approaches with varying complexity

Several approaches to genetic improvement feasible with fish

genomic selection (?)

"combined" selection

within-family selection

cohort selection

individual (mass) selection

increasing complexity

selective breeding

multiple selection approaches with varying complexity

Application in fish lags far behind livestock or crops

…but we are making progress

genomic selection (?)

"combined" selection

within-family selection

cohort selection

individual (mass) selection

increasing complexity

selective breeding

multiple selection approaches with varying complexity

Tilapia genetic improvement : a brief history

Background – problem identification

- WorldFish (ICLARM) and partners' research on Tilapias, which began in late 1970s, indicated that:
  - **inadequate seed supply** and
  - **deteriorating performance** in many systems were a major bottleneck

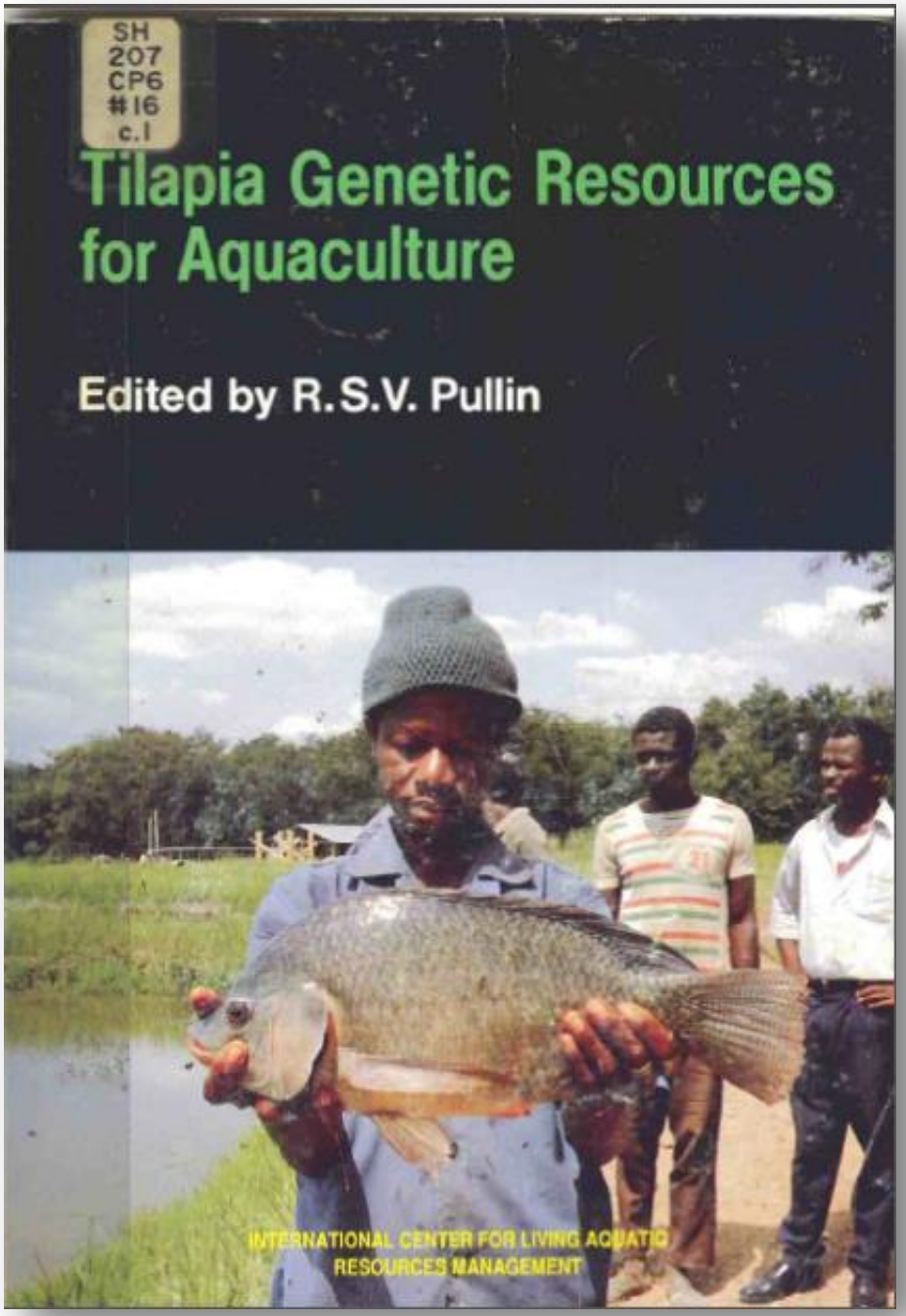
- In Africa, production was in its infancy, wild stocks of native tilapias were under threat
  - habitat degradation
  - uncontrolled fish transfers
  - over-exploitation

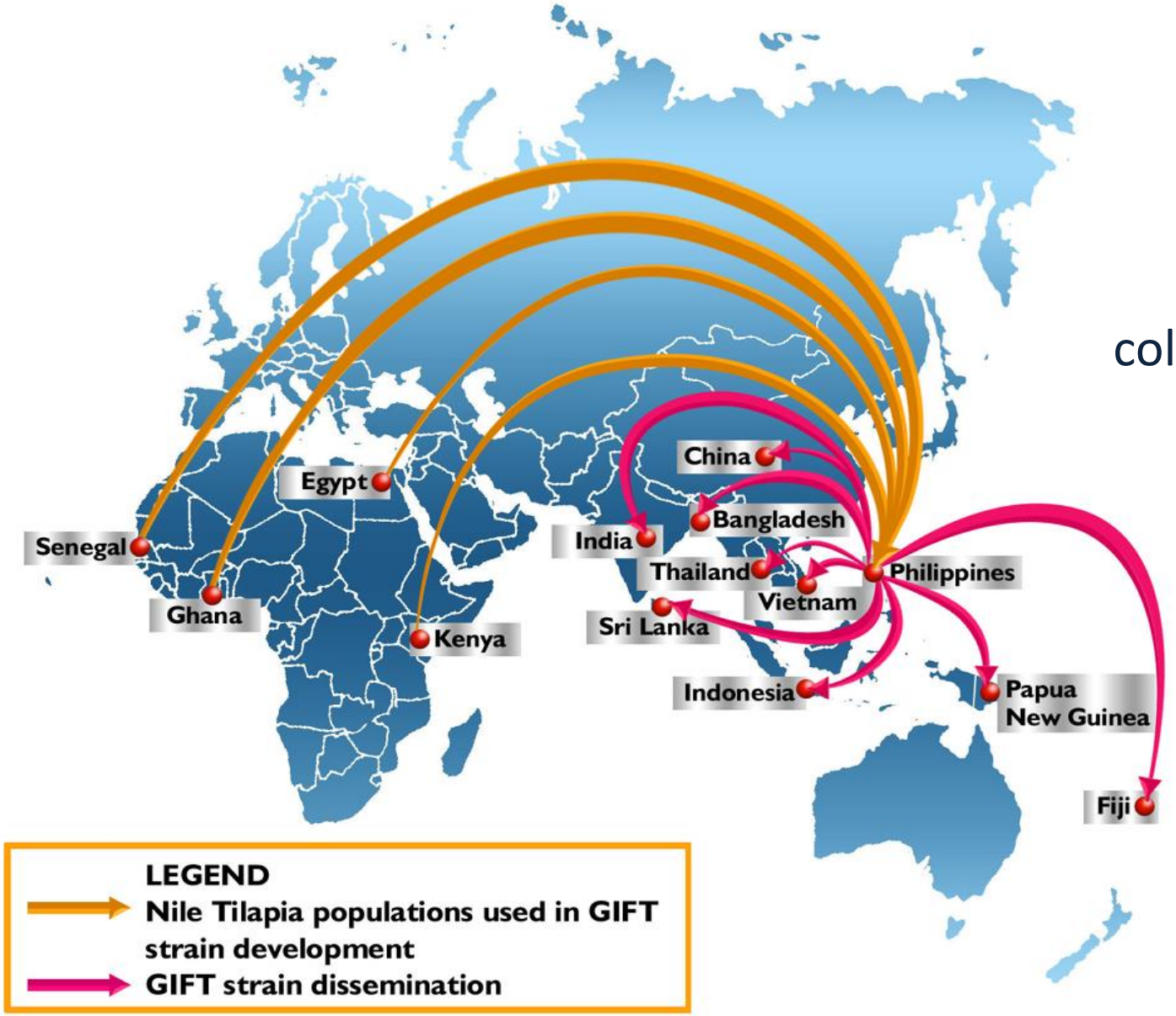
In response…

1983-87 WorldFish (ICLARM) brought together **partners from Asia and Africa**, experts to review the status of Tilapia genetic resources

Outcome to undertake a **major research project on genetic improvement** of tropical finfish

Genetic Improvement of Farmed Tilapia (**GIFT**) project





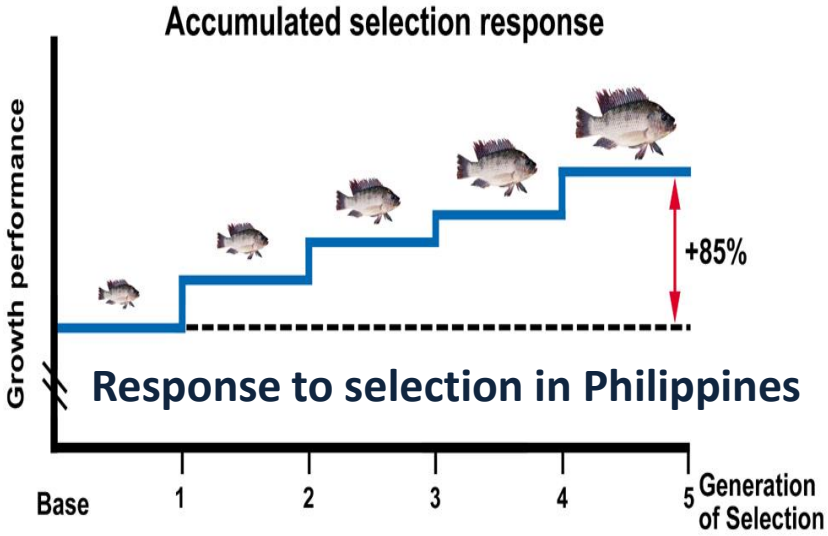
Project years (1988-1998)

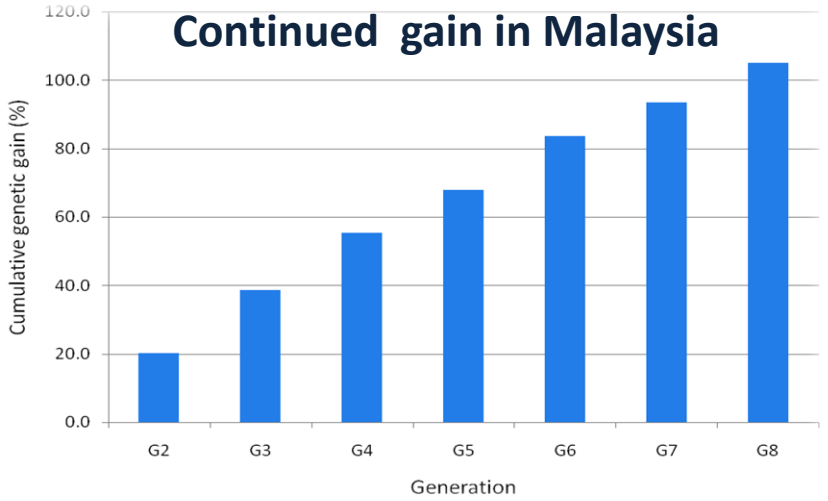
germplasm collected from Asia and Africa

partnership with AKVAFORSK

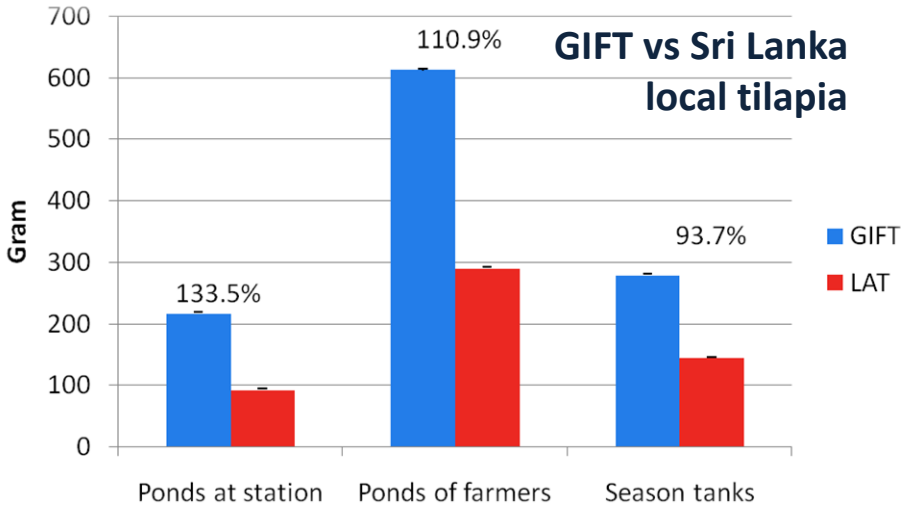
index-based selective breeding

Eknath & Hulata (2009), Reviews in Aquaculture, 1: 197–213.
Gupta & Acosta (2004), NAGA, 27(3-4):4-14
Ponzoni et al. (2010), GIFT: The Story Since Leaving ICLARM, FNI Report 14/2010, 47pp

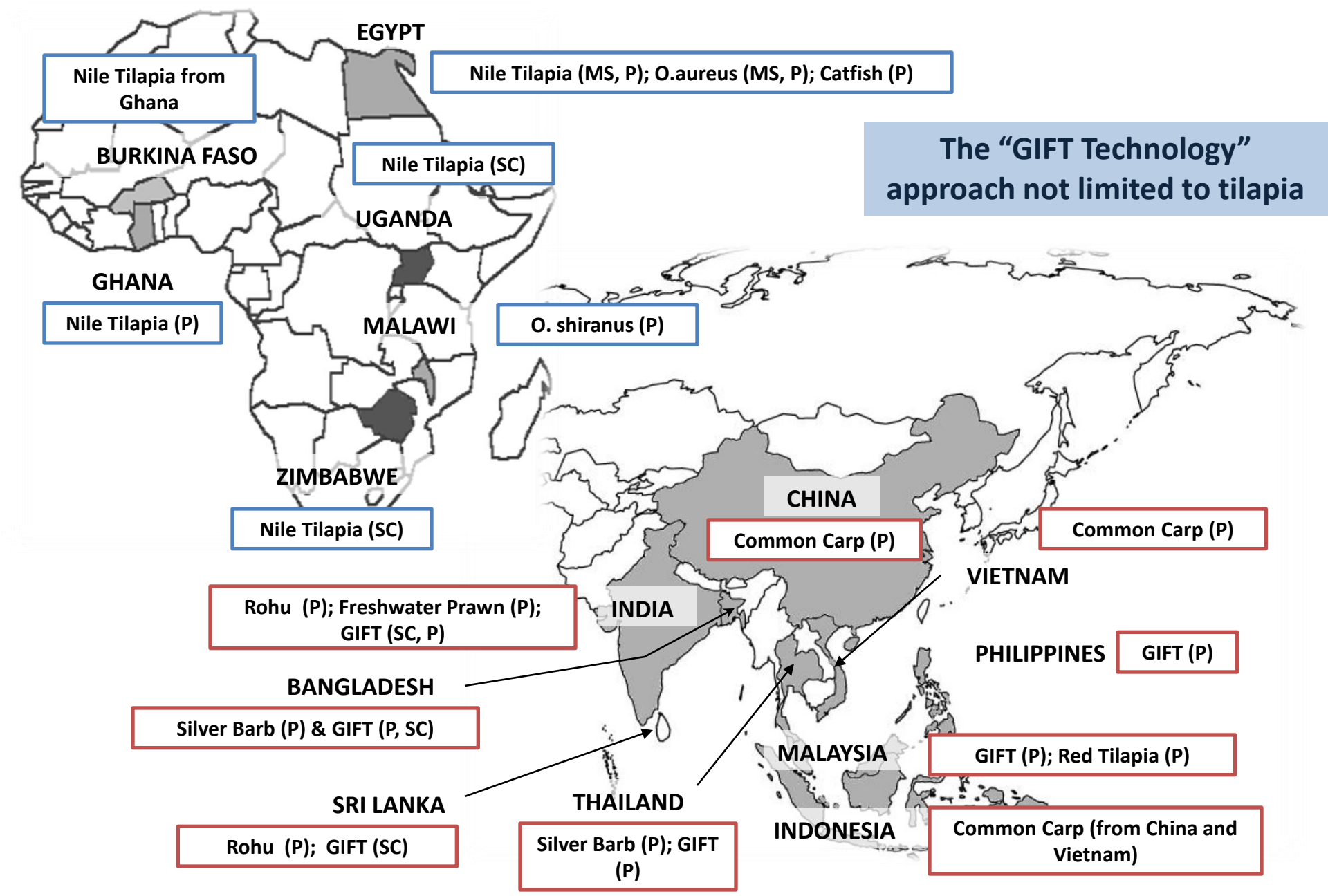




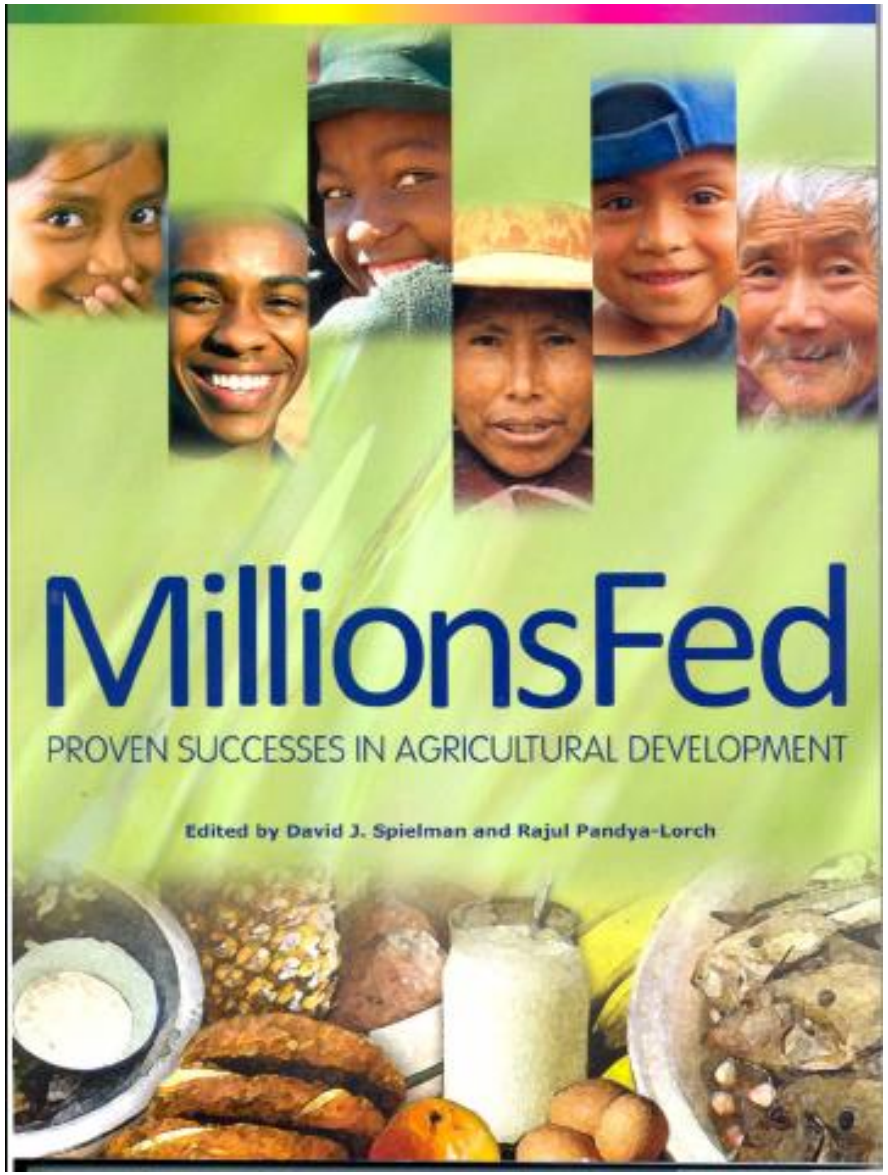
Superiority of improved strains



"GIFT Technology" - Egypt


The "GIFT Technology" approach not limited to tilapia
EGYPT
Nile Tilapia from Ghana
Nile Tilapia (MS, P); O.aureus (MS, P); Catfish (P)
BURKINA FASO
Nile Tilapia (SC)
UGANDA
GHANA
Nile Tilapia (P)
MALAWI
O. shiranus (P)
ZIMBABWE
Nile Tilapia (SC)
CHINA
Common Carp (P)
Common Carp (P)
VIETNAM
Rohu (P); Freshwater Prawn (P); GIFT (SC, P)
INDIA
PHILIPPINES
GIFT (P)
BANGLADESH
Silver Barb (P) & GIFT (P, SC)
MALAYSIA
GIFT (P); Red Tilapia (P)
SRI LANKA
Rohu (P); GIFT (SC)
THAILAND
Silver Barb (P); GIFT (P)
INDONESIA
Common Carp (from China and Vietnam)

Economic and development impacts of improved tilapia strains



GIFT was a proven success

GIFT was featured as a proven success in “Millions Fed”

Sent to 16 countries from WorldFish (more requests in)

Grows 50 to 80% faster, high survival

Significant impact in Bangladesh, Thailand, China, Philippines (ADB, 2006)

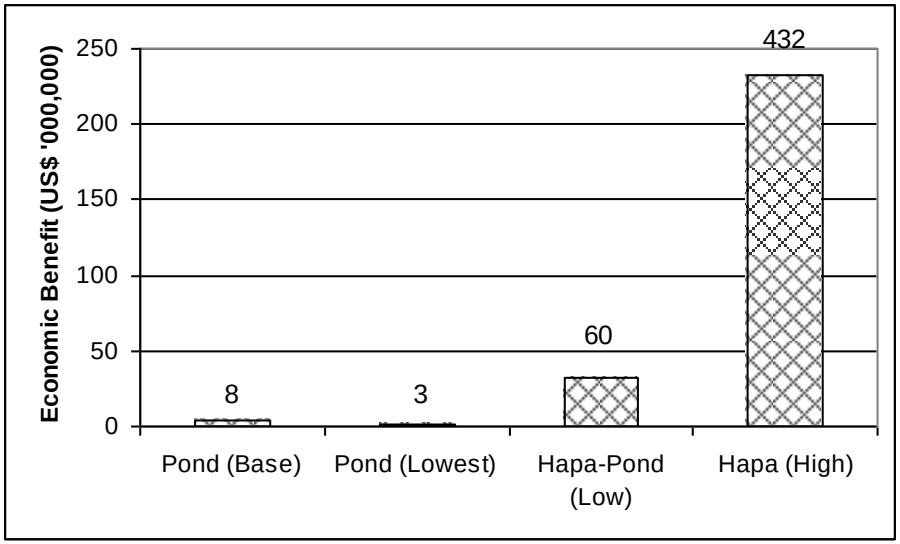
Philippines, 70% of market

GIFT-Technology extends reach beyond tilapias

Cost / Benefit of breeding programs can be large

Study by Ponzoni et al. (2007) *Aquaculture*, 267, 188-199

Assumption of breeding program	Sensitivity
Initial investment	Very low
Annual cost	Very low
Year at 1st return	Moderate
Heritabilities	Moderate
Fish price	High
Feed cost	Moderate
Dissemination	Very high



Dissemination is a critical factor

Improved strain introduction in Ghana could increase GDP by 1%, just from productivity increases (Ansah et al. *Sustainability* **2014**, *6*, 3697-3721)

"indirect" benefits breeding programs

recall the issues pre-GIFT…

rapid inbreeding, poor productivity

low effective population size (*Ne*)

difficult to maintain pedigree

high reproductive rate
(a good thing too!)

→ large populations from a few breeders

breeding programs help industry-wide

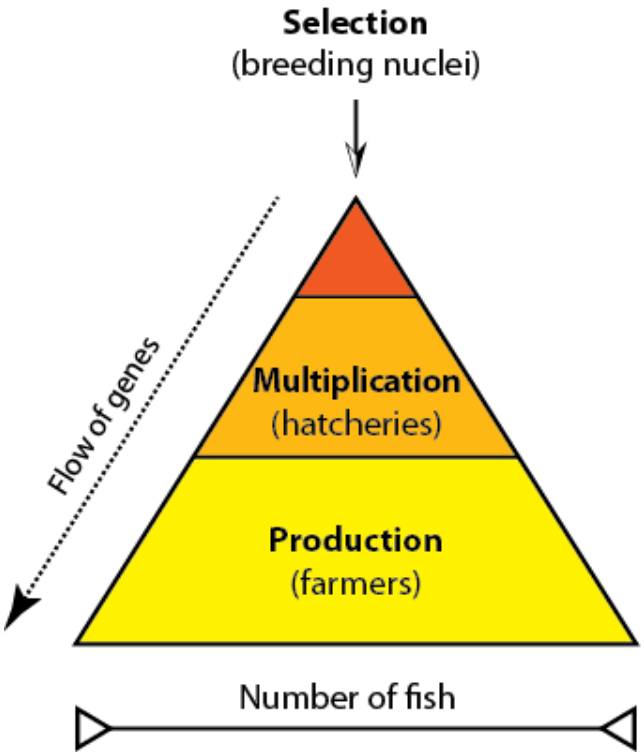
"indirect" benefits breeding programs

inbreeding can be managed through proper hatchery practices and training

...and a developed industry structure

generally not present

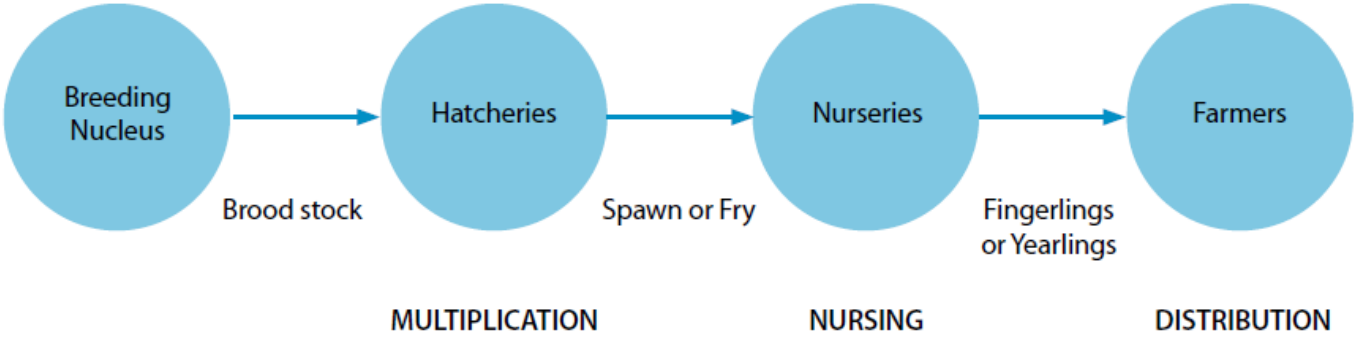
production level diversity not critical if maintained in nucleus

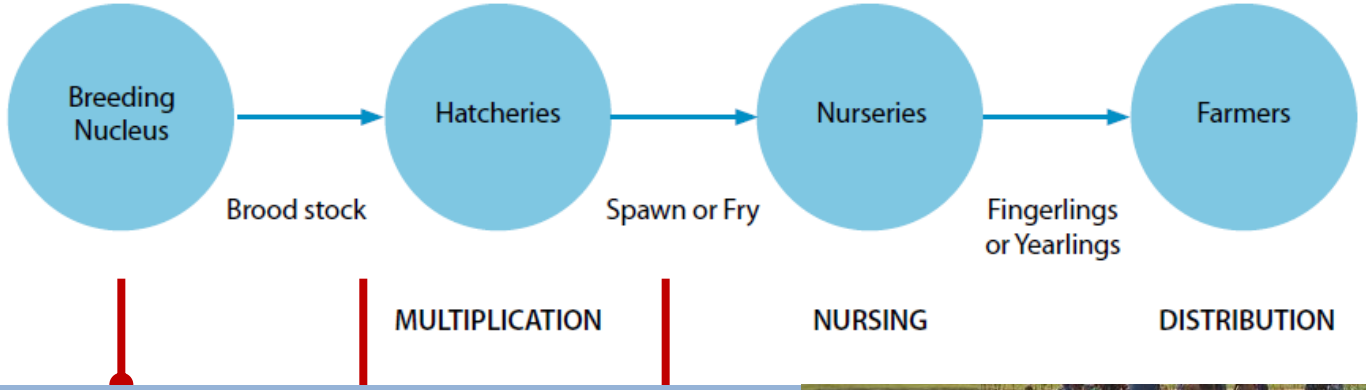


this basic structure necessitates a lot of
other basic improvements for the industry

improved management practices (e.g. feeding), greater opportunity for participation along value chain

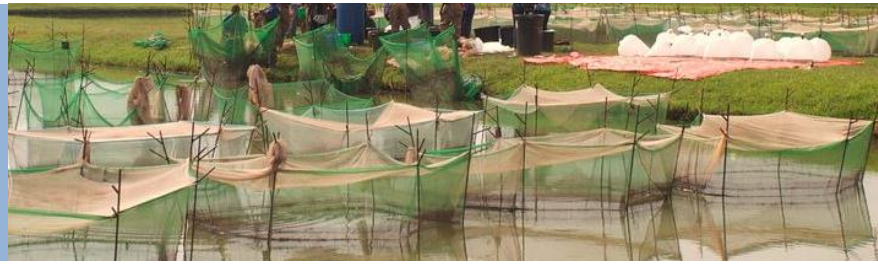
the situation will **almost certainly vary** from region to region; technically and socio-economically


Breeding Nucleus
Brood stock
Hatcheries
Spawn or Fry
Nurseries
Fingerlings or Yearlings
Farmers
MULTIPLICATION
NURSING
DISTRIBUTION



Technical issues:

- Inbreeding management
- Terms of accreditation
- Training and capacity
- and more…

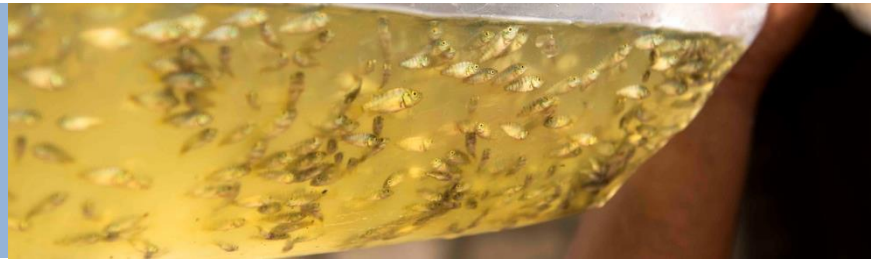


Social issues:

- Participation and role of women
- Access to extension and training
- Decision making roles
- and more…

Economic issues:

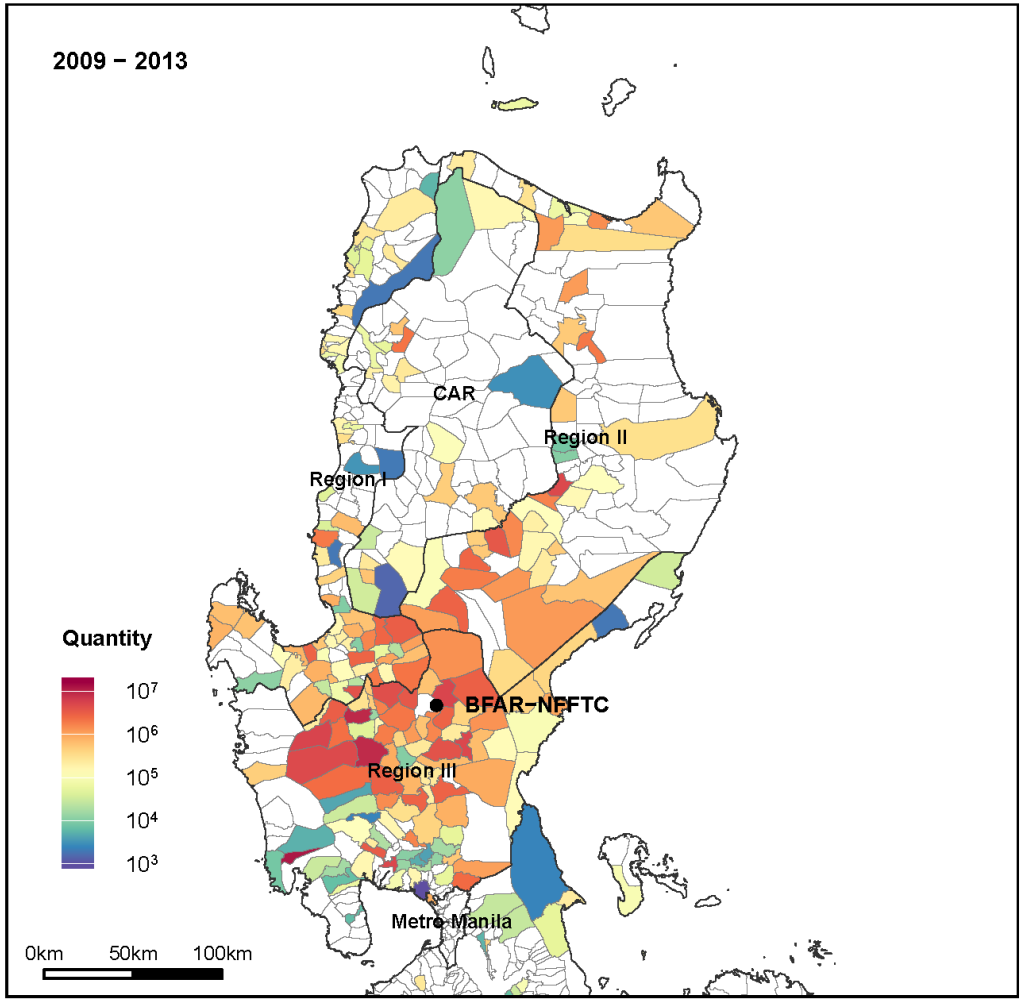
- Business models for the nucleus
- Marketing improved seed
- Access to finance
- and more…



Tools for monitoring

Well managed dissemination strategies can also provide excellent opportunities for monitoring and evaluation

In Philippines, BFAR hatchery registration practices require certain data to be recorded and reported



Both private and government hatcheries should be considered in effective dissemination strategy

Private:

- established production areas
- attractive investment opportunities

Government:

- areas insufficiently served by private hatcheries
- areas where lack of competition may result in abuse of market
- stimulate industry in regions with future production potential
- eventually role taken over by private sector

Institutional arrangements and partnerships

GIFT project provided valuable lessons regarding Public-Private partnerships

GIFT Foundation International Inc. was created in 1998

- continue research
- market the strain
- dissemination

Was unable to be financially self-sufficient, entered agreement with private company in 1999 (GenoMar)

- successful in increasing production (200 million fingerlings by 2001)
- focus shifted towards profitability (e.g. target larger operations)
- rights of strain use and info restricted
- relationship ended in 2005

Institutional arrangements and partnerships

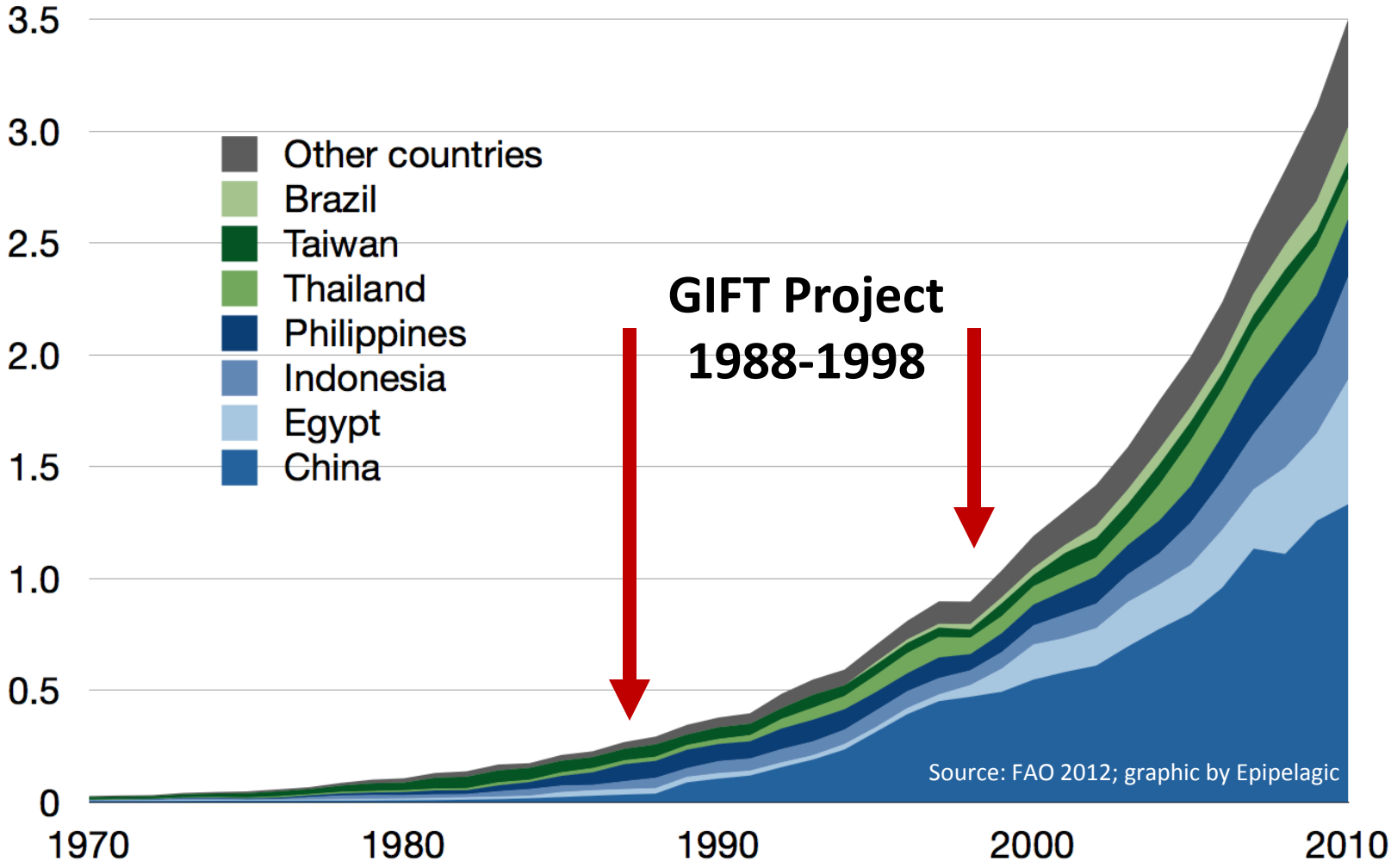
Concluding remarks

- Strain development in tilapias has had large success in creating highly productive strains
- GIFT project instrumental in this process
  - Developing methodologies
  - GIFT dissemination
  - Focus on poor or small farmers
  - Showing the way
  - Tilapia genetic research

Concluding remarks

- Structured sector able to deliver improved genetic material can benefit industry in other ways
- Developing efficient dissemination pathways are critical to achieving impact
- Public-Private relationships will play an important role in this
- All together will result in a more sustainable sector and continued production increases

Production of farmed tilapia by country
(million tonnes)



Thank you

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