The Role of Productivity, Technical Change and Farmer's Efficiency in the Dynamic Growth of the Tilapia Industry

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Outline of Presentation

- Brief Industry Profile
- Genetic Improvements in Tilapia Strains
- Estimation of TFP using
  - Tornqvist Index approach
  - Parametric approach
- Identification of sources of output growth
- Some policy directions to boost tilapia production

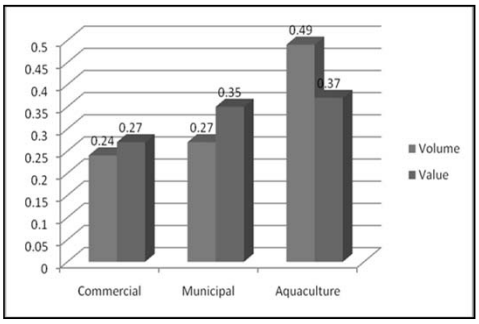
Importance of Fishery Sector in Philippine Economy

- Fisheries contributes 2.2% to GDP
- Only a sub-sector in Agriculture but net food producer
  - Crops 61%
  - Fishery 15%

Important source of FOREX
- Export 26, 239 M PhP
- Import 7 M PhP
- Philippines is net exporter of fish

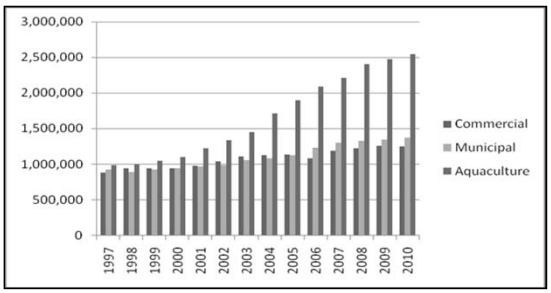
Source: BAS 2010

Fisheries Production by Sector, 2010



Source: BAS 2010

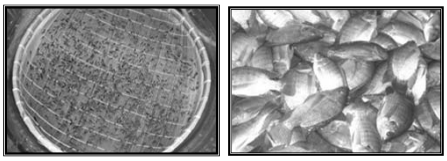
Growth in Fisheries Production



Source: BAS 2010

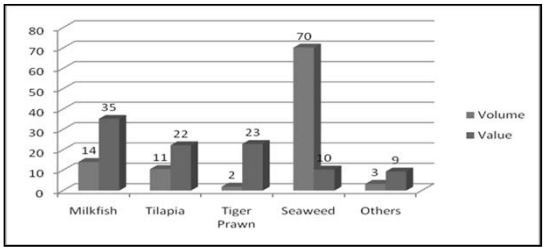
Average Growth rates: 1997-2010
- Aquaculture - 7.66%
- Municipal - 3.12%
- Commercial - 2.75%

Tilapia (*Oreochromis niloticus*)



- Nearly a hundred different species of tilapia all over the world.
- Freshwater fish species which originated in Africa.
- Omnivorous fish
- Due to its prolific nature, it had spread worldwide and had become one of the most important aquaculture species especially in Asia.

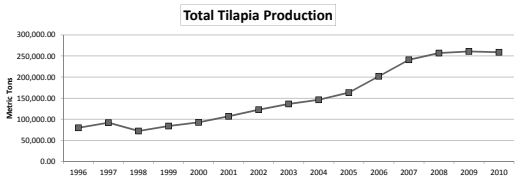
Importance of Tilapia as an Aquaculture Species

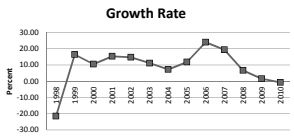


In terms of production 11% - ranks 3rd (next to seaweeds and milkfish)
In terms of value 23% - also ranks 3rd (next to milkfish and tiger prawn)

Tilapia Production

Tilapia production (MT) and growth (%) 1997-2007

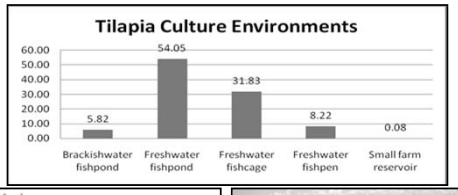




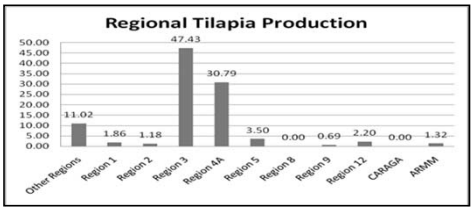
Phase 1 - Prior to 1999
Phase 2 - 1999 - 2006
Phase 3 - 2006 - present

Source of basic data: BAS

Tilapia (Culture Environments)



Tilapia (Regional Production)

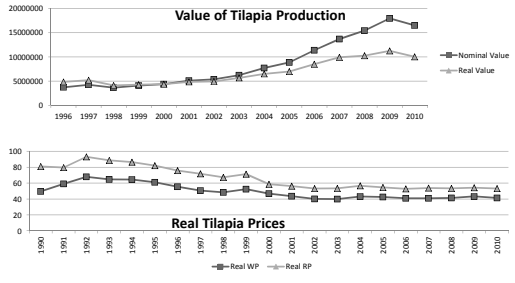


Top Producing Provinces

1. Pampanga (Region 3)	**93,357.23**	**39%**
2. Batangas (Region 4A)	**54,077.41**	**22%**
3. Rizal (Region 4A)	**10,576.23**	**4%**
		65%

Value of Production

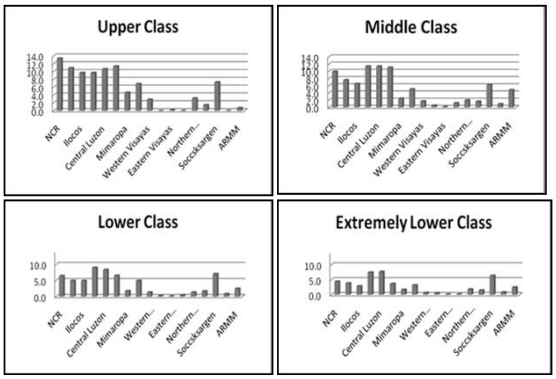
Nominal and Real value of Tilapia production



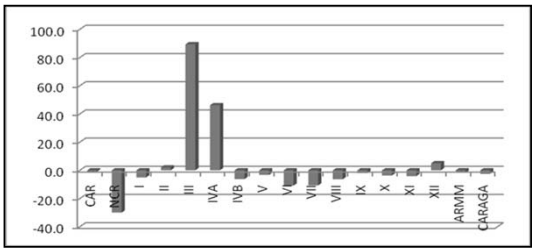
Nominal value of production is growing faster than real value
Implication: real price of tilapia is declining over time

Source of basic data: BAS

Regional Tilapia Consumption

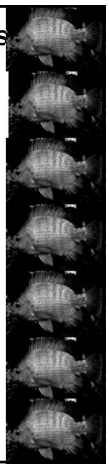


Regional Net Supply of Tilapia



Country Level – production surplus of 95 M metric tons
Surplus producing regions
- **Region 2**
- **Region 3**
- **Region 4A**
- **SOCCSKSARGEN**

Development of Different Tilapia Strains

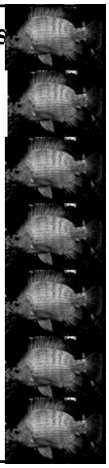


First introduced in the Philippines in 1950s
- *Oreochromis mossambicus*
- not successful as food fish species

1972 : Tilapia aquaculture took off
- *Oreochromis niloticus*
- *accepted as food fish mostly in Luzon*

Mid 1970s: Sex- reversed tilapia
- all male tilapia
- using feeds with synthetic male hormone
- Freshwater Aquaculture Center (FAC) (Guerrero and Abella, 1976)

Development of Different Tilapia Strains

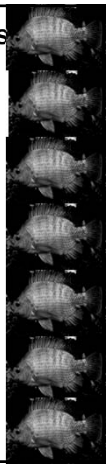


Late 1970s : Tilapia Genetic R&D started
- hybridization of Nile tilapia
- FAC-CLSU and ICLARM (now WorldFish)

1986 FaST (FAC Selected Strain)
- also called IDRC strain
- FAC-CLSU

1988 GMT (Genetically Male Tilapia)
- YY-male technology
- supermale tilapia with YY genotype
- alternative to hormone-treated sex reversed tilapia
- (FAC, BFAR and University of Swansea)

Development of Different Tilapia Strains



1997 Genetically Improved Farmed Tilapia (GIFT)
- selective breeding technique
- WorldFish Center funded by UNDP in collaboration with FAC and BFAR

1997 GET-Excel
- **G**enetically **E**nhanced **T**ilapia **Ex**cellent strain that has **C**omprarative advantage with other tilapia strain for **E**ntrepreneurial **L**ivelihood
- NFFTC-BFAR

1998 Saline-tolerant Tilapia
- NFFTC-BFAR (Munoz, Nueva Ecija)
- BEST (Brackishwater Enhanced Selected Tilapia)
- NITFDC-BFAR (Dagupan, Pangasinan)
- Molobicus strain

Productivity Growth in Tilapia Industry

Identifying the sources of output growth, whether such growth is sustainable?
- **technological progress (modern strains, new cultural practice…)**
- **area expansion**
- **input intensification**

Objectives:
a. **Identify the sources of growth in total factor productivity in terms of technological change, farmer's efficiency, scale and price effects**
b. **Identify the other sources of output growth aside from change in TFP, i.e., prices and intensity of input use**
c. **Compare the relative contribution of the different sources of output growth to identify a strategic policy directions towards improving productivity of tilapia aquaculture**

Definitions of Factor Productivity

- **Ratio of output to a particular input (Partial FP)**
- **Ratio of output to total inputs (Total FP)**
- **TFP is growth in output "not" explained by the amount of inputs used in production**
- **determined by how efficiently and intensely the inputs are utilized in production**

Two measures employed in the study
1. **Parametric Approach (Frontier Production Function)**
2. **Tornqvist Index Decomposition**

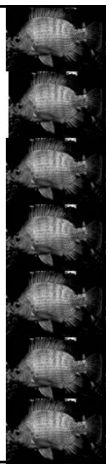
Measurement of Growth in Total Factor Productivity using Tornqvist Index

Properties of the Tornqvist TFP Index Index

Decomposition of the Nominal Revenue Function:
Revenue increases due to either
- increase in output prices
- increase in input use (positive MP)
- growth in TFP

Decomposition of the Nominal Cost Function:
Cost increases due to either
- increase in input prices
- increase in production (positive MC)
- fall in TFP growth

Hence, TFP growth is both
- revenue enhancing and
- cost reducing



Growth Decomposition

Growth in Revenue :

$\ln TR_{st} = \Sigma\ ½(r_{i,s}+r_{i,t})\ \ln (P_{it}/P_{is})$ - increase in output price

$+\ \Sigma\ ½(c_{j,s}+c_{j,t})\ \ln(X_{jt}/X_{js})$ - increase in input use

$+$ TFP - growth in TFP

Growth in Cost:

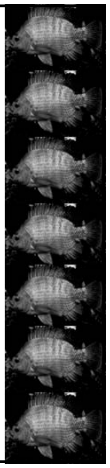
$\ln TC_{st} = \Sigma\ ½(c_{i,s}+c_{i,t})\ \ln (W_{jt}/W_{js})$ - increase in input prices

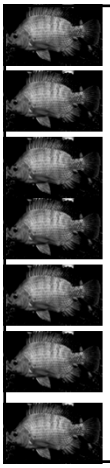
$+\ \Sigma\ ½(r_{j,s}+r_{j,t})\ \ln(Q_{it}/Q_{is})$ - increase in production

$-$ TFP - negative of TFP growth

Since CRS is assumed together with competitive profit maximization, ΔTFP is interpreted as technical change.

Source: Dumangan, J.C. and Ball ,V.E. 2008. "Decomposing growth in revenues and cost into price, quantity and total factor productivity contributions", Applied Economics 99999:1, pp 1-11.





Sources of Data

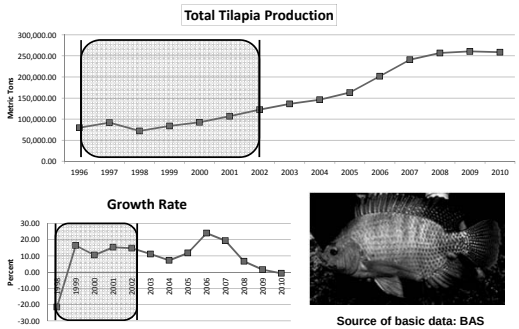
STRIVE FOUNDATION (1996)
- Pangasinan
- Pampanga
- Bulacan
- South Cotabato

BAS Cost and Return Survey (2002)
- Batangas
- Camarines Sur
- Nueva Ecija
- Pampanga

Published cost and return data

Growth in Tilapia Production

Output growth 1996-2002 =8.48% or 1.41% annually

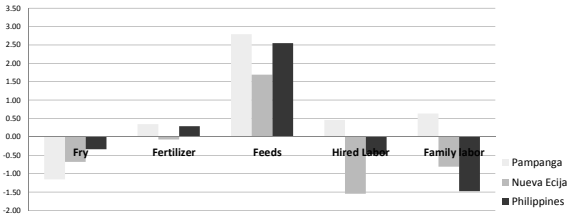


Source of basic data: BAS

SOURCES OF GROWTH IN REVENUES / COST (in percent) (1996-2002)	Pond Tilapia aquaculture		
	Pampanga	Nueva Ecija	Philippines
Component of Growth in Total Revenues:	37	102	61
Increase in output prices	34	16	12
Increase in input use	-18	7	33
Component of Total Cost Inflation:	11	28	95
Increase in input prices	29	21	62
Increase in output	3	86	50
Growth in TFP 1996-2002	21	79	16
Annual TFP Growth	3.5	13.2	2.7

Change in Input Use

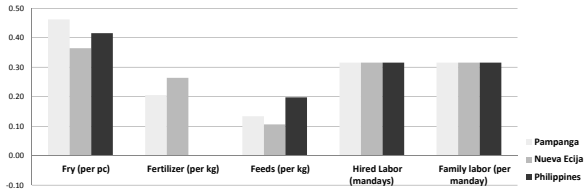
Increase in TR due to Input Use for Tilapia



Increase use (Fertilizer, Feeds)
Decrease use (Seeds, Hired and Family Labor)

Change in Input Prices

Increase in TC due to increase in Input Prices of Tilapia



Increase prices of all inputs (Seeds, Feeds, Fertilizer, Hired and Family Labor)

Decomposition of Growth in Total Factor Productivity through Parametric Approach (Frontier Production Function)

$$\Delta TFP = \Delta TC + (\Sigma\beta_j - 1) \sum \lambda_j \Delta X_j + \Delta TE + \Sigma(\lambda_j - S_j) \Delta X_j$$

Technological Change Effect — *Scale Effect* — *Technical Efficiency* — *Price Effect Effect*

Where:

β_j - *slope parameter (output elasticities) of the production function*

RTS - returns to scale; $\Sigma\beta_j$ *or sum of the output elasticities*

λ_j - ratio of individual output elasticity to RTS;

$\lambda_j = \beta_j / \Sigma\beta_j$

ΔXj - change in the use of input j between the two periods

S_j - *share in cost of input j to total cost;*

$S_j = w_j x_j / \Sigma w_j x_j$

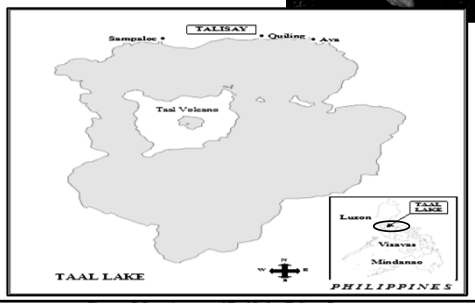
$$\Delta TFP = \Delta TC + (RTS - 1) \sum \lambda_j \Delta X_j + \Delta TE + \Sigma(\lambda_j - S_j) \Delta X_j$$

Technological Change Effect — *Scale Effect* — *Technical Efficiency* — *Price Effect Effect*

- *Technological Change Effect - captures the growth in productivity due to adoption of new technologies*
- *Technical Efficiency Effect - captures the growth in productivity due the improvement in farmers' management practices*
- *Scale Effect - accounts for TFP growth due to changes in the returns to scale of farm operations*
- *Price Effect - represents the change in TFP brought about by the deviation of input prices to the value of their marginal product*

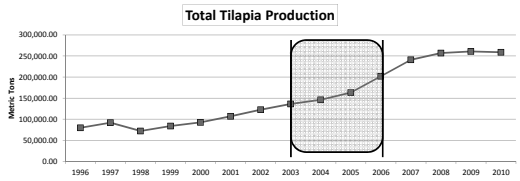
Sources of Data

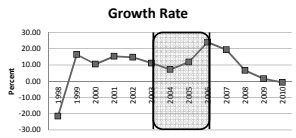
WorldFish Center
Taal Lake - Tilapia Fish cages
2003 data - 40 respondents
2006 data - 67 respondents



Growth in Tilapia Production

Output growth 2002-2006 = 13.52% or 3.38% annually





Source of basic data: BAS

Technical Change Effe

ΔTC is measured by the coefficient of the time dummy in the frontier production function run using panel data of 2003 and 2006

Location	Coefficient of time (in percent)	Standard Error	t-Value	Conclusion
Taal lake 2003-2006	1.168*	0.591	1.976	Technological change is significant

Technological development in tilapia culture is in the form of varietal strains which evolved extensively over the years, example: FaST, GIFT, GET-EXCEL

Although there was an observed technological progress in tilapia cage culture in Taal Lake,TC was very small, only 1.2% of TPF growth over three years

However, based on farmers interview, the strains that are commonly farmed in Taal Lake are not the modern strains but the traditional *O. niloticus* species

Technical Efficiency Effect

Location	Technical Efficiency 2003 (%)	Technical Efficiency 2006 (%)	Difference in technical efficiency (%)	Conclusion
Taal lake	62.52	67.76	5.24*	TE significantly increased

- **Technical efficiency of tilapia cage operators increased significantly by 5%**
- **However, the TE in both periods were still very low (<70%), there is still plenty of room for increasing technical efficiency.**
- **Appropriate strategy to further increase production is not to change the present technology they are using but to improve the capability of farmers in improving their efficiency**
- **This can be done thru proper training and more serious technology extension either from public or private sectors**

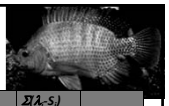
Scale Effect

Inputs	Coefficient bi	bi/RTS	Growth rate in input use	(bi/RTS)*GR
stocking density	0.534	0.783	38.18	22.395
feeds	-0.088	-0.129	13.44	-7.693
labor	-0.005	-0.007	12.9	-0.095
capital	0.065	0.095	6.98	1.779
	RTS = 0.506		Total	16.39
	Scale Effect	(0.506-1)*16.39 = -8.09		

Tilapia cage culture - operation is characterized by DRS
- therefore negative scale effect

Implications:
- **present cages size in Taal lake is no longer conducive for expansion**
- **Agreeable to the current move of the municipal government to limit aquaculture operation in some parts of the lake**

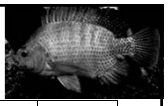
Price Effect



	bi/RTS	Sj 2003	Sj 2006	DSj	GR	$(\lambda_j - S_j)$	$\Sigma(\lambda_j - S_j)\Delta x_j$	
stocking density	0.783	0.0004	0.0005	0.00012	38.18	0.782	29.89	VMP > P_{inputs}
feeds	-0.129	0.0151	0.0161	0.00095	13.45	-0.128	-1.722	VMP < P_{inputs}
labor	-0.007	0.1546	0.1517	-0.00290	12.9	-0.004	-0.057	VMP < P_{inputs}
capital	0.095	0.8298	0.8316	0.00183	6.98	0.093	0.652	VMP > P_{inputs}
						Price Effect	28.760	VMP > P_{inputs}

In general, tilapia cage operation is not input price efficient
To achieve input price efficiency:
- **there is under-utilization of fingerlings and capital inputs (can be increased);**
- **over-utilization of feeds and labor input (can reduce it to be more price efficient)**

Total TFP Growth



Location and Year	TFP	TC Effect	TE Effect	Scale Effect	Price Effect
Total Growth from 2003-2006	27.08	1.17	5.24	-8.09	28.76
Annual Growth rate	9.03	0.39	1.75	-2.70	9.59

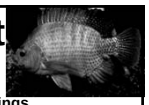
- **Large positive price effect presents opportunity for intensifying input use but has to consider the carrying capacity of Taal Lake**
- **Scale effect is negative suggesting increasing size of operation is no longer advisable**
- **Technical efficiency of farmers offers plenty of room for improvement**
- **Technical change have little effect since farmers do not take advantage of the available technological improvements in terms of strain development**
- **Based on the results of the Tornqvist decomposition, TC can grow >10%**

Summary of Results

TFP Estimates	Batangas	Pampanga	Nueva Ecija	Philippines
Tornqvist Index				
Annual TFP Growth 1996-2002 (All technical change)		3.5	13.2	2.7
Frontier PF approach				
Annual TFP growth 2003-2006	9.03			
Technical Change Effect	0.39			
Technical Efficiency Effect	1.75			
Scale Effect	-2.70			
Price Effect	9.59			

In general, pond-based culture of tilapia has the poten for higherTFP growth.
- Intensive production
- Semi-intensive production
- Extensive production

Concerns and Constraint



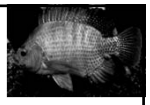
The phenomenal growth of the tilapia industry
1. Availability of high quality (improved strains) fingerlings
2. Culture intensity
   Note: Intensive production means high input use eg, feeds, seeds

1. Given higher cost of production due to input intensification and decreasing real prices of tilapia (wholesale and retail prices)
   - Double squeeze in the profit margins of tilapia farmers
   - serious issue in sustaining the growth of the industry

Addressing the problem
a. Cheap alternative for commercial feeds
   - duckweed as supplementary feed but production is a constraint
b. Reversing the trend in real tilapia prices
   - demand creation in non-traditional tilapia consumption areas

2. Environmental pollution caused by too much feeding leads to disease outbreak and fish kills
   - Good Aquaculture Practice
   - awareness of proper environmental management is crucial in sustaining production and incomes of tilapia farmers

Strategies to further boost tilapia production:



- Quantity and price intervention policy
  Example: 1. Fingerling dispersal of BFAR (GET-EXCEL)
  Cheaper and quality fingerlings for the farmers

  2. Farm-to-market roads to reduce transaction costs indirectly helping farmers to get better price for their harvest

  3. Altering consumer preference for tilapia thru food fairs
  - live vs fresh chilled
  - value addition (tilapia fillet)

- Investment in R&D can be focused on saline tilapia strains, eg.,
  (Molobicus from Pangasinan and BEST from BFAR Nueva Ecija)
  - freshwater environment (10%)
  - brackishwater environment (90%)

Thank You for your Attention