Potency of Aquatic Local Resources in Cambodia

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Introduction

- In Cambodia, freshwater fish: human wellbeing and livelihoods
- Ca. 70% of the animal protein consumed is from fresh water fish
- > 1.2 million people depend on fishing for their livelihood

Table 14: Fish catch and population of the four major countries worldwide.

	Country	Fish catch 2000[1]	Population 2000[2]	Catch/inhabitant (kg.capita^{-1}.year^{-1})	
1	China	1 222 955	1 265 830 000	0.97	3
2	India	416 490	1 014 003 817	0.41	4
3	Bangladesh	591 300	129 194 224	4.58	2
4	Cambodia	245 300	12 212 306	20.09	1

FAO (1999)

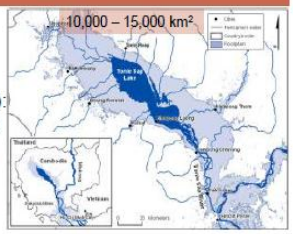
Introduction

- > 500 fish species present in the country (Rainboth 1996)

Number of fish species in ASEAN countries recorded in FishBase (Froese and Pauly 2015).

Country	Order	Family	Genus	Native species	Exotic species
Indonesia	22	82	1224	1093	20
Thailand	20	71	867	705	22
Viet Nam	20	72	754	704	20
Malaysia	22	71	639	619	20
Laos PDR	15	52	587	549	12
Myanmar	17	63	520	507	13
Cambodia	21	69	489	476	13
Philippines	21	71	357	210	48
Brunei	9	25	108	104	3
Singapore	11	38	143	77	58

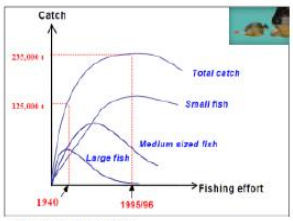
Introduction



- Tonle Sap Lake (2,700km²): one of the most productive freshwater ecosystems in the world
- Due to its rich biodiversity supported by its great floodplain and inundated forests, rivers and streams
- The Mekong River: ~480km
- Tonle Sap River: 120 km

Introduction

- Overfishing is recently concerned



Van Zaling et al. (2001)

E.g. Giant catfish: *Pangasianodon gigas*

Giant barb: *Catlocarpio siamensis*

Cyprinid: *Henicorhynchus* spp.

Introduction

E.g., Tonle Sap River:

- Number of fishermen
  1940s: **360,000**
  1995: **1,200,000**
  Hortle et al. (2004)
- Aquaculture production has recently contributed to the domestic fish consumption

Allan et al. 2005

Introduction

- Existing data are less statistically analysed and interpreted

Introduction

Objectives:

- To understand the trend of local freshwater fish resources (i.e. capture fishery and aquaculture production), and
- To explore their association with socioeconomic and climatic factors

Hypotheses:

- Clear patterns of fish production and export, and
- These linked to human activities (e.g. population, fish consumption rate, per capita livelihood)

Methods

To understand the production trend of freshwater fish

- Annual reports: MAFF & DoF

Year	Aquaculture	CaptureFisheries	FishExported	FishSeed
1984	1380.60	55304.30	NA	NA
1985	3318.30	57245.60	NA	NA
1986	2323.70	64088.50	NA	NA
1987	3283.30	63086.00	NA	604664.00
1988	5223.50	62087.70	NA	1195085.00
1989	5672.00	51513.91	NA	2961844.00
1990	6167.40	64989.50	NA	3493840.00
1991	7127.20	74774.70	NA	2378712.00
1992	8087.10	68871.40	NA	2792862.00
1993	7400.00	67900.00	32332.00	1089631.00
1994	7640.00	65000.00	27673.00	5680182.00

2014

Fish Consumption per Capita

$$FCC = \frac{(AC+CF)-FE}{Population}$$

FCC: fish consumption/ capita
AC: aquaculture
CF: capture fisheries
FE: fish export

Methods

To explore their association with socioeconomic & climatic variables

- Population, population density, GDP, GDP per capita, agricultural land, & forest coverage (World Bank 2015)
- Min., max. & average temperatures, & rainfall
  From the Tyndall Centre (Mitchell et al. 2002, 2004)
- 18 variables over the last 31 years (1984 – 2014)
- Significant predictors (e.g. Van Zalinge et al. 2001; Baird 2006; Heinonen 2006

Methods

Statistical analyses

- PCA used to explore patterns of association among the variables
- GAM model: response variable ~ explanatory variable, e.g. fish production ~ population
- Multiple linear regressions model: to relate the fish production (i.e. capture fishery, aquaculture or fish seed production) to FCC, fish export, GDPC and population
- Stepwise selection procedures ➔ the best model based on the AIC values

Results

History of fish production and export

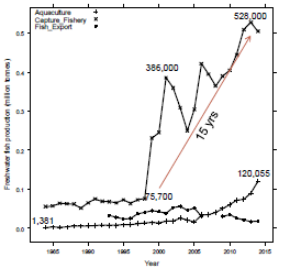


Fig. 2: Production trend of freshwater fish production and export (data from MAFF 2000-2014; DoF 2005)

Results

Freshwater fish production and variable correlations

Table 2: Correlation matrix of the 12 variables (Pearson's correlation).

	1	2	3	4	5	6	7	8	9	10	11	12
1. Aquaculture	-	0.84	-0.57	0.94	0.81	0.85	0.97	0.96	0.76	-0.88	0.83	-0.71
2. Capture fishery	***	-	-0.20	0.80	0.91	0.87	0.84	0.85	0.79	-0.93	1.00	-0.95
3. Fish export	**	0.40	-	-0.59	-0.23	0.35	-0.57	-0.59	-0.08	0.01	-0.25	0.15
4. Fish seed	***	***	**	-	0.78	0.67	0.97	0.97	0.77	-0.79	0.80	-0.69
5. Population	***	***	0.33	***	-	1.00	0.91	0.88	0.93	-0.99	0.94	-0.89
6. PopDensity	***	***	0.18	***	***	-	0.90	0.86	0.93	-0.99	0.88	-0.84
7. GDP	***	***	**	***	***	***	-	1.00	0.93	-0.92	0.85	-0.75
8. GDPC	***	***	**	***	***	***	***	-	0.93	-0.90	0.84	-0.74
9. AgriLand	***	***	0.76	***	***	***	***	***	-	-0.97	0.88	-0.84
10. Forest	***	***	0.96	***	***	***	***	***	***	-	0.86	0.87
11. FCC	***	***	0.29	***	***	***	***	***	***	***	-	-0.95
12. 3/1+2	***	***	***	**	***	***	**	**	***	***	***	-

Results

- Most of the variables were correlated, which explained 82.87% of the variation with two axes

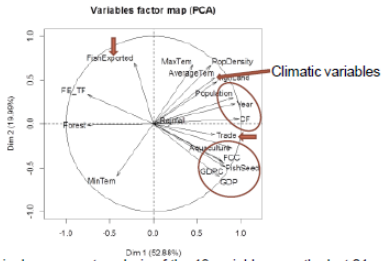


Fig. 3. Principal component analysis of the 18 variables over the last 31 years.

Results

GAM model: FCC ~ GDPC

- $P < 0.001$, $R^2_{adj.} = 0.68$, $n = 20$,
- deviance explained = 72.2%

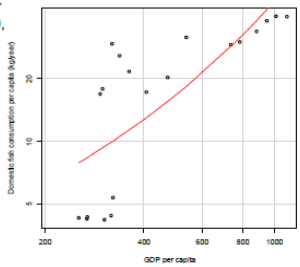


Fig. 4: Relationship between the FCC and GDPC

Results

GAM model: AC ~ FS

- $P < 0.001$, $R^2_{adj.} = 0.68$, $n = 20$
- deviance explained = 72.2%

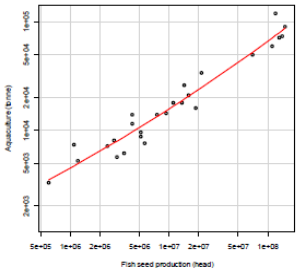


Fig. 5: Relationship between the aquaculture and fish seed.

Results

GAMs model: FP ~ Population

- FC: $P < 0.001$, $R^2_{adj.} = 0.96$, $n = 31$, deviance explained = 97.5%
- AC: $P < 0.001$, $R^2_{adj.} = 0.99$, $n = 31$, deviance explained = 98.9%

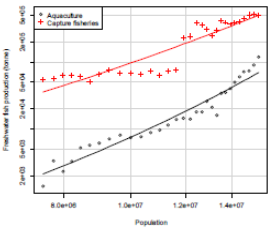


Fig. 6: Relationship between the freshwater production and population

Results

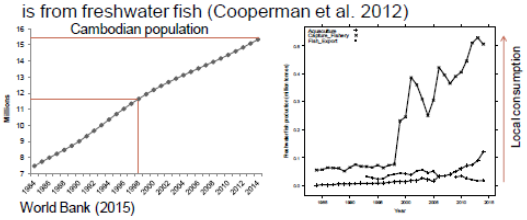
Table 3: Multiple linear regression models (stepwise selection procedure) of the freshwater fish production in Cambodia.

Model	$R^2_{adj.}$	P
CF = 3.08 + 0.09 AC + 0.85 FCC + 0.18 FE + 0.17 GDPC	0.99	< 0.0001
AC = – 6.50 + 2.14 CF – 1.62 FCC – 0.33 FE + 1.07 GDPC	0.95	< 0.0001
FS = 0.37 + 1.57 AC	0.93	< 0.0001

Note: AC: aquaculture production (tonne), CF: capture fishery (tonne), FCC: domestic fish consumption per capita (kg/year), FS: fish seed production (head), FE: fish export (tonne), and GDPC: gross domestic product per capita (US$).

Discussion

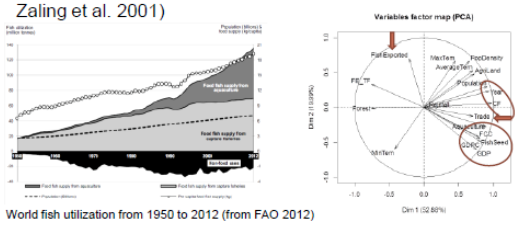
- Overall catch are higher now than the past
- Food fish supply mainly from the capture fisheries, which are larger than the fish cultured
- ~70% of the animal protein consumed within the country is from freshwater fish (Cooperman et al. 2012)



World Bank (2015)

Discussion

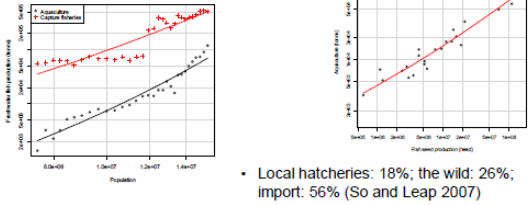
- FCC, FE, GDPC & AC are better variables for predicting the CF, whereas CF, FCC, FE & GDPC are the most important predicators for the AC
- Local consumption: FISH is a food item after rice (Van Zaling et al. 2001)



World fish utilization from 1950 to 2012 (from FAO 2012)

Discussion

- ~67 kg/person (Ahmed et al. 1998)
- Wide fish: ~40 kg/person (Van Zaling et al. 2001)
- FC ~ per capita income (Hortle 2007)



- Local hatcheries: 18%; the wild: 26%; import: 56% (So and Leap 2007)

Discussion

- Fish cultured contributes annually < 20% of the total fish production, and fish seed production is a main factor supporting its production
- Annually, FCC has creased with population & GDPC growth, and AC has increased slower than the CF increased while FE has declined because of local fish utilization

Discussion

- Aquaculture needs improving to increase its production to contribute to local food fish demand for not only declining the catch to avoid overfishing of the larger fish spp., but also enhancing fish export for the national economic development
- Exotic spp. (invasive spp.) vs. native spp.: to save our biodiversity

Giant catfish caught in the Tonle Sap Lake

On going projects

- Project "Maintaining Productivity and Income in Tonle Sap Fishery in the Face of Climate Change (TLSCC)" funded by the USA
- Project "Protecting Human Food Security by Understanding how Climate Change will Impact the Inland Fisheries of Cambodia (HOT FISH)" funded by the Carleton University, Canada

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