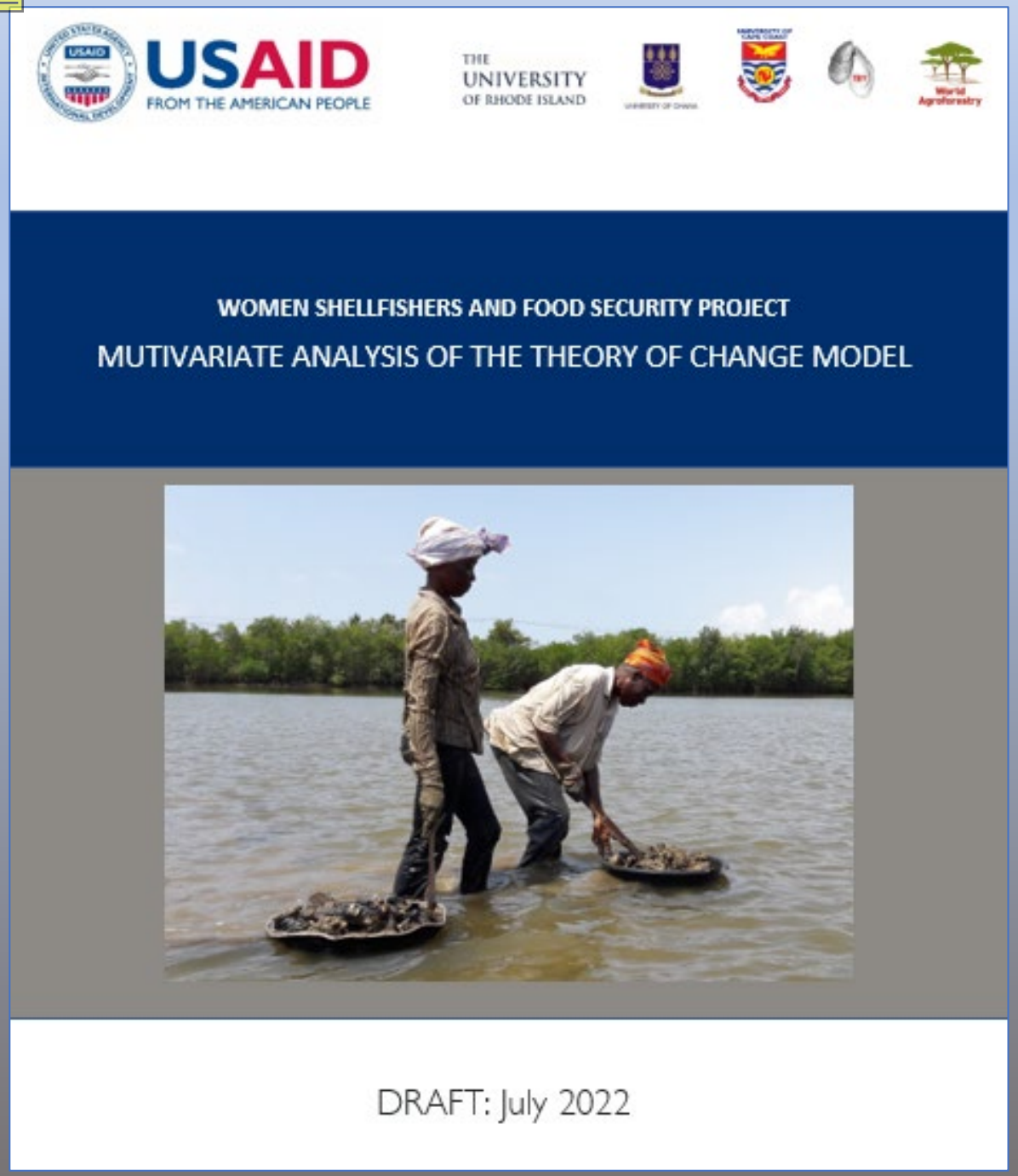
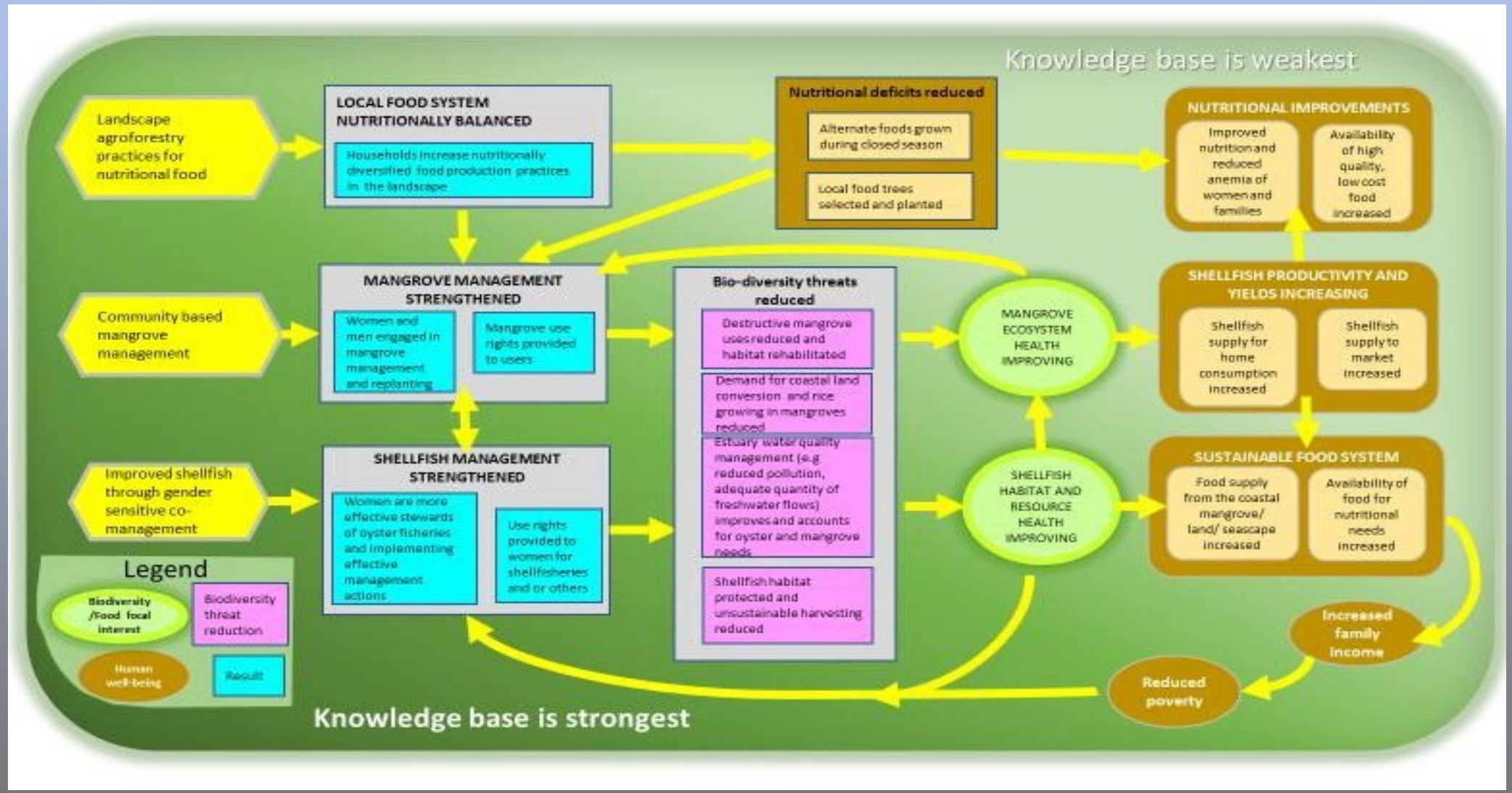


Seeking empirical evidence to support the Women Shellfisher's and Food Security Theory of Change

The Theory of Change Model from the Program Description



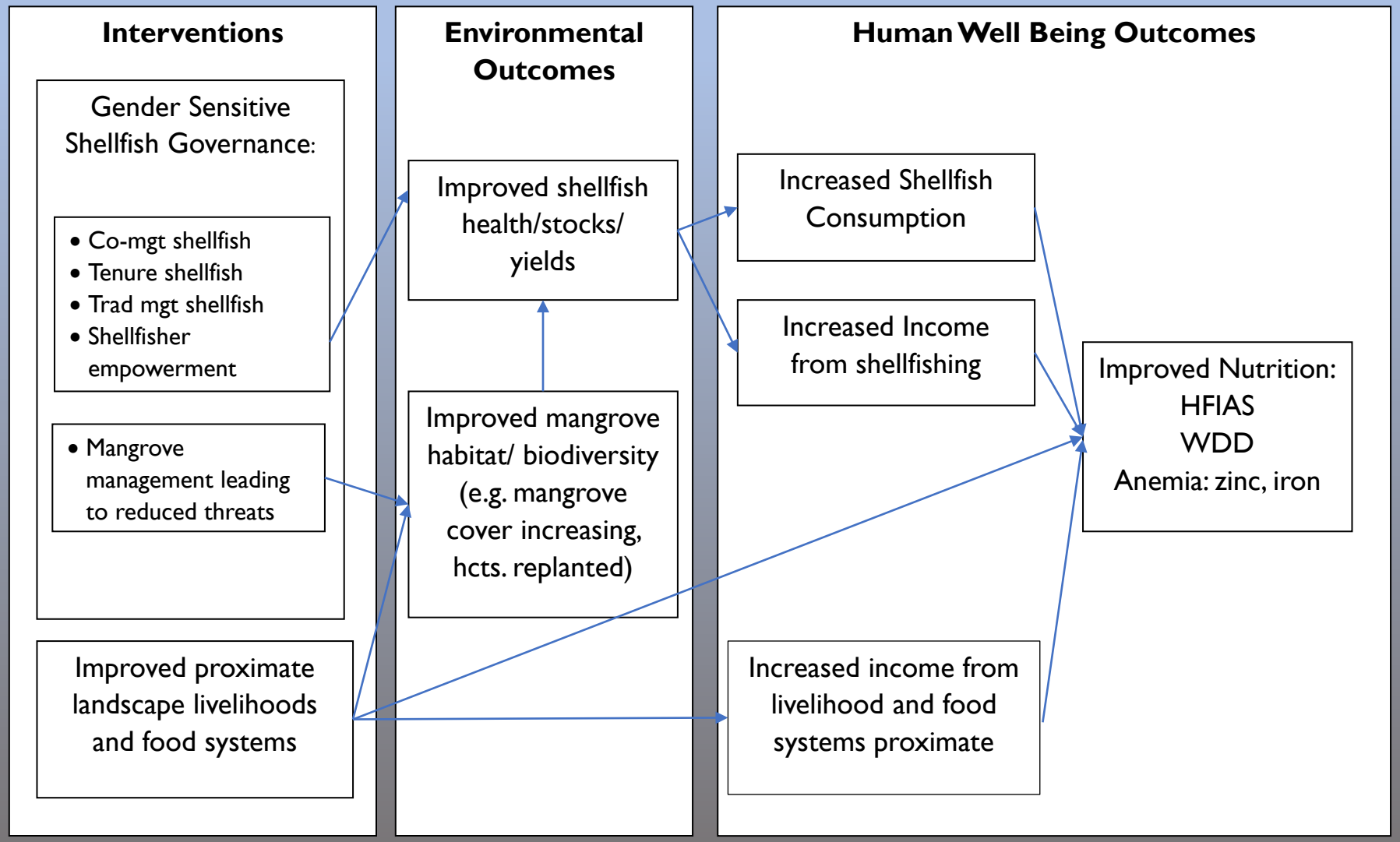
Four Hypotheses to be Tested

1. Improved and gender equitable management of shellfisheries and mangroves increases shellfish yields and availability of this nutrient rich food protein, which increases shellfish consumption and contributes to improved household nutrition and income of those engaged in shellfishing.
2. Gender sensitive governance that promotes co-management and tenure rights and empowered women that manage shellfisheries sustainably improves conservation of mangroves.
3. High consumption of shellfish contributes to lower prevalence of anemia in women of reproductive age and is shown as a main contributor compared to other factors such as malaria or hookworms.
4. Enriching landscapes around mangrove-shellfish estuaries systems with complementary food and nutrition sources reduces the extractive pressure on the mangroves thereby improving its health which subsequently boosts the productivity of the shellfishery having direct impact on household food security.

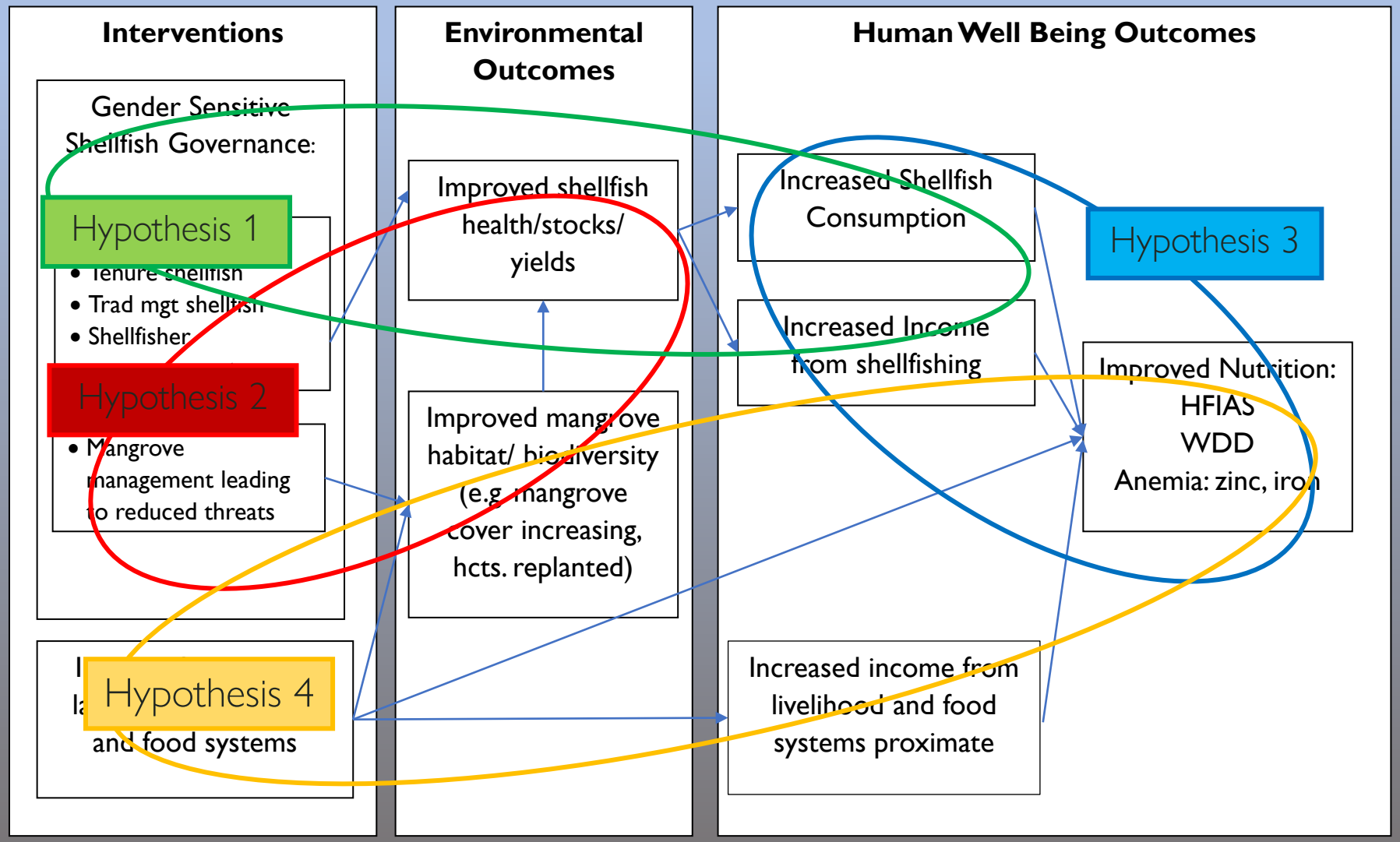
Data collected on the following themes:

1. Mangroves (ICRAF)
2. Shell fishery (UCC)
3. Water quality (UCC)
4. Landscape level food systems (ICRAF)
5. Governance (ICRAF and UCC)
6. Socio-economics of shellfishers (UCC)
7. Nutrition (Univ of Ghana)

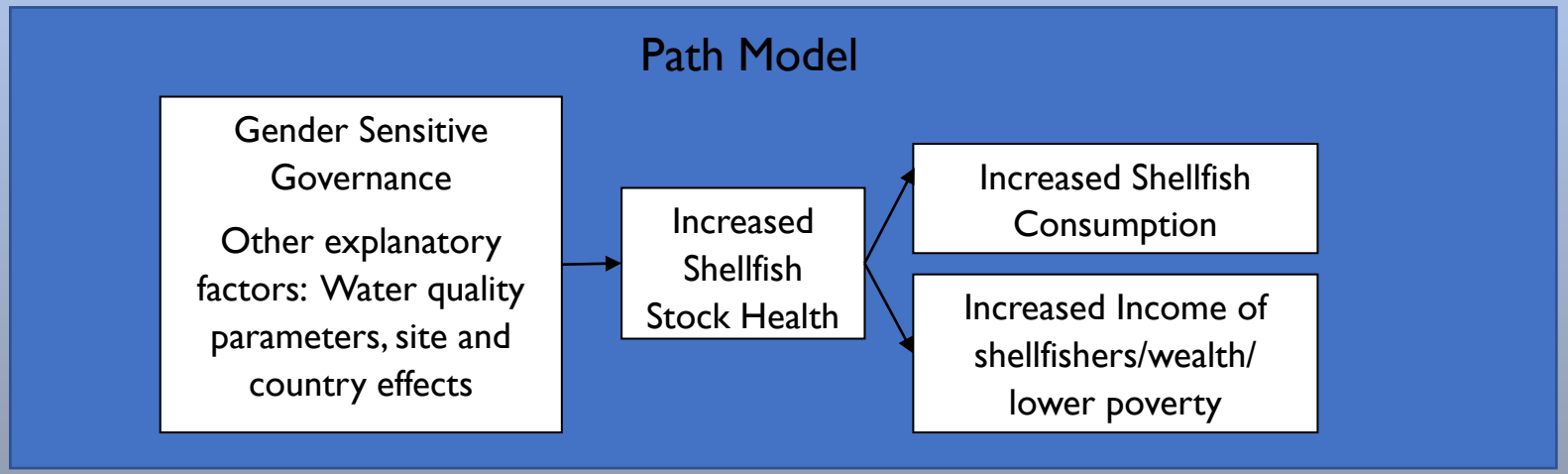
The Refined Theory of Change Model and Associated Hypotheses



Overlay of Four Hypotheses on the Theory of Change Model



Example of Hypothesis 1: Path Model, Variables and "Equations"



Model equations (outcome = predictors)

Increased shellfish health/yields = gender sensitive governance (total gov score + WEAI) + water quality parameters + country + site

Increased shellfish consumption = increased shellfish health + country + site

Increased income = increased shellfish yields + country + site

Gender sensitive governance = co-mgt + tenure + trad mgt + women empowerment

Variables
Shellfish Governance
Co-management
Tenure rights
Traditional mgt
Governance_total_score
Women's empowerment score
Water Quality
Salinity
Dissolved Oxygen (DO)
Turbidity
pH
Depth
Temperature
Shellfish Health
Fishing_mortality
Exploitation_ratio
Fisheries _Health_rank
Shellfish_Height_cm
Shellfish Consumption
Total_oyster_consumption
Income
Household_income rank
Shellfish_income
Shellfish_income_rank
Per_capita_food_consumption
Poverty /Wealth measures
Poverty_index
Livelihoods
Livelihood_dependency
Livelihood_diversity

Approaches for Data Analysis

- Qualitative across sites and countries
- Statistics
  - Parametric and non-parametric
  - Regression and correlation

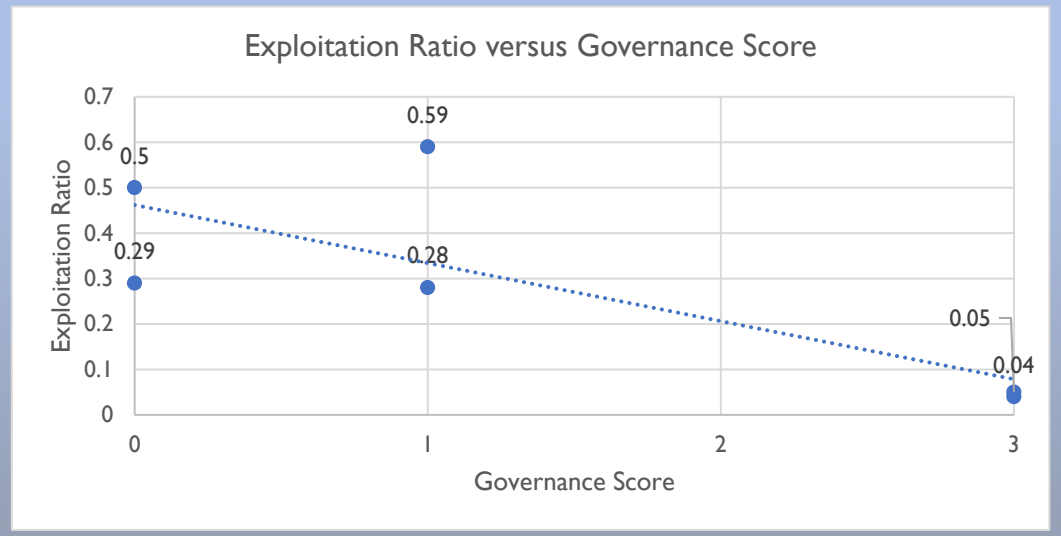
Challenges for Data Analysis

- Small number of sites (n = 6)
- Statistics: clustering to account for site effects – use of mean per site
- Some household data collected by different groups making it difficult to compare with statistical power

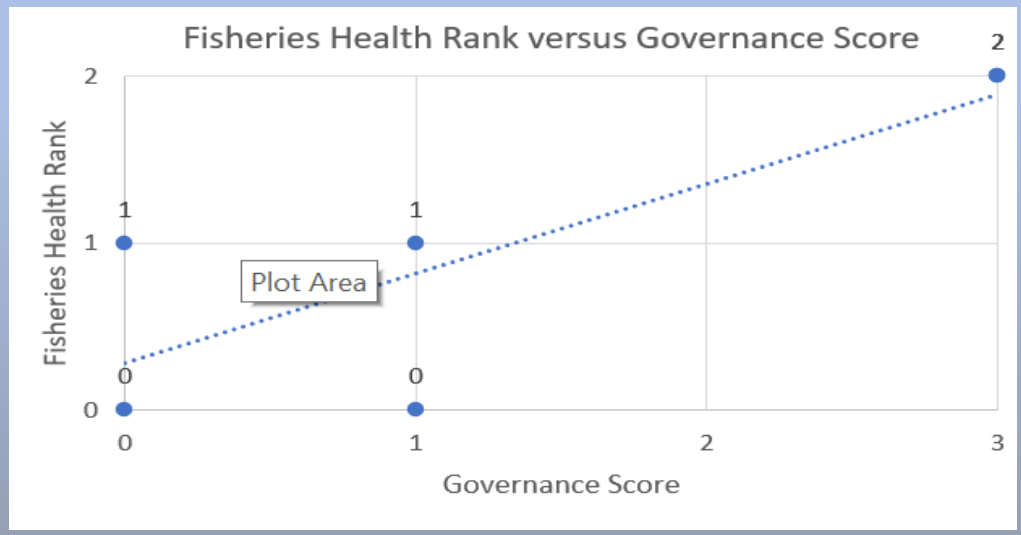
Results

Hypothesis 1: **Improved and gender equitable management of shellfisheries increases shellfish yields, which increases shellfish consumption and income of those engaged in shellfishing.**

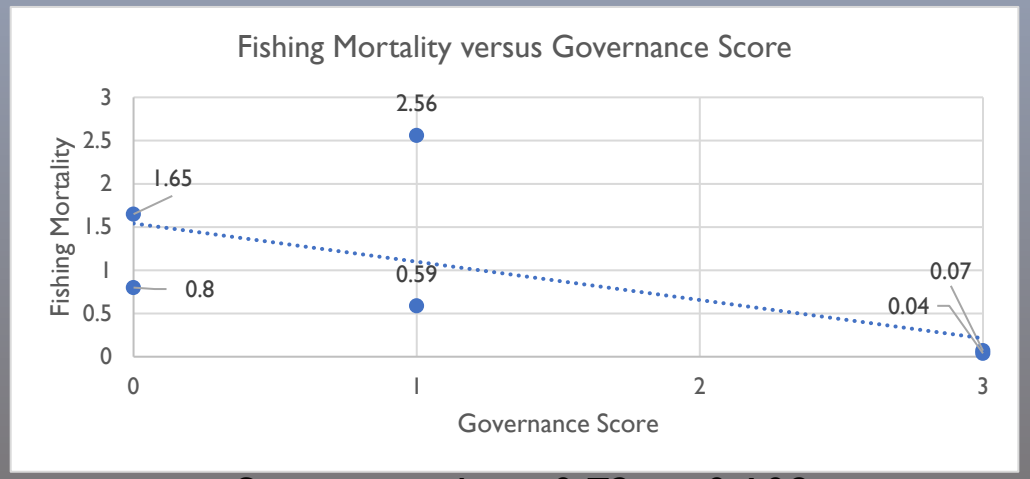
Governance and Shellfishery Health



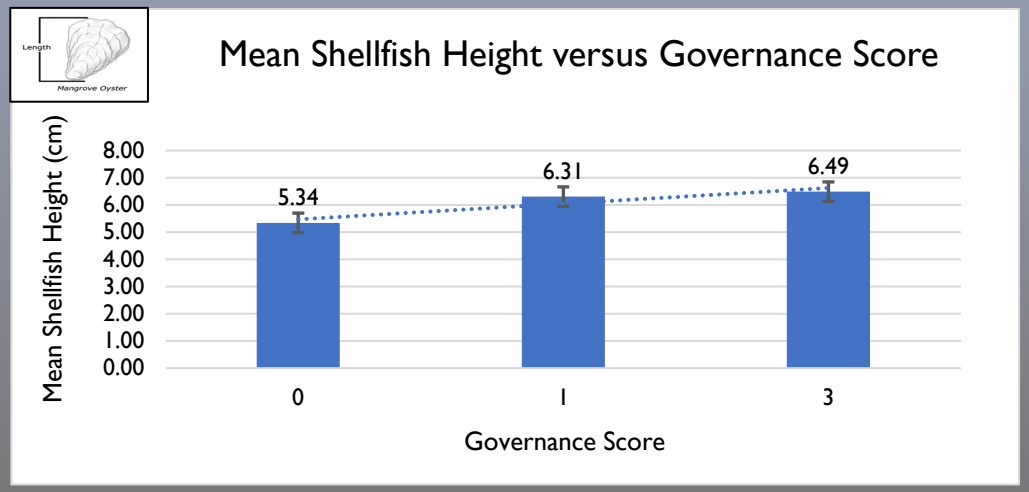
Spearman rho=-0.72, p=0.109



Spearman rho=0.75, p=0.086

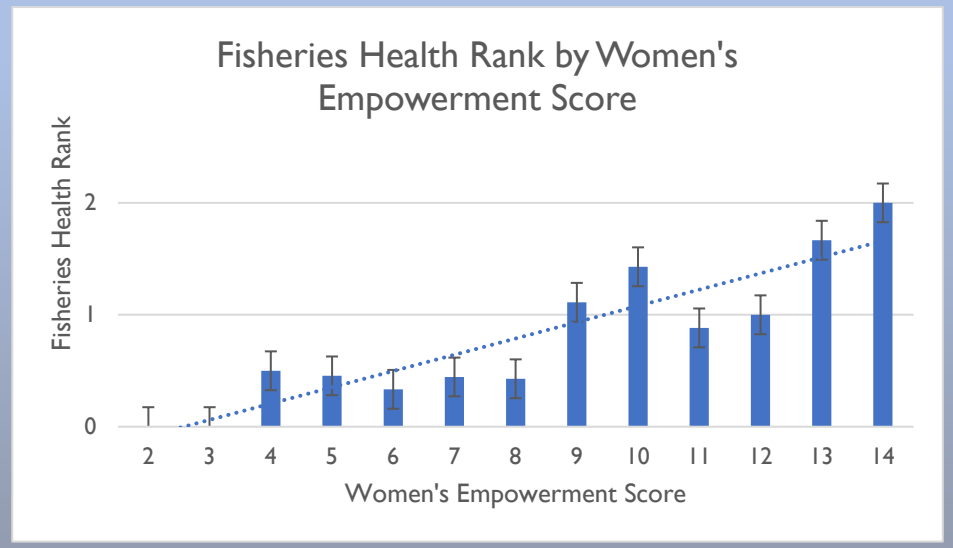


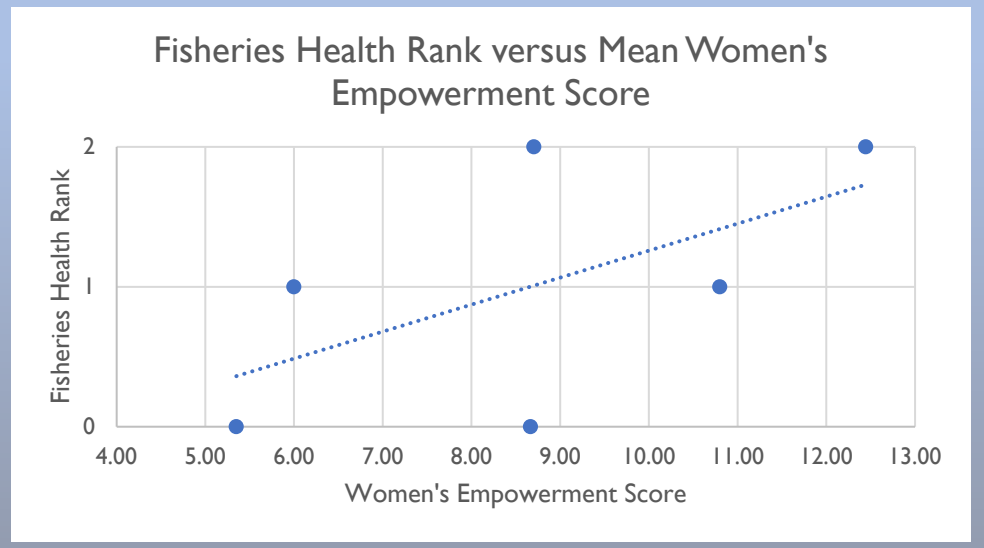
Spearman rho=-0.72, p=0.109

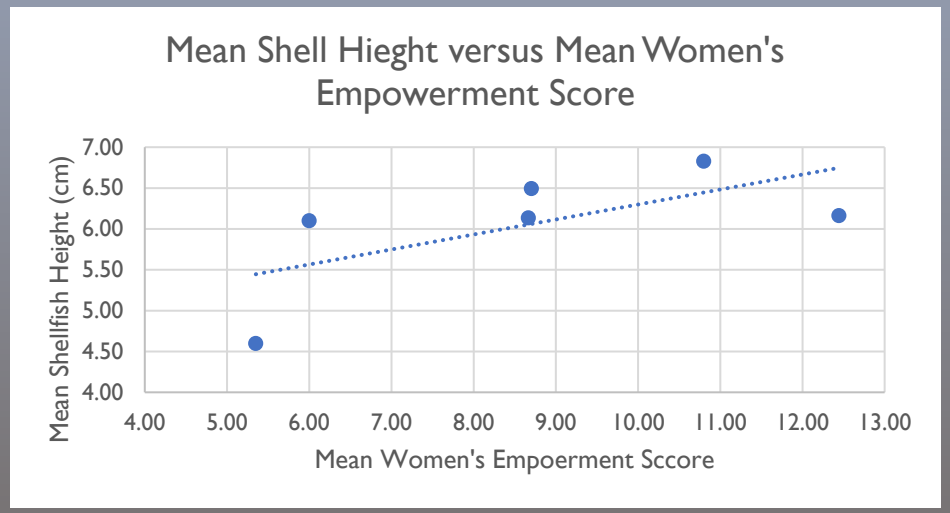


Spearman rho=0.84, p = 0.038

Women's Empowerment and Shellfishery Health







Mean shell height = mean waei, rho=0.83, p=0.042

Fisheries health rank = mean waei, rho= 0.72, p=0.109

Fishing mortality = mean waei, rho=-0.66, p=0.156

Exploitation ratio = mean waei, rho=-0.60, p=0.208

Fisheries health rank by mean shell height and physico-chemical parameters

Fisheries Health Rank	**Shell height (cm)**	Temp (0C)	DO (ug/l)	**Salinity (ppt)**	pH	**Depth (m)**	**Turbidity (NTU)**
Mean values of site parameters by Fisheries Health Rank							
overexploited	***5.51***	28.81	5.30	***24.77***	7.74	***1.84***	***17.65***
fully exploited	***6.12***	28.80	5.62	***24.50***	7.85	***1.20***	***21.85***
underexploited	***6.49***	28.11	5.22	***34.20***	7.46	***2.97***	***5.91***
Mean values of site parameters by Fisheries Health Rank dichotomized							
over or fully exploited	***5.82***	28.80	5.50	***24.61***	7.80	***1.45***	***20.20***
under-exploited	***6.49***	28.11	5.22	***34.20***	7.46	***2.97***	***5.91***

Underexploited sites have greater shell height, higher salinity and greater depth compared to the over and fully exploited sites.

Mean natural mortality, fishing mortality, exploitation ratio and shell height per country.

Country	Mean M (N=3)	Mean F (N=3)	Mean E (N=3)	Mean shell height (N=4200)
Ghana	1.783	0.840	0.277	5.84
The Gambia	1.370	1.063	0.307	6.26

Ghana sites have a higher mean temperature, pH, turbidity and lower mean depth and salinity, as well as higher mean natural mortality and shorter mean shell height than sites in The Gambia.

Shellfish Consumption and Fishery Health

There were no statistically significant differences between fishery health ranks and shellfish consumption or per capita food expenditures.

Income, livelihood dependency and poverty index versus fisheries health rank dichotomized

Variable	Mean value for over and fully exploited	Mean value for underexploited
Household income rank	2.51	2.94
Shellfish livelihood dependency	1.62	1.67
Livelihood diversity	1.66	1.00
Shellfish income rank	6.66	8.39
Poverty/wealth index	2.43	3.53

$p > 0.1$ in models adjusting for clustering, N=120

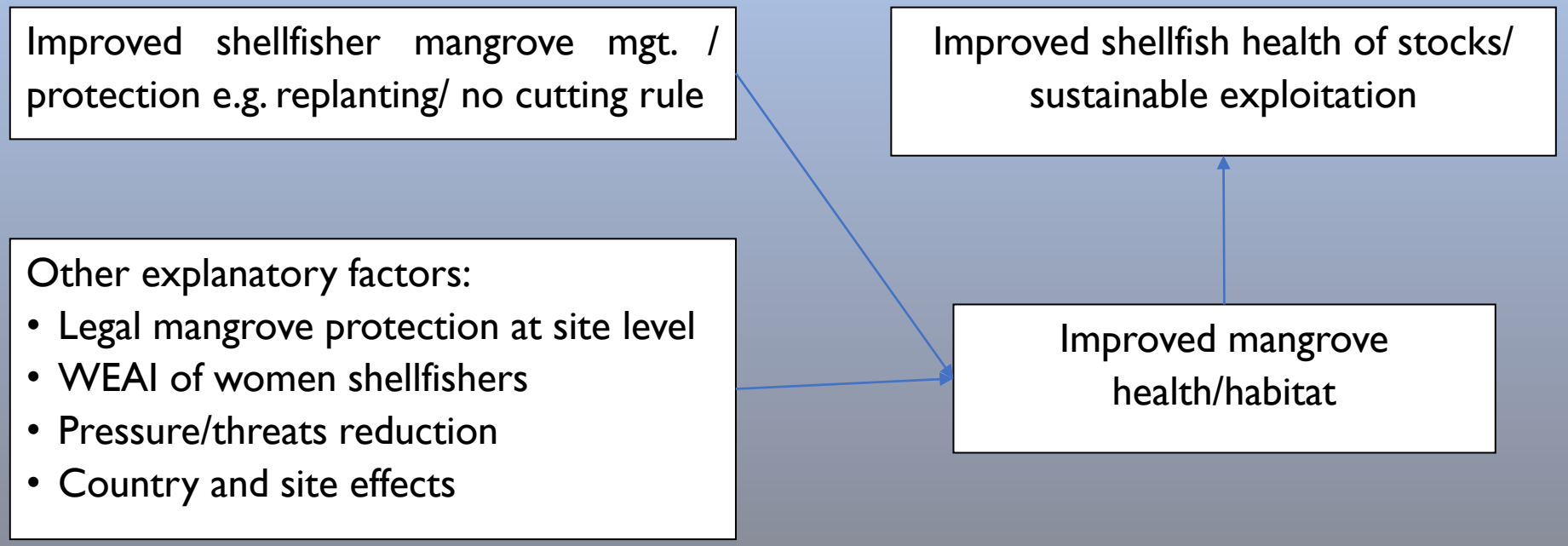
Hypothesis 1 Conclusions

Hypothesis	Conclusion	Comments
Improved governance improves the health of the shellfishery resource.		Qualitatively some evidence, statistical significance on 1 parameter
Women's empowerment improves the health of the shellfishery resource.		Qualitatively some evidence, statistical significance on 1 parameter
Physico-chemical parameters of the waterbody influences shellfishery health.		Some evidence for some parameters – depth, salinity, turbidity
Improved shellfishery health increases shellfish consumption.		No evidence
In sites with healthier shellfisheries, women shellfishers have higher shellfishing income, overall household income, and lower poverty rates.		Qualitatively some weak evidence, no statistical significance
Greater livelihood diversity is related to higher household income.		No evidence

Results

Hypothesis 2: Shellfisher mangrove management actions improves mangrove habitat which in turn improves the health of shellfish stocks.

Hypothesis 2 Path Model

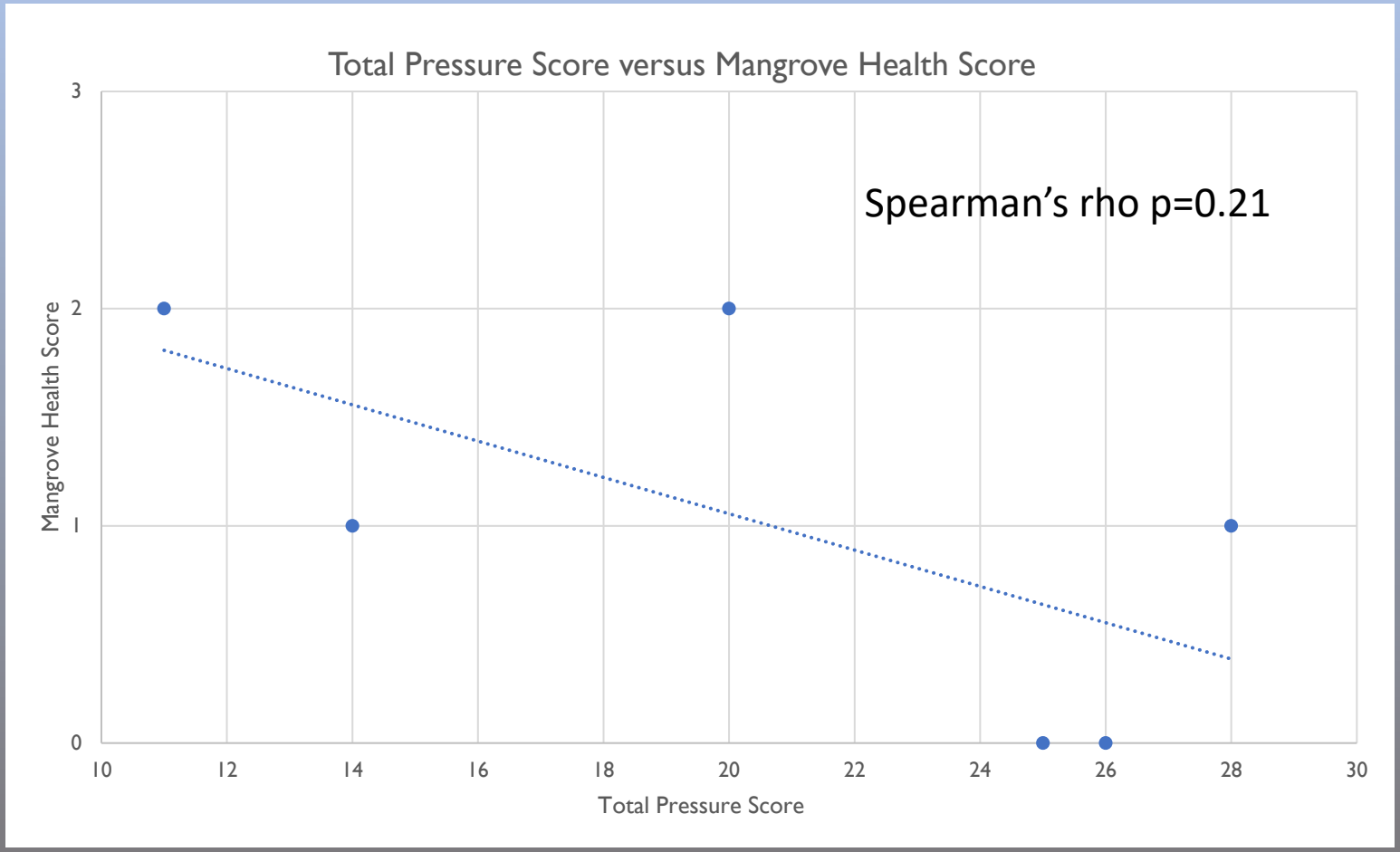


No relationship between Mangrove Health variables with:

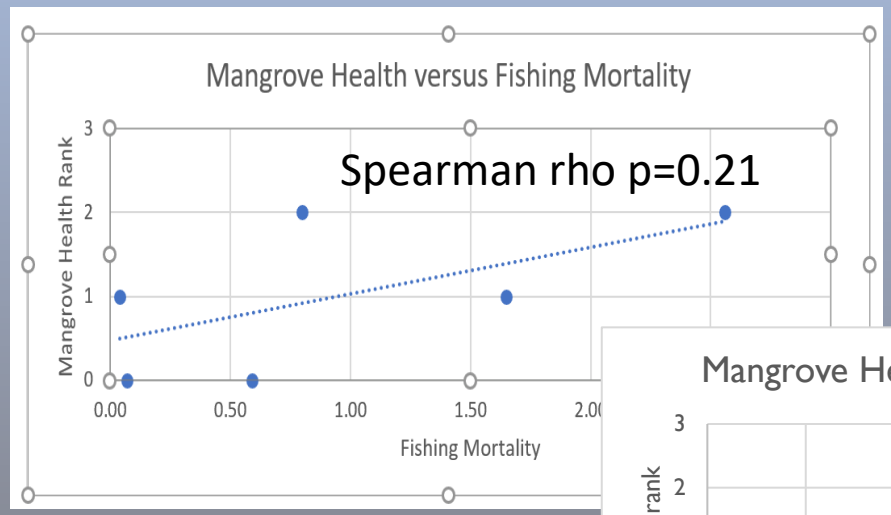
1. Shellfisher protections for mangroves
2. Legal site protection
3. Increasing women's empowerment

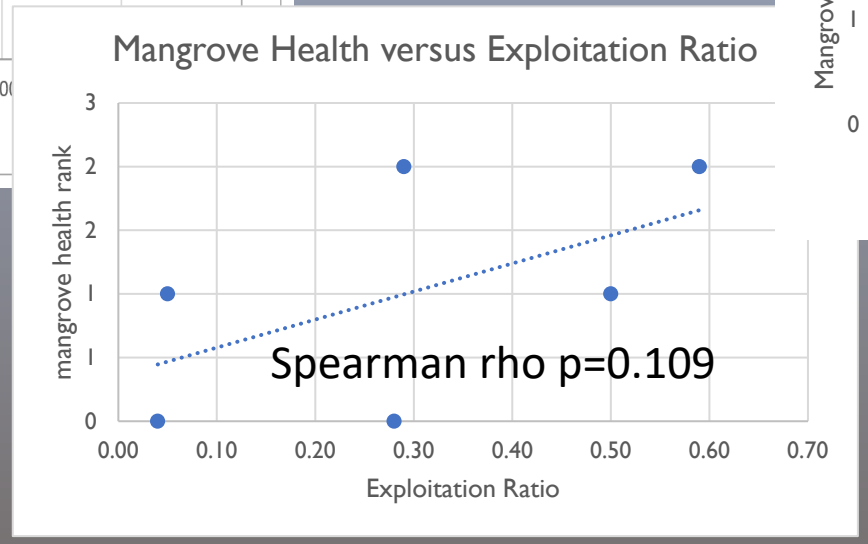
Site	Shellfisher Mangrove Protection	Mangrove Legal Protection	Mangrove Change 2010 - 2020 (%)	Mangrove Trajectory of Change between 2000-2010 & 2010-2020	Mangrove Qualitative Health	Mean Women's Empower Score
Densu	1	1	+313	significant improvement	low	10.80
Narkwa	0	0	+680	significant improvement	moderate	5.35
Whin	0	0	+37	modest improvement	high	6.00
Tanbi	1	1	-0.67	slight decline	moderate	12.44
Bullok	0	0	-1.36	slight improvement	high	8.70
Allahien	0	0	+10.4	modest improvement	low	8.67

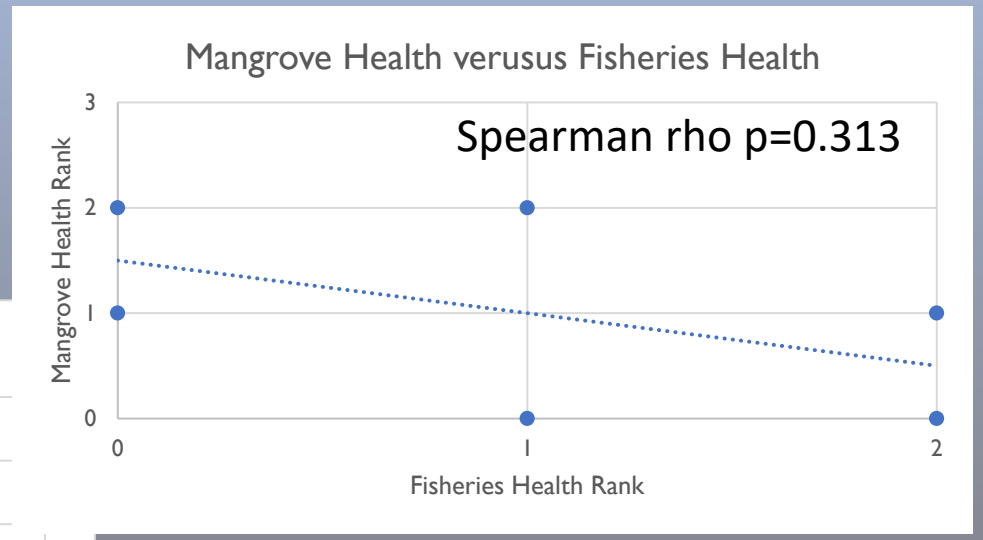
Some weak evidence between mangrove health and pressure scores



Weak evidence that in healthier mangrove systems: fishing mortality and exploitation ratios are higher, and fisheries health lower.







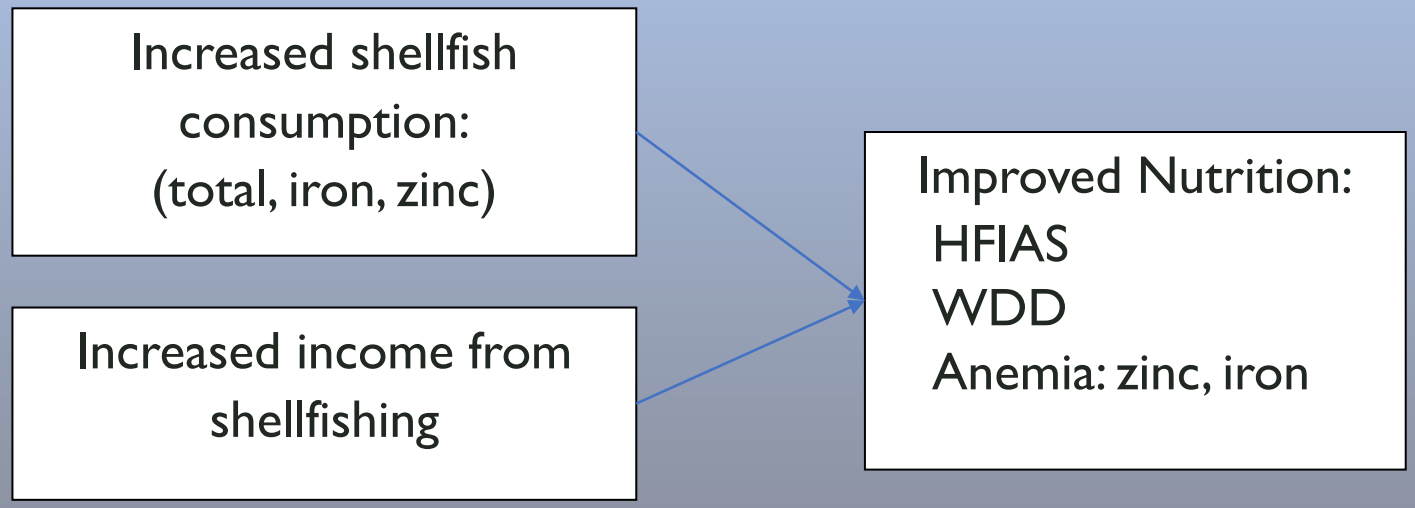
Hypothesis 2 Conclusions

Hypothesis	Conclusion	Comments
Improved governance by shellfishers improves the health of the Mangrove resource.		No evidence
Improved legal protection at site level improves the health of the Mangrove resource.		No evidence
Women's empowerment improves the health of the shellfishery resource.		No evidence
Higher pressures and threats results in less healthy mangrove resource.		Weak qualitative evidence
Healthier Mangroves leads to Healthier Shellfisheries		Weak qualitative evidence in the opposite direction of expectations

Results

Hypothesis 3: High consumption of shellfish and increased income from shellfishing contributes to lower prevalence of anemia in women of reproductive age.(and improves other nutrition variables). Shellfish consumption is shown as a main contributor to reduced anemia compared to other factors such as malaria or hookworms, geographic factors or household and individual characteristics.

Hypothesis 3 Path Model



No evidence that increased shellfish consumption reduces anemia

Some evidence that shellfish income and wealth factors influence nutrition

Outcome	Predictor	Case level regression (beta coef or odds ratio)	p-value	rho	p-value
Diet diversity score	wealth score	0.07 (0.02, 0.12)	0.01	0.66	0.156
Min diet diversity	wealth score	1.09 (1.01, 1.18)	0.04	0.66	0.156
Food secure or mild insecurity	shellfish income			0.80	0.010
Food secure or mild insecurity	wealth score	1.24 (1.19, 1.31)	0.001	0.83	0.042

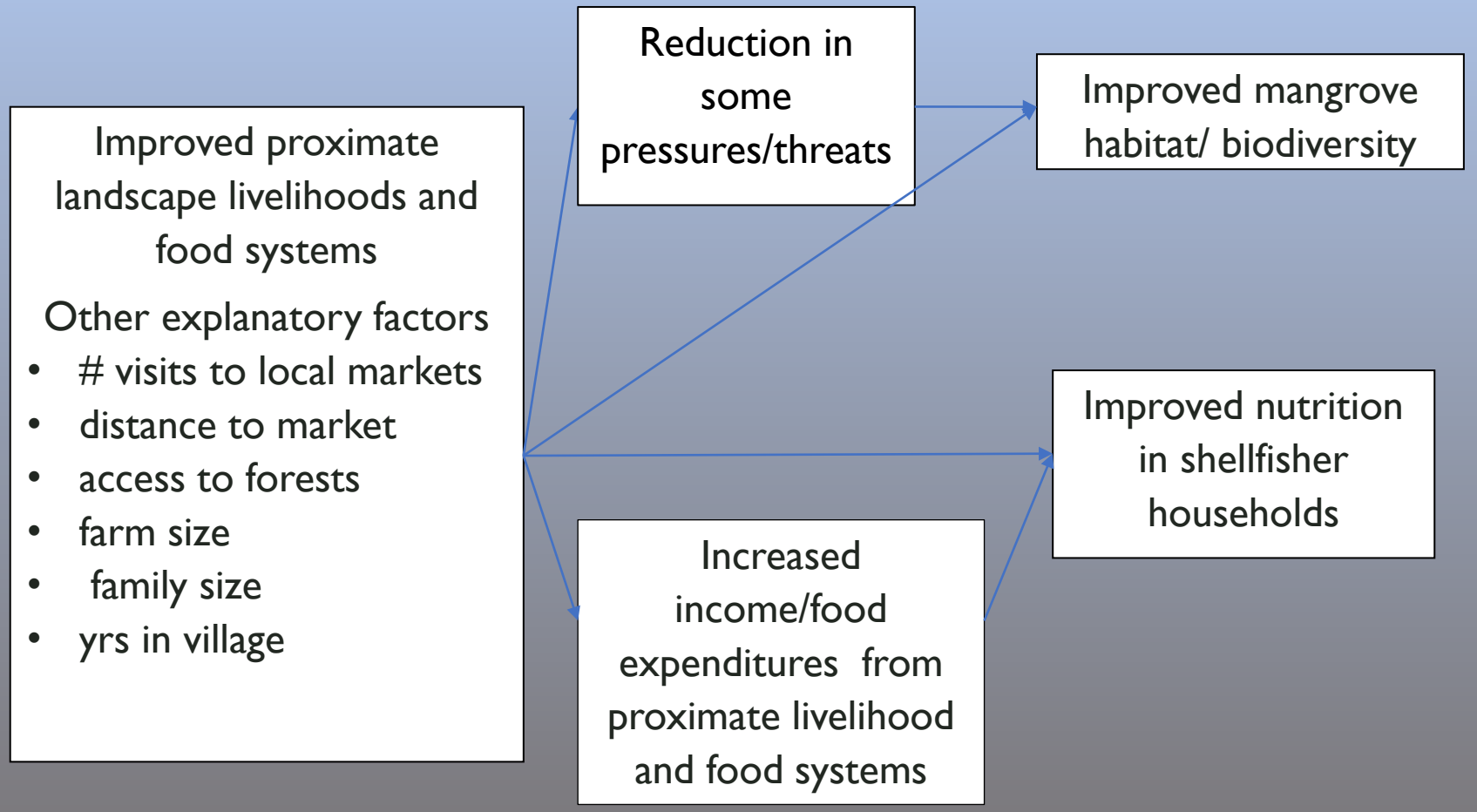
Hypothesis 3 Conclusions

Hypothesis	Conclusion	Comments
Increased shellfish consumption decreases anemia		No evidence Consumption levels very low
Increased shellfish consumption improves nutrition		No evidence Consumption levels very low
Increased shellfish income and household wealth improves nutrition		Some evidence

Results

Hypothesis 4: Enriching landscapes around mangrove-shellfish estuaries systems with complementary food and nutrition sources reduces the extractive pressure on the mangroves thereby improving mangrove health and improves shellfisher household income and household food security.

Hypothesis 4 Path Model



Some weak evidence of value of household diverse food systems

- Inverse correlation of mangrove trajectory and diverse food system may be a coping mechanism.
- Inverse correlation of food expenditure and diverse food system may indicate more subsistence food dependence.

Outcome	Predictor	case level regression (p-value)	Spearman rho (case level)	p-value
Mangrove trajectory	HH diverse food system	0.008	-0.77	0.076
Dietary diversity score	HH diverse food system		0.77	0.072
Min diet diversity	HH diverse food system		0.77	0.072
Per capita food expenditure	HH diverse food system		-0.77	0.072
HH income	HH diverse food system		0.77	0.072

No evidence of per capita expenditures on food consumption or household income influence nutrition in this study.

Hypothesis 4 Conclusions

Hypothesis	Conclusion	Comments
Diverse food systems reduce pressure and threats on mangroves.		No evidence
Diverse food systems increase income.		Weak qualitative evidence
Diverse food systems increase household food expenditures.		Opposite our expectations. Households grow rather than buy food?
Diverse food systems improve dietary diversity		Weak evidence.
Diverse food systems improve mangrove health		Weak qualitative evidence opposite our expectation. May be a coping mechanism to declining resource base?
Increased per capita expenditure on food consumption improves nutrition		No evidence
Increased income improves nutrition		No evidence

Some thoughts for future research

- Increase the number of sites sampled
- All household data in one survey of the same household
- Review variables used and consider different measures where possible
- Time series rather than one off snapshot in time
- The COVID factor?