WATER-SMART AQUACULTURE

Input Use, Efficiency & Productivity in Aquaculture — Odisha, India

Oral presentation framed around water-use efficiency, conservation,
best practices and evidence-based success lessons

Based on: "Input Use, Efficiency, and Productivity in Aquaculture: A Double-Bootstrap DEA Analysis Across Farming Systems, Odisha, India"

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Why water-smart aquaculture is an efficiency problem?

The central message: more inputs do not automatically mean more productive use of water.

3	236	2,000	VRS
Production systems compared	Farmers surveyed in 2024	Bootstrap replications	Input-oriented DEA

Water-smart principle

Use the minimum necessary combination of feed, seed, labour and other operating inputs to sustain the desired output.

Management matters

The study finds that management, experience, technical knowledge, institutional support and infrastructure shape how efficiently resources are used.

Theme relevance — with a caveat

The paper supports resource-efficiency lessons for water management, but it does not estimate direct water withdrawal or litres/kg.

Key message: Efficiency is about reducing avoidable resource use while maintaining production.

Source: Field survey, 2024; study estimates.

Study scope: three contrasting aquaculture systems

Selected districts of Odisha; primary farmer survey conducted in 2024.

POLYCULTURE PONDS

Private earthen ponds
Small-scale farmers
multiple species and inputs

n=119

MIP TANKS

Freshwater tanks under
Minor Irrigation Projects
Community/institutional context

n=62

BIO-FLOC TANKS

Intensive, technology-driven
Tank production
Tight process control

n=54 reported

Key message: Different production systems require different efficiency and water-management strategies.







How the evidence was generated

Double-bootstrap DEA strengthens the efficiency comparison by correcting bias and supporting statistical inference.

1

FIELD DATA

Structured household survey
236 farmers • 2024

2

DEA

Input-oriented VRS
Technical efficiency scores

3

BOOTSTRAP

2,000 replications
Bias-corrected estimates

4

DETERMINANTS

Truncated regression
Efficiency drivers

5

PRODUCTIVITY

OLS with robust SEs
Productivity drivers

Interpretation of TE: a score of 1 indicates operation on the estimated production efficiency; lower scores indicate scope to reduce variable inputs while maintaining the same output, under the model assumptions.

Key message: The study estimates relative efficiency using a statistically corrected approach

Source: Study methods; Stata 18; Simar-Wilson double-bootstrap framework.

Where the input pressure sits: feed dominates variable c

Average values per hectare from farms reporting production data.

Polyculture

Revenue
INR 477,120/ha

Feed
INR 205,699/ha

Labour
INR 103,765/ha

MIP tanks

Revenue
INR 224,670/ha

Feed
INR 39,647/ha

Labour
INR 26,361/ha

Bio-floc

Revenue
INR 53,194/ha

Feed
INR 6,973/ha

Labour
INR 3,924/ha

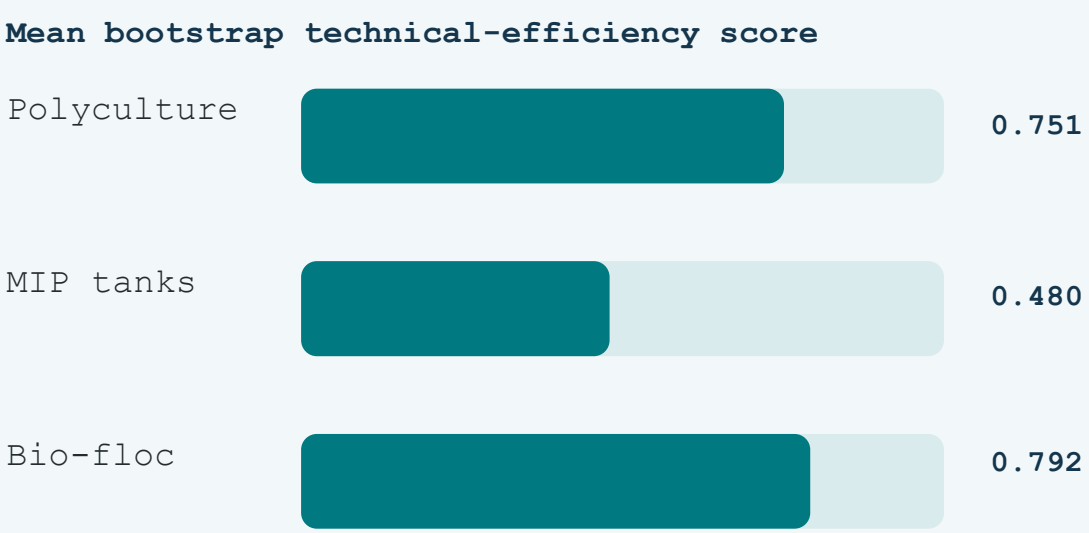
Feed share of variable costs: 57.1% • 53.76% • 36.90% respectively

Key message: Feed optimization is an important entry point for improving both economic and environmental efficiency.

Source: Field survey, 2024; study estimates.

Core result: large differences in technical efficiency

Bias-corrected bootstrap TE scores, input-oriented VRS.



Polyculture ponds

Mean TE = 0.751
≈25% input-use gap relative to production efficiency

MIP tanks

Mean TE = 0.480
≈52% input-use gap relative to production efficiency

Bio-floc tanks

Mean TE = 0.792
≈21% input-use gap relative to production efficiency

Interpretation: higher TE = closer to the estimated production efficiency, not higher production by itself.

Key message: Before increasing resource use, identify and reduce avoidable inefficiency.

Source: Field survey, 2024; study estimates.

What the findings mean for water-use efficiency

A careful translation from input efficiency to water-smart practice.

WHAT THE PAPER DIRECTLY SHOWS

- Efficiency is about producing the same output with fewer variable inputs.
- Management, experience and institutional support affect input optimization.
- MIP tanks have the largest efficiency gap.
- Bio-floc and polyculture are closer to the estimated frontier.

WATER-SMART IMPLICATION

- Avoid unnecessary input intensity around a fixed water resource.
- Match stocking, feeding and labour to system capacity.
- Use continuous monitoring where the technology requires it.
- Prioritize optimization before expansion.

WHAT THIS PAPER DOES NOT MEASURE

- Direct water withdrawal
- Water exchange volume
- Litres of water per kg fish
- Water-quality discharge load

Therefore, no direct water-saving percentage should be claimed from this study.

Theme framing based on the study; direct water-use metrics were not part of the reported DEA inputs.

What drives efficiency? — experience, institutions and a

The regression results show that technology alone is not enough.

Experience	**Positive association across systems**	Learning-by-doing and accumulated management knowledge
Farmer organization / membership	**Positive in selected systems**	Peer learning, technical information, inputs and market linkage
Family size / household labour	**Positive in MIP and bio-floc**	Can support knowledge sharing and routine farm management
Infrastructure / market access	**Context-dependent; remoteness can constrain access**	Transaction costs and access to services matter
Off-farm income	**Negative association with efficiency in the reported models**	Competing management attention can reduce farm focus

Key message: Water-smart production requires capacity building, collective learning and supportive institutions.

Source: Field survey, 2024; study estimates.

Productivity: experience and institutional links matter

OLS results reinforce the role of learning and farmer organization, with effects varying by system.

POOLED RESULT

Aquaculture experience was significantly associated with higher fish productivity ($p<0.01$).

The paper describes this as cumulative learning improving farm decision-making.

MIP SYSTEM

Age of household head ($p<0.01$) and group membership ($p<0.10$) were positively associated with productivity.

This supports peer learning and collective action as management tools.

BIO-FLOC

Gender of household head and distance to district town showed positive associations with productivity in the reported model.

The paper stresses that spatial effects are context-dependent.

Key message: Experience and institutional learning are important components of productive resource management.

Source: Field survey, 2024; study estimates.

Best-practice package by production system

The paper points toward differentiated management — not one-size-fits-all intensification.

POLYCULTURE PONDS

Optimize feed and stocking decisions
Use farmer experience and peer learning
Maintain strong market linkages

INPUT OPTIMIZATION

MIP TANKS

Prioritize input optimization before intensification
Strengthen farmer organizations
Improve management capacity + extension
Reduce transaction/access constraints

MANAGEMENT FIRST

BIO-FLOC TANKS

Continuous monitoring and process precision
Build operator experience
Use skilled/permanent labour where justified
Address knowledge, finance and market

PROCESS CONTROL

Key message: Technology selection and management capacity must go together.

Source: Field survey, 2024; study estimates.

Evidence-based success lessons for water conservation

Not individual farm case studies — system-level lessons emerging from the 2024 field evidence.

LESSON 1 — CLOSE TO THE PRODUCTION EFFICIENCY

Polyculture and bio-floc systems recorded mean bootstrap TE scores of 0.751 and 0.792.

The evidence indicates scope for efficient input combinations without relying only on additional inputs.

LESSON 2 — FIX THE MANAGEMENT GAP

MIP mean TE was 0.480, with 55.56% of MIP farmers in the 0.10–0.40 TE range.

The paper points to input misallocation and insufficient management capacity rather than simply a need for more inputs.

LESSON 3 — INVEST IN PEOPLE + SYSTEMS

Experience, farmer organizations, household labour and access to infrastructure shape efficiency.

Water-smart production therefore needs capacity building, extension, collective action and connectivity alongside technology.

Key message: The most transferable success lesson is to optimize the system before intensifying it.

Source: Field survey, 2024; study estimates.

TAKE-HOME MESSAGE

Water-smart aquaculture is not simply about using less water.
It is about getting more fish from the available resource base with less avoidable input wa

The Odisha evidence points to three priorities:

1. Optimize inputs before intensifying.
2. Build farmer capability, experience and collective learning.
3. Match technology and management practices to each production system.



Thank you

Questions & discussion