Valorization of farm pond biomass as fertilizer for economically recycling phosphorus

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Agricultural Ponds

- 6% of global farmland (78,000 km^2)
- End of the farm
- Ponds/Reservoirs/Stormwater Detention
- 10-15% farm area
- Water supply (irrigation) and quality
- USA
  - Flood protection, nutrient treatment
  - Best Management Practice (BMPs)
  - Gravity, pumped
  - Wetland, wildlife habitat

Phosphorus Losses, Capture, and Treatment

- Long-term P (and N) input and losses
- N, P cause of eutrophication of waterbodies
- Aging Ponds ➡ Legacy P ➡ Soil P saturation
- **P (and N) released**
  - **After large storms**
  - **Annual plant dieback**
- **Annual application of P fertilizer**
- **Shrinking global P reserves**

IMPOUNDMENTS AS A WATER QUALITY BMP

Strategic Location

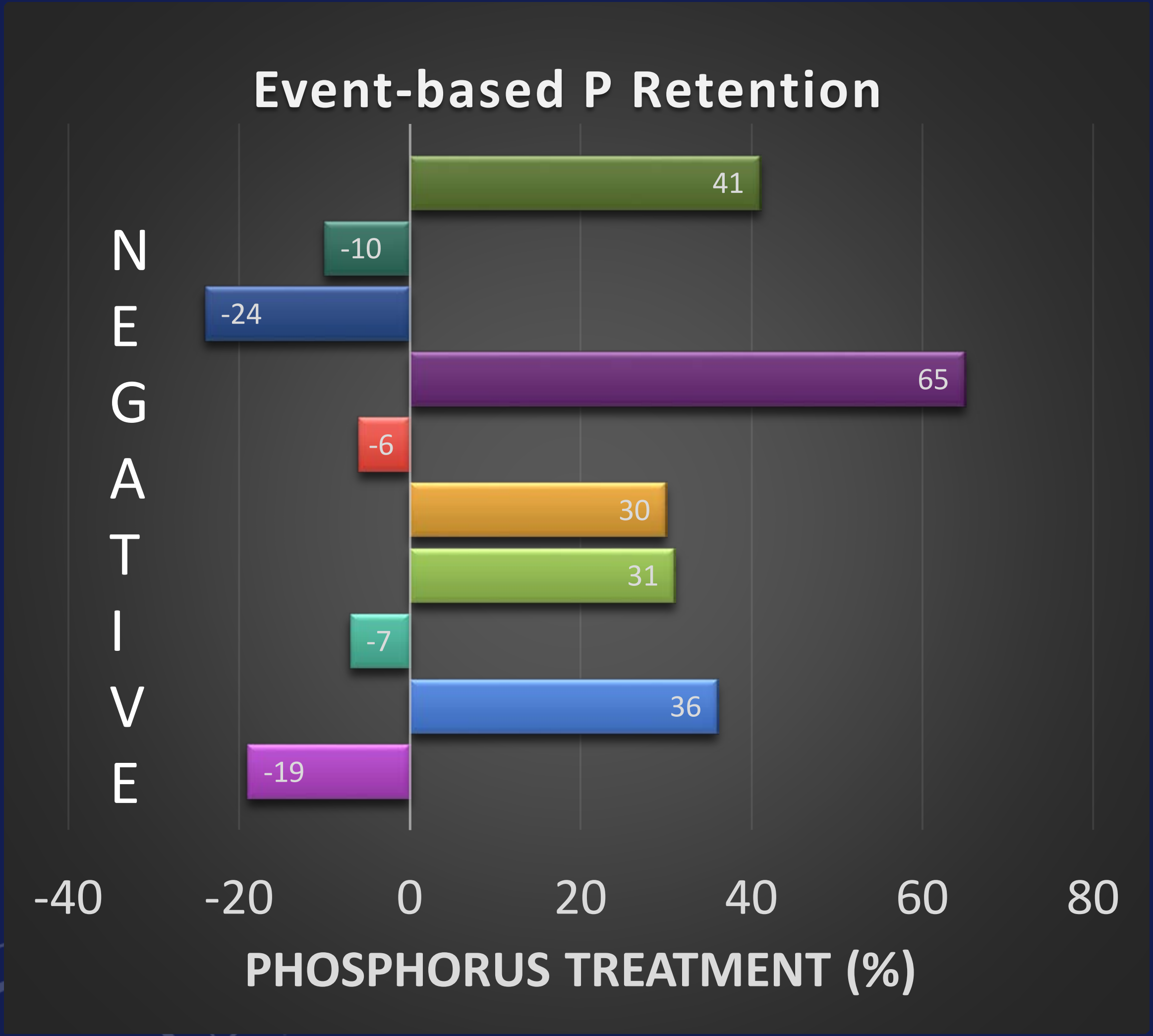
In-farm BMPs

Opportunity to capture and recycle nutrients

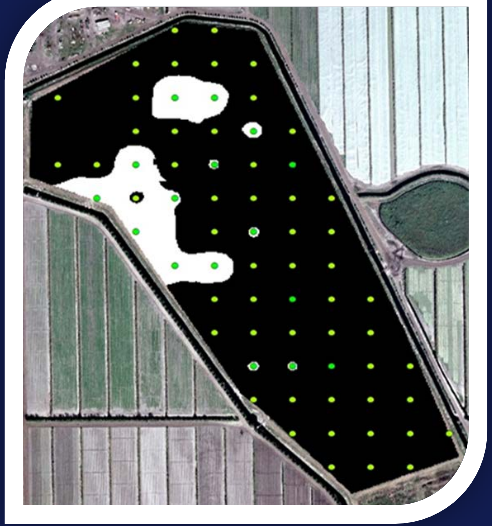
Downstream

Water & Phosphorus Retention: Current

Soil Phosphorus Saturation and Release

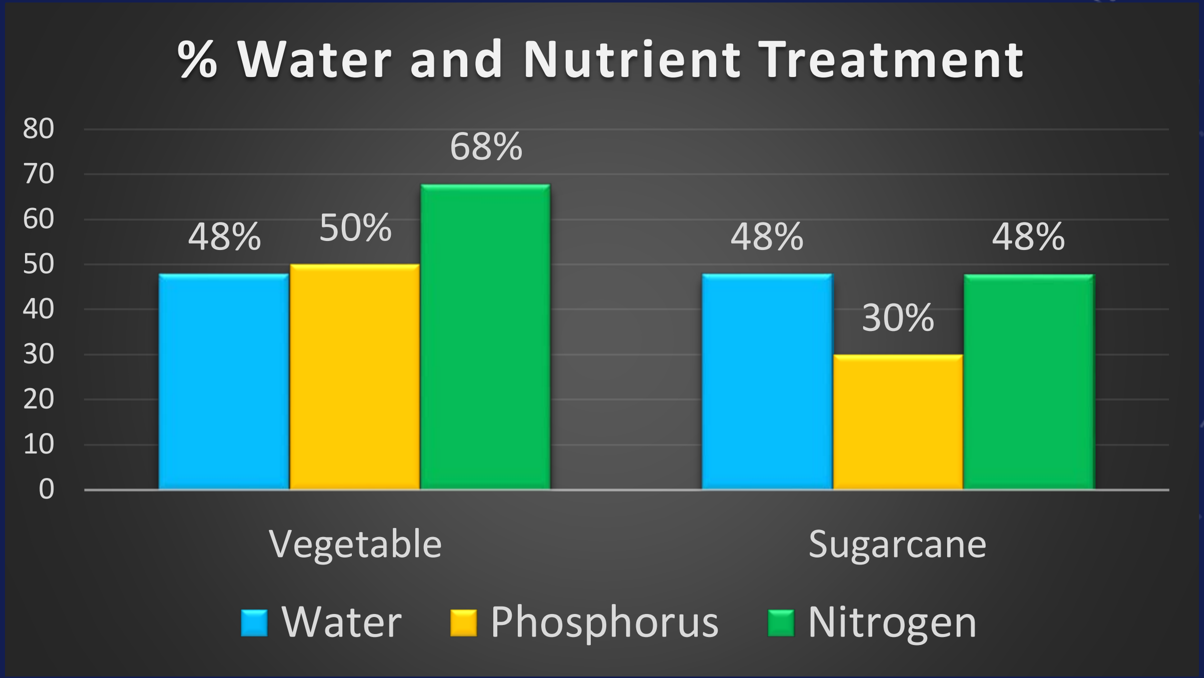


Shukla et al., 2017



Fresh Vegetable
Farm = 112 ha, Pond = 15 ha

Sugarcane
Farm = 122 ha, Pond = 14 ha



Nutrient Capture, Re-use, Long-term Sink

Reducing soil P levels

Limiting vegetation dieback

Biomass Harvesting-Composting: Closing the loop

Biomass Harvesting

- Harvest vegetation at end of growing period (winter)
- Reduces soil P density in the pond
- Eliminates plant-bound P release to water column

Composting

- Harvested biomass as feedstock

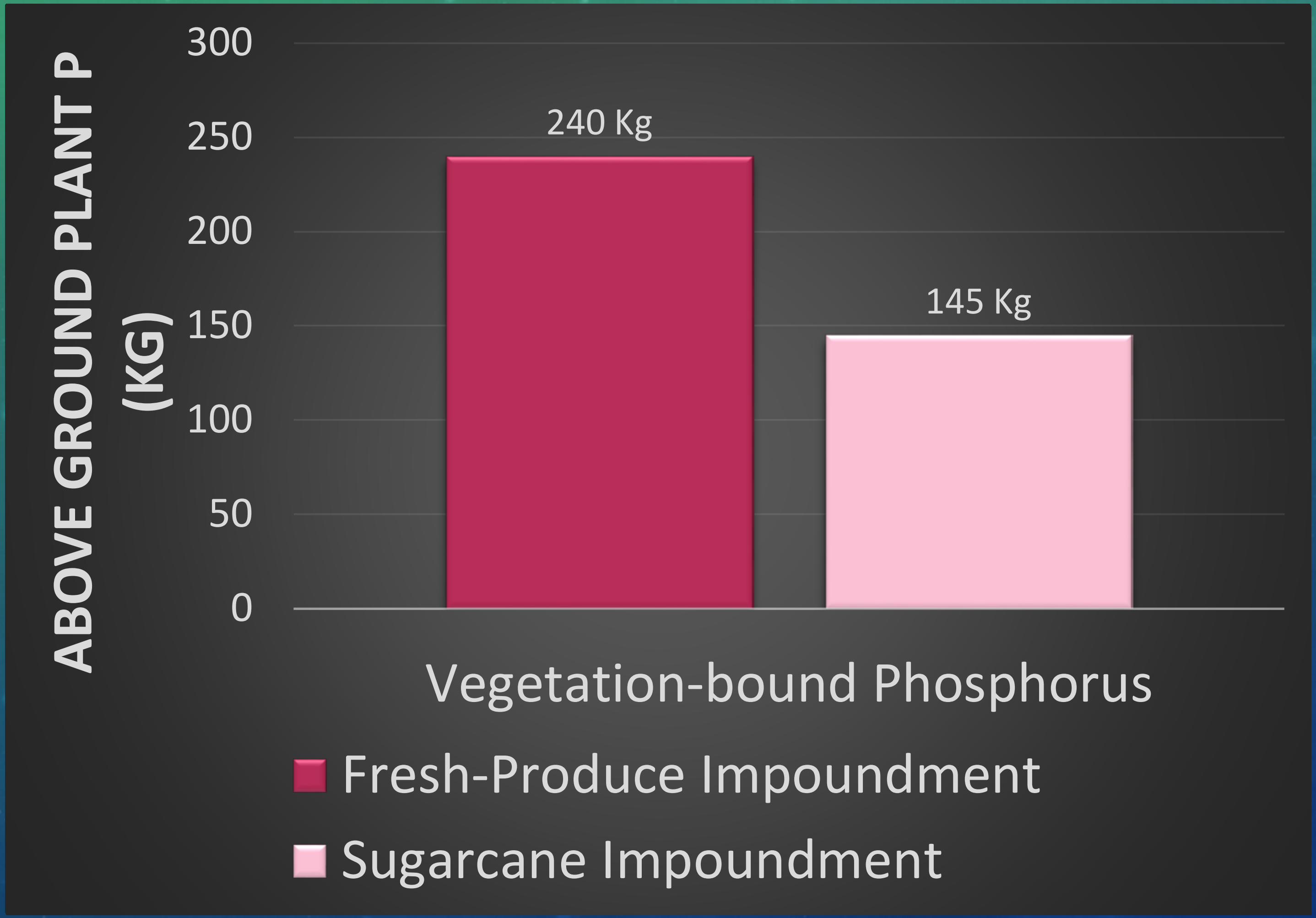
On-farm compost use

- Reduces
  - Irrigation and fertilizer inputs
  - Leaching, drainage (27%), nutrient loads
  - Improves soils health, ecological diversity
  - Reduction in carbon and energy footprints

*Shukla and Pandey, 2006

Biomass Phosphorus

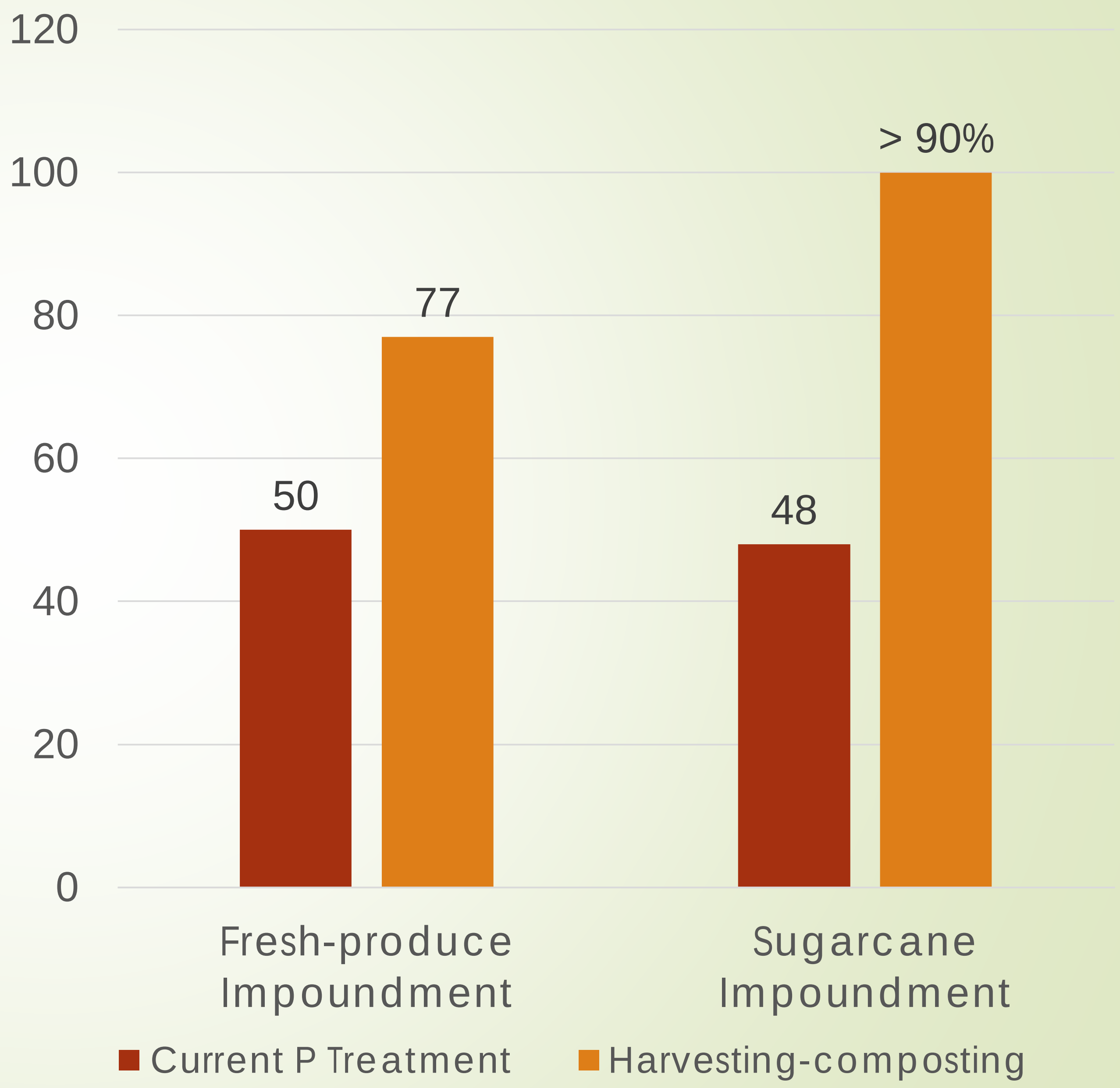
- Vegetation – An important P pool inside the impoundment
- Plant uptake negligible, senescence, decay, and return to soil and water



Harvesting-Composting: Current and Phosphorus Recycling

	Vegetable	Sugarcane
Harvestable P	180 kg	109 kg
Soil P at risk of release	1035 kg	96 kg

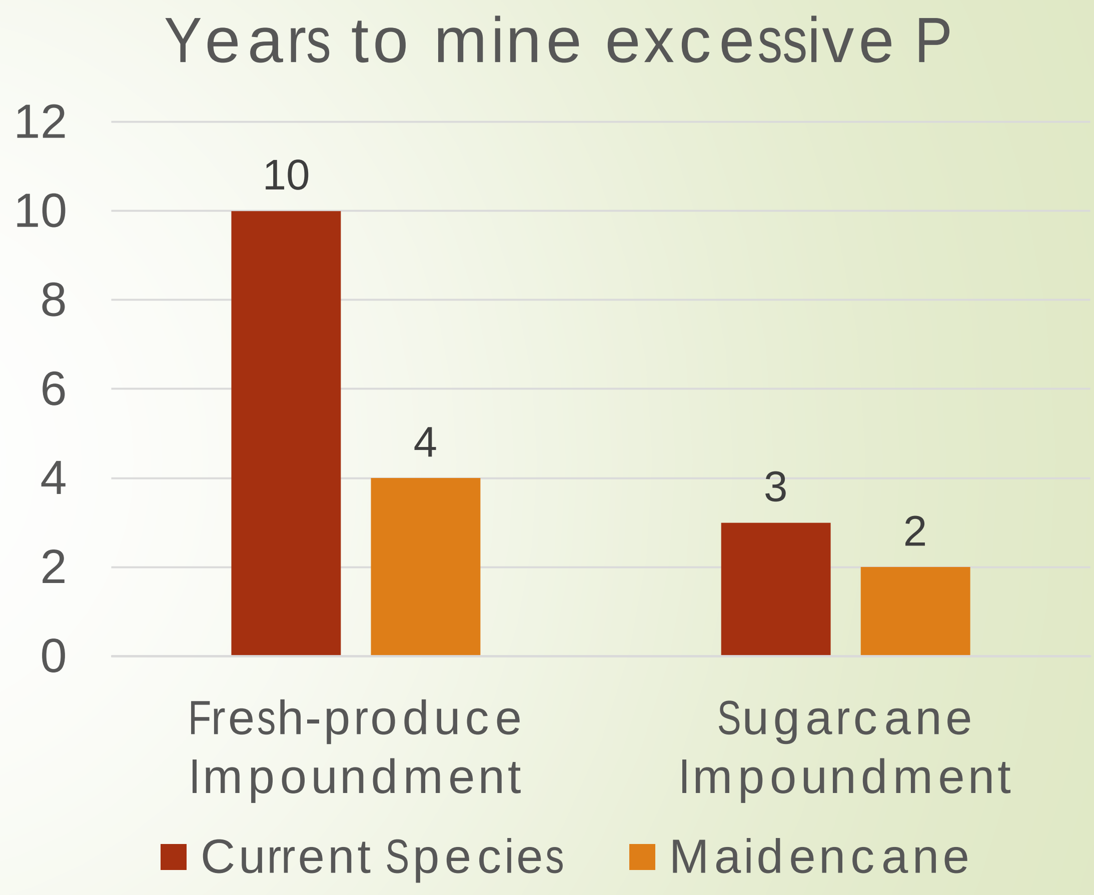
***75% of area is harvested**



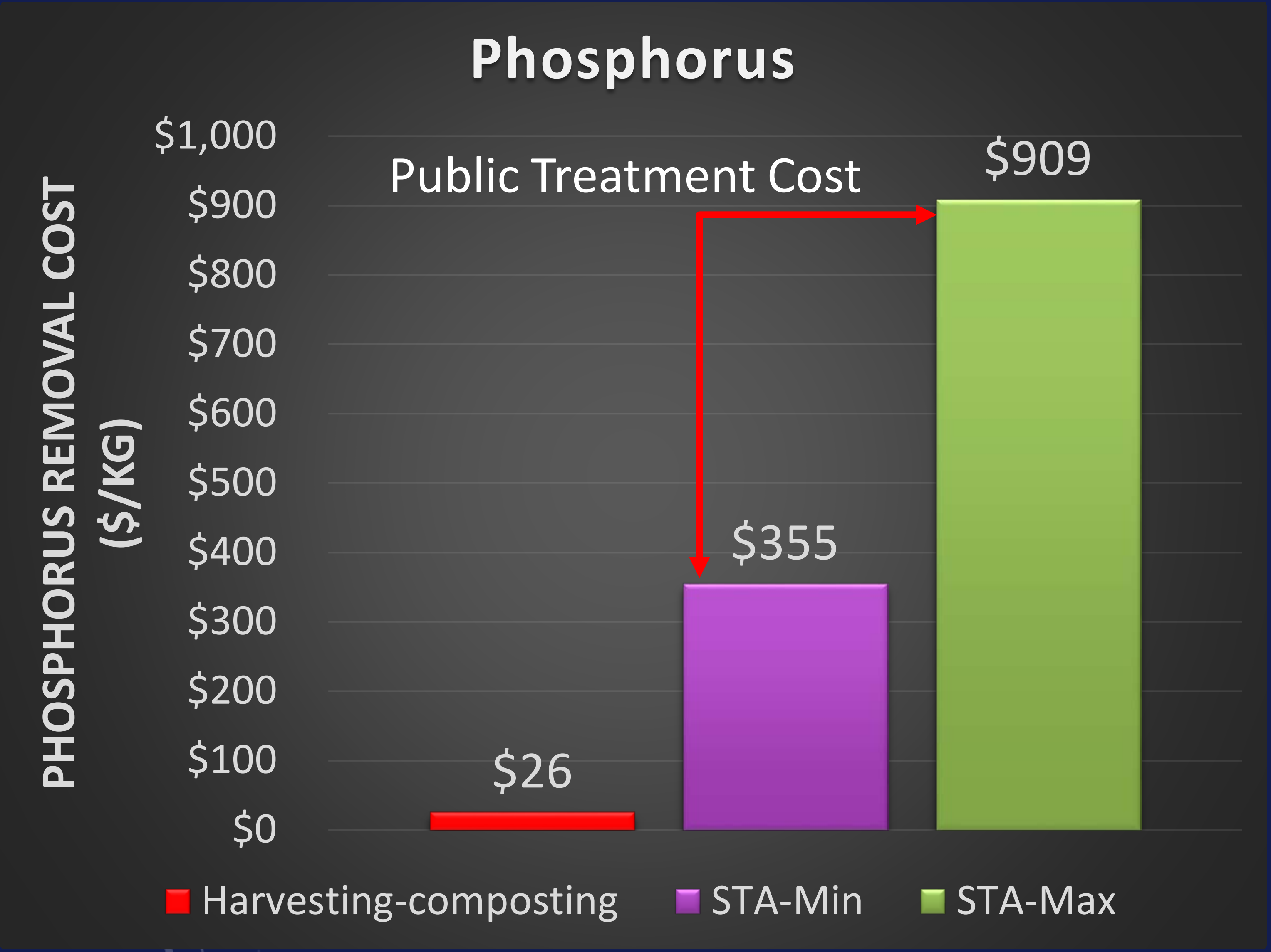
Harvesting-Composting: Vegetation Type

- Invasive plants (e.g., Para grass, cattails, etc.)
- Establish native species (e.g., Maiden cane)
- Harvest current or native species

- Assumptions
  - 2 years to establish Maiden cane
  - 50% stand is harvested every year



Phosphorus & Nitrogen Removal Costs: Current and Recycling (Vegetable)



Nitrogen ($/kg)

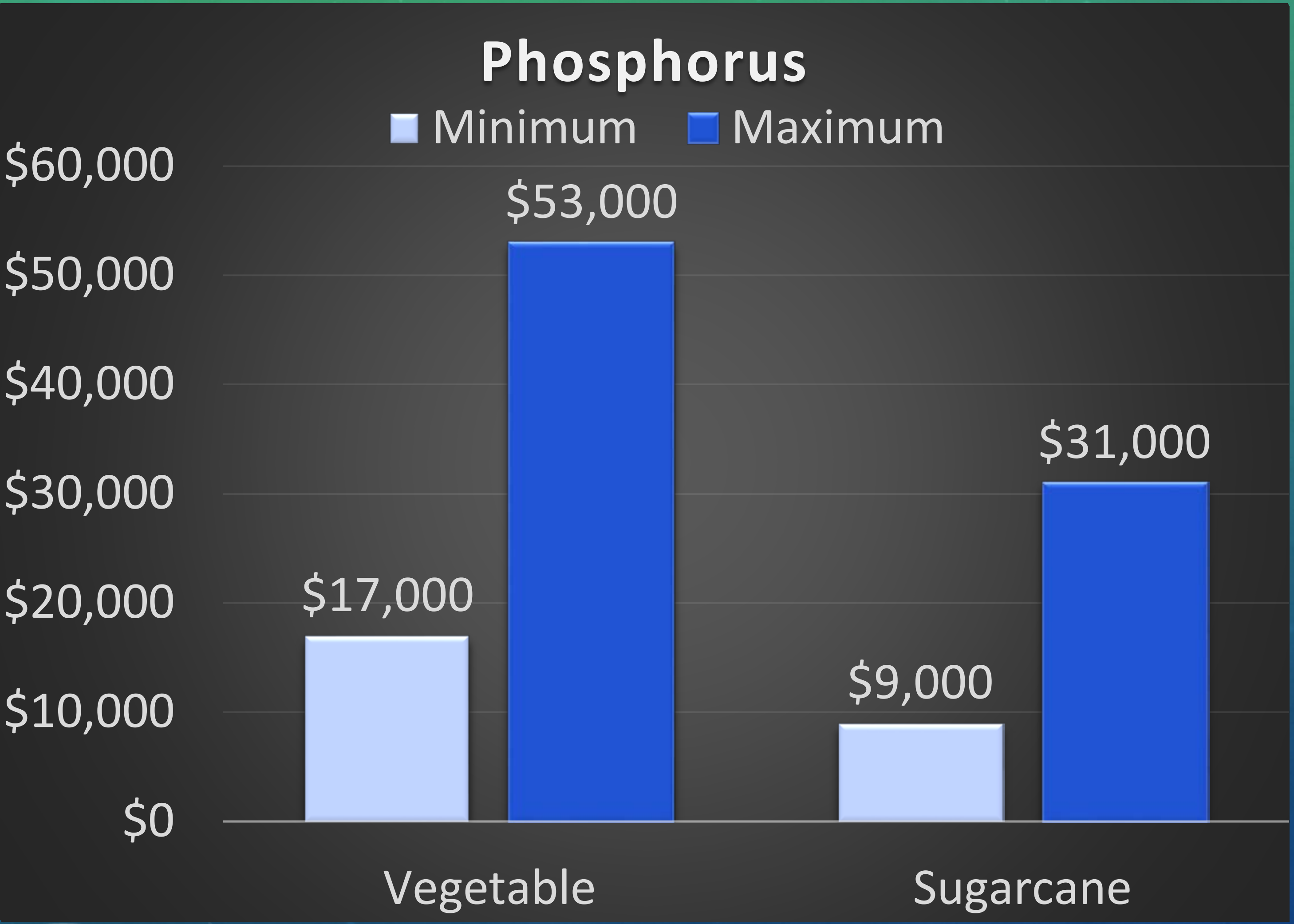
Recycling	Treatment Wetland
$9	$103

Harvesting-composting sustainable and cost-effective

Need Field-verification

STA – Stormwater Treatment Areas (constructed wetlands)

Annual Payments to Farmers for Water Quality Services



Nitrogen Treatment

- **$42,000/yr.**

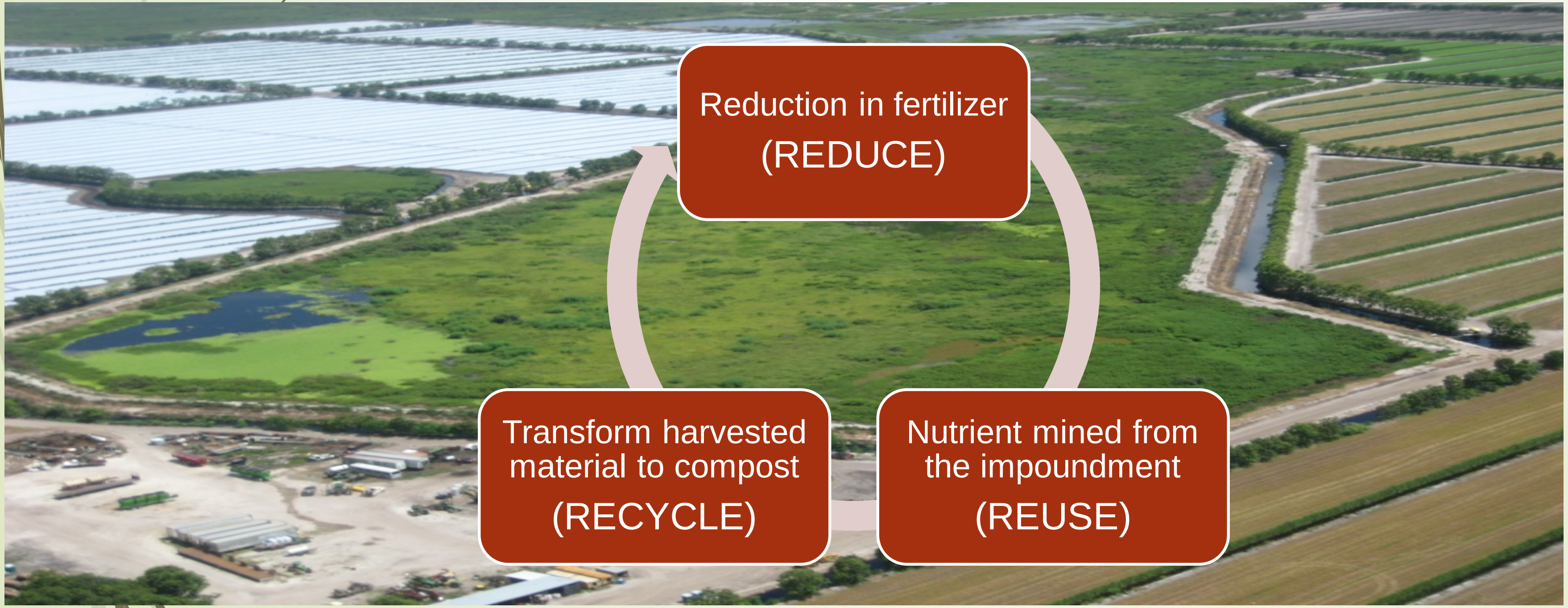
Policy for Long-term P Sink

- Farmers implement harvesting-composting
- **State compensates farmers**
  - **Payment for Environmental Services**
  - **Cost-share**

Circular Nutrient Economy: A Win-win

Reducing soil nutrient saturation through harvesting-composting

Adoption: Payment for Water, Nutrient, Ecological Diversity, Carbon Services

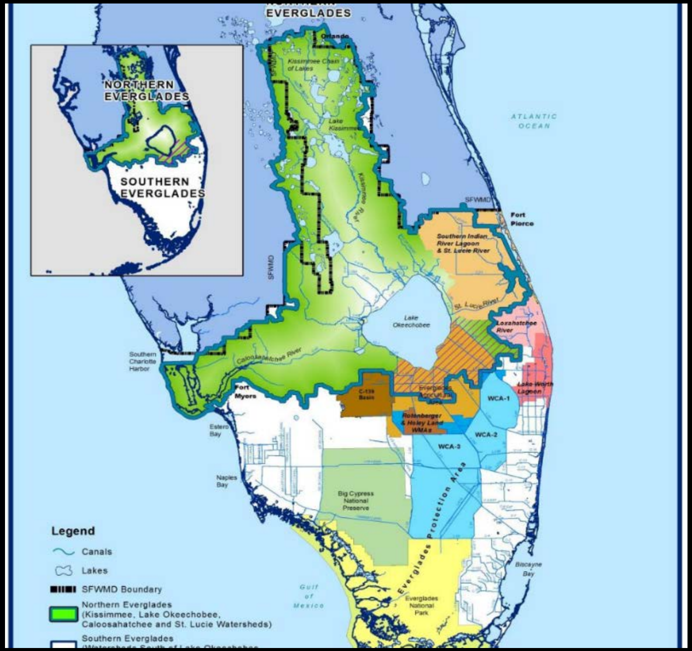


Harvesting-Composting: Basin Scale P Reduction Potential


Courtesy: sugaralliance.org


Courtesy: citrusindustry.net

Harvestable
854 metric tons



2018
Phosphorus Loads to EPA
151 metric tons

MORE INFORMTAION

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- Shukla, A., S. Shukla, and M. D. Annable. 2015. Using nocturnal water level fluctuations for estimating seepage from stormwater detention systems. *Hydrological Processes 26(26): 5465-5476.* DOI: 10.1002/hyp.10600
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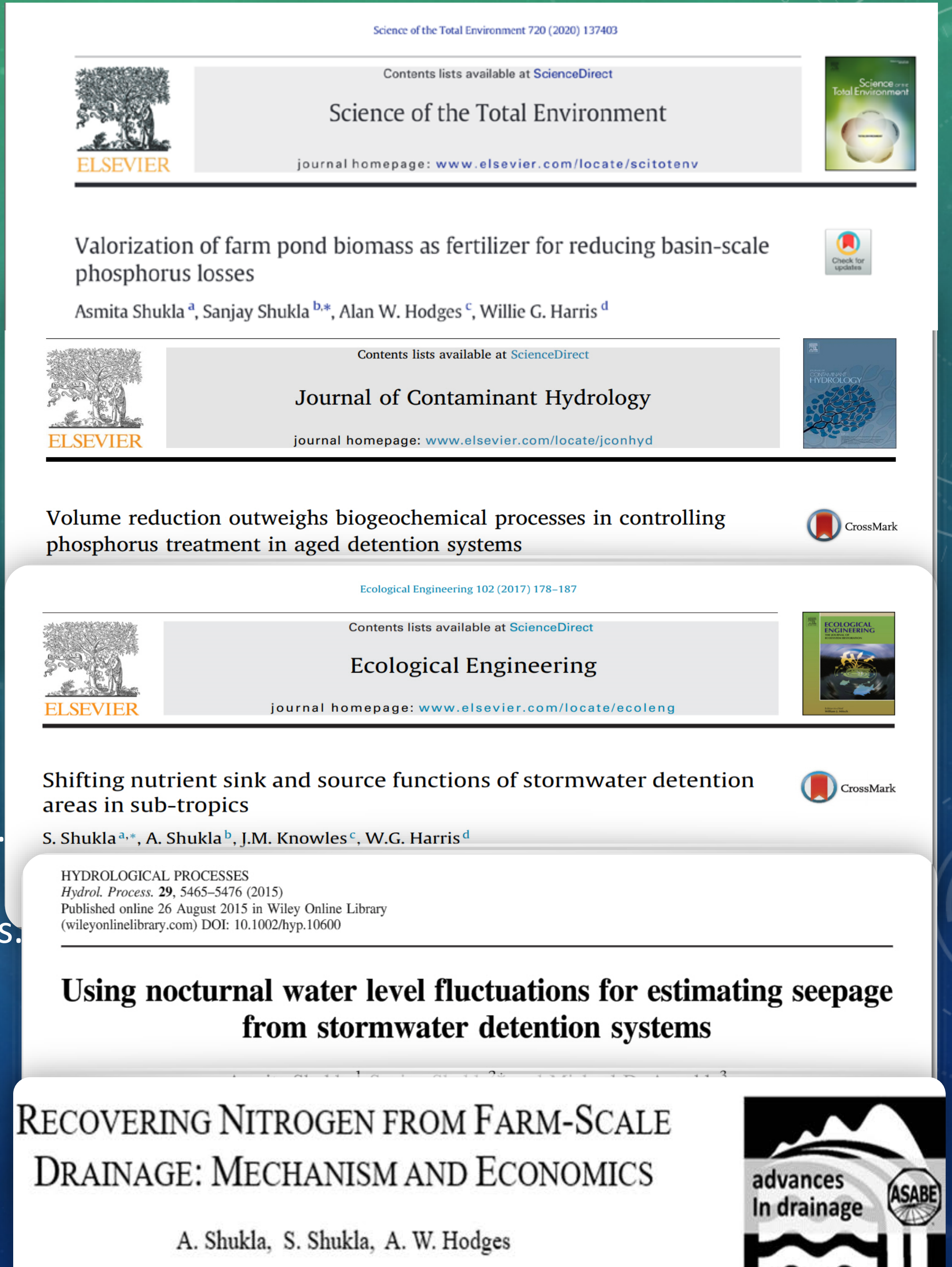
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Using nocturnal water level fluctuations for estimating seepage from stormwater detention systems

RECOVERING NITROGEN FROM FARM-SCALE DRAINAGE: MECHANISM AND ECONOMICS

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