Farmponds for Horticulture: Boon or Curse?
Analyzing Impact on Farm Profitability, Resource Sustainability and Social Welfare

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Organization

• Introduction: Context and the problem statement
• Conceptual model
• Model setup, baseline calibration and scenario details
• Results
• Conclusion
Indian agriculture: the emerging situation

• >50% population in farming; but agricultural output is 15% of GDP

• Government push to increase farm incomes by promoting horticulture
  • High value fruit and vegetable crops; water intensive with need for assured water

• Rising uncertainty in water availability
  • Erratic rainfall, frequent droughts and depleting ground water levels

• Farmponds for water assurance
  • Tremendous popularity in the past decade
  • “Miracle drought-proofing tool”; “game-changer in Indian agriculture”, “response to climate change” [Ansari 2016, Pawar 2012]
  • State Government has announced “Magel tyala shettale” (Farm pond for anyone who demands it)
Farm ponds

• Large plastic lined ponds: Not rainwater harvesting but groundwater storage
• Built in areas with groundwater (GW) uncertainty
• Filled with groundwater during monsoon, used in summer months large evaporation losses
• Owned by economically better off farmers with larger landholding
• Considered by many as exploitative and environmentally unsustainable [Kale 2017]
Objective: Farmponds - Boon or curse?

- To assess the impact of ground water filled farm ponds
  - **Multiple dimensions:** hydrological, economic and social
  - **Multiple stakeholders:** Farmers, state agencies, politicians, economists, environmentalists, policy makers
  - **Multiple goals:** to raise farm incomes, to be drought-resilient, judicious use of a scare resource, maintain social welfare
  - **Dynamic analysis is crucial** because agents adapt and respond

- Model based on extensive data gathering and field observations in different parts of Maharashtra state
Conceptual model: Feedback due to GW uncertainty

Feedback due to rising groundwater uncertainty

- Evaporation loss from farm ponds
- Groundwater demand
- Area under horticulture crops
- Uncertainty in groundwater availability
- Farm ponds

Feedback due to GW uncertainty: 

1. Evaporation loss from farm ponds → Groundwater demand 
2. Groundwater demand → Area under horticulture crops 
3. Area under horticulture crops → Evaporation loss from farm ponds 
4. Evaporation loss from farm ponds → Uncertainty in groundwater availability 
5. Uncertainty in groundwater availability → Farm ponds
Conceptual Model: Feedback due to profitability

Feedback due to relative profitability of farmers with farmponds

- Horticulture Crop yield
  - Farm output value
  - Profitability of FP owning farmers
    + Relative profitability of FP owners
  + Cost of water
    + Groundwater demand
    + Area under horticulture crops
    + Farm pond

+ Unmet irrigation demand: Horticulture
Feedback due to relative profitability of farmers with farmponds

- Profitability of traditional farmers
- Traditional crop yield
- Horticulture crop yield
- Farm output value
- Cost of water
- Groundwater demand
- Area under horticulture crops
- Farm pond
- Unmet irrigation demand: Horticulture
- Unmet irrigation demand: traditional crops

Profitability of FP owning farmers
Relative profitability of FP owners
Conceptual Model: Putting it together

Feedback due to relative profitability of farmponds farmers

Unmet irrigation demand: traditional crops

Unmet irrigation demand: horticulture

Farm output value

Cost of water

Feedback due to groundwater uncertainty

Groundwater demand

Area under horticulture crops

Evaporation loss from farm ponds

Uncertainty in groundwater availability
Model Setup

- Biophysical attributes based on attributes of Gondala village, Hingoli district
  - Geomorphology, soil properties, cropping patterns etc.
- Generalized approach: Watershed divided in 2 zones
  - Zone 1: recharge zone – hilly, poor quality shallow soil causing high runoff
  - Zone 2 discharge zone – better soils, comparatively water rich, primarily agricultural land
- Objective: to study the impact of creating farm ponds in zone 2. System boundary includes both zones to capture stream and ground water flows
Hydrological Model

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>481.63 ha</td>
<td>565.15 ha</td>
</tr>
<tr>
<td>Ground elevation (m)</td>
<td>510 m</td>
<td>465 m</td>
</tr>
<tr>
<td>Average Well depth (m)</td>
<td>7 m</td>
<td>9 m</td>
</tr>
<tr>
<td>Baseline Rabi sown area</td>
<td>200 ha</td>
<td>250 ha</td>
</tr>
<tr>
<td>Baseline Rabi GW demand</td>
<td>200 mm</td>
<td>250 mm</td>
</tr>
<tr>
<td>Bandhara capacity</td>
<td>50 TCM</td>
<td>300 TCM</td>
</tr>
</tbody>
</table>

Our focus is creation of farm ponds in agriculture rich zone 2.
Baseline Calibration

• Monthly time-step (t=0 is June 1\textsuperscript{st}); monsoon rains (t = 0 to 4); winter crop or Rabi extraction (t=5 to 8)

• Model run for 5 years

Well behavior and GW flows consistent with field observations
Change in cropping pattern

- New FP triggers shift in cropping pattern and change in ground water demand
Farmpond losses and GW risk factor

- Monthly ground water demand = crop water demand + water demand to fill FP
- Ratio of GW demand to GW availability: GW risk factor
  - As risk factor rises, more farmers build farm ponds
Profitability and feedback to new FP creation

- Yield and Profitability for each type of farmer computed by allocating groundwater based on priority
- Feedback loop: Relative profitability of FP owning farmers to traditional farmers results in new farmers building FPs
Results: Hydrological impact

Baseflows dry up. No longer any “excess” GW in the system. Any further GW extraction severely impacts GW stock.

Wells no longer fill up to the brim.
Non farm-pond farmers are the first to face unmet irrigation demand. The landless and farmers with shallow wells are impacted for drinking water and livelihoods.
Results: Economic and social impact

Unmet demand leads to fall in yields and profits for traditional farmers. Horticulture crops continue to be profitable longer resulting in more FP investments.
Results: Economic and social impact

Total community profitability reaches a maximum and starts to fall, GW levels deplete yet FP owning farmers continue to profit and FP creation accelerates.

By the time FP farmers are hit, GW crisis is in place and everyone is worse off compared to where they had started.
Conclusion

• Farmpond: contentious topic with strongly polarized stakeholders’ views
• Possible to compute a band of operation within which farm ponds can be beneficial without being unsustainable
• Necessary to regulate this limit of farm pond use. System does not self regulate. Profitable for individuals to invest in farm ponds even as community loses as a whole, ultimately leading to the tragedy of the commons
• Important implications for government programs such as the National Horticulture Mission which subsidize horticulture and creation of groundwater filled farmponds
Thank you
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