
Mohottala G Kularatne, Sean Pascoe, Clevo Wilson, Tim Robinson
Department of Economics, Faculty of Social Sciences, University of Kelaniya
Email: Kule_econ@kln.ac.lk, kuleecon@gmail.com
Mobile: +94718522540

AARES-2016
2-5 February Canberra-Australia
At Park Hyatt Hotel
Overview:

Reservoirs in Sri Lanka

- The reservoir density is about 2.7ha per km² of land area (Fernando, 1993)
- There are four types of reservoirs which are categorised based on their capacity and the functions
  i. Large (major) reservoirs
  ii. Medium sized reservoirs
  iii. Minor perennial reservoirs
  iv. Village irrigations system (VISs)
      (mainly in low rainfall region)
1. VISs located as a cascade system

2. VIS associated with a village
Cont...

3. Water in VISs use for multiple uses
Two main issues of allocation of water

1. Inter-sectoral water allocation

Saving more water for CBF means less water for rice?

Releasing more water for rice means less water for CBF?
2. **Intra-sectoral water allocation**

![Diagram showing types of fields: Head-end fields, Middle fields, Tail-end fields, and the reservoir.](image)
Solution for intra-sectoral allocation: Share cropping system (Bethma)

Water is not sufficient to cultivate the entire area!

Let’s cultivate land in one part located at the head-end, this will diminish water losses, through seepage and percolation!!
Is this *haphazard method of water allocation* (share cropping system or Bethma system) *technically efficient*?
Share cropping system/Bethma?

1. **Non-cultivation of one or two tail-end zones** in times of water scarcity simply is Bethma (Leach, 1961; Uphoff et al., 1981; Gunaratne & Madduma Bandara, 1989).

2. **The redistribution of land whereby top-end farmers give lands to tail-end farmers**, is a *government intervention* (Leach refers to Bethma as described by Farmer (1957)).


4. **The cultivation of a different part of the command area in consecutive years.** Some authors found that some kind of payments to land giving farmers by land receiving farmers (Begum, 1987; Perera, 1986; Murray- Rust & Rao, 1987).
General features of the Bethma

1. The cultivation of only part of the command area when water is not sufficient to cultivate the entire area

2. The concentration of the cultivated land in one part to better control the water and if located at the top end, diminish water losses through seepage and percolation

3. Access to water by both top enders and tail enders

4. Bethma also is a solution for top and tail conflicts of water shearing
Technical efficiency (TE)

In general, TE is ‘the ability of a firm to obtain maximal output from a given set of inputs vector’ or ‘the ability to minimise input use in the production of a given output vector’ (Kumbhakar & Lovell, 2000; Coelli et al., 2005).

Technical efficiency (TE) in the context of “Bethma” system is the ability of all farmers to obtain maximal output from a available volume of water in the reservoir.
Research Methods

1. Data

(i). Secondary data: Digital database of VIS in Sri Lanka (Department of Agrarian Development, 2000)

(ii). Primary data: Collected from a sample survey form 14 villages associates with the VISs, total sample is 460 farmers from three locations in the command area.

2. Sample

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance from dam (Metres)</th>
<th>No of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-end fields</td>
<td>Less than 1000</td>
<td>160</td>
</tr>
<tr>
<td>Middle fields</td>
<td>1000 to 2000</td>
<td>152</td>
</tr>
<tr>
<td>Tail-end fields</td>
<td>Above 2000</td>
<td>148</td>
</tr>
</tbody>
</table>

3. Data Collection

Face-to-face interview with selected rice farmers using a pre-tested questionnaire

4. Data Analysis

The Stochastic production functions were estimated following a Simple three steps procedure for imposing theoretical consistency of the translog production functions (Henningsen & Henning, 2009).
Model for estimating technical efficiency for rice farming

\[
\ln Y_i = \beta_0 + \sum_{i=1}^{5} \beta_i \ln x_{i,k} + \frac{1}{2} \sum_{i=1}^{5} \sum_{k=1}^{5} \beta_{i,k} \ln x_{i,k} \ln x_{i,l} + v_i - u_i
\]

- \( x_{r1} \) = individual volume of water use by \( i^{th} \) farmer (M/ha)
- \( x_{r2} \) = labour (total operational man days in rice farming)
- \( x_{r3} \) = mechanical power (minutes)
- \( x_{r4} \) = irrigating time/total time for irrigating (minutes)
- \( x_{r5} \) = pesticides (ml)
- \( \beta_i \) = the parameters to be estimated
- \( u_i \) = technical inefficiency
- \( v_i \) = random error
Inefficiency model

\[ U_i = \delta_0 + \sum_{j=1}^{11} \delta_j Z_{ij} \]

- \( Z_1 \) = farmers’ age (years)
- \( Z_2 \) = farmer’s education level (years)
- \( Z_3 \) = participatory rate for activities of Farmer Organisation (FO)
- \( Z_4 \) = membership of FO (Dummy; 1 = yes, 0, otherwise)
- \( Z_5 \) = paddy field location (Dummy; 1 = located at head-end, 0, otherwise)
- \( Z_6 \) = paddy field location, (Dummy; 1 = located at the middle, 0, otherwise)
- \( Z_7 \) = locational water sharing issue (Dummy; 1 = yes, 0, otherwise)
- \( Z_8 \) = paddy field ownership (Dummy; 1 = own land; 0, otherwise)
- \( Z_9 \) = use of insecticides (Dummy; 1 = yes, 0, otherwise)
- \( Z_{10} \) = use of weedicides (Dummy; 1 = yes, 0, otherwise)
- \( Z_{11} \) = success of field level water management (%)
Results of estimated sectoral technical inefficiency models

<table>
<thead>
<tr>
<th>Inefficiency variables of the models</th>
<th>HEFs</th>
<th>MFs</th>
<th>TEFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of farmer</td>
<td>0.0047</td>
<td>0.0206**</td>
<td>0.0036</td>
</tr>
<tr>
<td>Farmer’s education level</td>
<td>-0.0060</td>
<td>0.0241</td>
<td>0.0572*</td>
</tr>
<tr>
<td>Participation rate for FO activities</td>
<td>-0.0121*</td>
<td>-0.0045</td>
<td>-0.0115</td>
</tr>
<tr>
<td>FO membership</td>
<td>-0.5929**</td>
<td>-0.3872*</td>
<td>-0.7195*</td>
</tr>
<tr>
<td>Water sharing issues</td>
<td>0.9149**</td>
<td>0.3924*</td>
<td>1.4232*</td>
</tr>
<tr>
<td>Land ownership</td>
<td>0.4594*</td>
<td>-0.0142</td>
<td>-0.1194</td>
</tr>
<tr>
<td>Use of insecticides</td>
<td>1.0500**</td>
<td>0.6648*</td>
<td>2.8940</td>
</tr>
<tr>
<td>Use of weedicides</td>
<td>-0.8458*</td>
<td>0.0826</td>
<td>-3.4103</td>
</tr>
<tr>
<td>Success of field level water mgt</td>
<td>-0.0096**</td>
<td>-0.0117**</td>
<td>-0.0072</td>
</tr>
</tbody>
</table>

Notes: significance at * 10%, **5%, ***1%.
Results of average productions and the TE scores

Intra-sectoral Average Production and level of Technical Efficiency Levels

<table>
<thead>
<tr>
<th>Location</th>
<th>Average production (Kg/ha)</th>
<th>Technical efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-end fields</td>
<td>1078</td>
<td>74</td>
</tr>
<tr>
<td>Middle fields</td>
<td>1076</td>
<td>55</td>
</tr>
<tr>
<td>Tail-end fields</td>
<td>1409</td>
<td>80</td>
</tr>
</tbody>
</table>
The FO membership, participation rates in FO activities and field level water management are positively influencing TE all three sectors.

Water sharing issues is more statistically significant factor which has a negative influence on technical efficiency in MFs and TEFs.

The relationship between average production and distance has no negative relationship in the command area as found by Daleus et al. (1989).

Tail-end fields are more productive and efficient in VISs.

Improvement of collective action and individual field level water management, increases in efficiency of intra-sectoral allocation of water.
Reasons for high technical efficiency in HEFs and TEFs.

There are two factors for higher TE in TEFs

1. The length of water retention period and
   water retention days per one water intake
   - HEFs: 2 days.
   - MFs: 2-3 days,
   - TEFs: 4 days.

   This is dependent on the soil type, slope and the water management practices of individual farmers.

2. Soil fertility

   Soil fertility is rich in TEFs with the inundation from the downstream reservoir
Cont…. 

There were three main factors increase soil fertility due to inundation of the TEFs:

1. **Sedimentation of organic material** due to submergence of TEFs during the high rainfall season (Daleus et al., 1988).

2. **Higher level of ground water and a higher clay content** of the soil (Daleus et al., 1988) due to siltation during the inundated period of the downstream.

3. **The effect of grazing by cattle and water buffalos** in the command area (Seniviratne, Kulasooriya, & Rosswall, 1994).
Policy implications

1. **Improvement of collective action** and individual field level water management can increase efficient intra-sectoral allocation of water by promoting alternative economic activities (i.e. CBF production in VIS).

2. Farmers will be motivated to manage their water demand not only through enforcement of rules, but also through the development of an understanding of the importance of an efficient water use in rice farming to increase reservoir water productivity as well as their incomes.