Reservoir Water Re-allocation and Community Welfare

Mohottala G. Kularatne\textsuperscript{a}, Sean Pascoe\textsuperscript{b}, Clevo Wilson\textsuperscript{c}

Emails: kule_econ@kln.ac.lk\textsuperscript{a}, Sean.Pascoe@csiro.au\textsuperscript{b}, Clevo.wilson@qut.edu.au\textsuperscript{c}
This paper examines whether the re-allocation of water to more efficient, high return uses would increase the total economic welfare of farmer community.

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Introduction

Water resources in Sri Lanka

The Island is surrounded by marine and brackish water

We are also rich in inland waters too.

- 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
  1. Large (major) reservoirs
  2. Medium sized reservoirs
  3. Minor perennial reservoirs
  4. Village irrigations system (VIS)
Basic economic characteristics of water in VIS as a commodity

<table>
<thead>
<tr>
<th>Basic characteristics</th>
<th>Total volume of water</th>
<th>Volume of water used for rice farming</th>
<th>Volume of water used for competing demands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Multiple</td>
<td>Used only for agriculture</td>
<td>Multiple uses</td>
</tr>
<tr>
<td>Price/costs</td>
<td>No cost for individuals</td>
<td>Minimum individual costs involved</td>
<td>No costs for individuals</td>
</tr>
<tr>
<td>Property rights</td>
<td>Weakly defined PR</td>
<td>Defined (PR) under FOs</td>
<td>Weakly defined PR</td>
</tr>
<tr>
<td>Excludability</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Rivalrous</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: Adapted from Baily (1995)

Notes: FOs: Framers organisations
Farmers Question on water use

Saving more water for **CBF** means less water for rice?

Releasing more water for rice means less water for CBF?
Existing inter-sectoral water uses assumed to be inefficient due to:
   (i). Market imperfections (Hanley et al., 1997; Li & Ng1995)
   (ii). Weak water user rights (Meinzen-Dick & Bakker, 2001)

Existing Intra-sectoral water use (rice and CBF farming) assumed to be inefficient due to:
   (i). Head-tail syndrome (Chakravorthy & Roumasset, 1991; Daleus et al., 1989)
   (ii). No water user rights (Amarasinghe, 2010; De Silva, 2003)

Suggested solution is re-allocating water from low to higher valued alternatives (Molden, 2010; Howell, 2001)

This paper examines whether the re-allocation of water to more efficient, high return uses would increase the total economic welfare of farmer community.
Research Design

i. Data

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

This database provides data related to the capacity of individual reservoirs but no field level data on rice and CBF farming is available.

(ii). Primary data, collected from two sample surveys:
   a. Rice farmer survey (sample size = 460) and
   b. CBF farmer survey (Sample size = 325)

(ii). Data collection:

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

(iii) Units of analysis

   Individual farmers in rice farmer survey
   CBF farmer groups in CBF survey
The method we analyse the issue/ **Analytical methods**

- Three main analytical methods are used:
  1. **Stochastic production frontier** estimation (for estimate technical efficiency of current water uses in rice farming and CBF production)
  2. Estimation of **optimal allocation** based on the equi-marginal condition for inter and intra sectoral water allocation
  3. **Consumer surplus estimation** for benefit calculations on the basis of the water demand functions for rice and CBF

- The production functions were estimated following a **simple three step** procedure for imposing **theoretical consistency** of the translog production functions (Henningsen & Henning, 2009).

  The models are estimated using the following software in each steps:

  - Step 1. FRONTIER, R:micEcon
  - Step 2. R:constrOptim|solve.QP|optim.
  - step3. FRONTIER, R:micEcon.
Results of technical efficiency of rice farming

➢ Collective action has significant positive influence on technical efficiency
➢ Water sharing issues (inter and intra sectoral) are the most significant (at 1% level) and the influential factor to decrease technical efficiency
➢ Mean technical efficiency is 73% and the distribution is skewed with most farmers achieving a high level of technical efficiency
Results of technical efficiency of CBF production

- Fish species with slow growth rates and the number of months of water use for other purposes (multiple use of water) had a positive effect on technical efficiency.

- The time spent meeting officials, supply of subsidised fingerlings, the expectation of receiving adequate rain water to the reservoir are negative factors that leads to technical inefficiency.

- Subsidies and transaction costs are two drawbacks in improving technical efficiency.

- In order to achieve a higher level of efficiency gains, it is important to strengthen group stability for solving water disputes, improving quality of consultation with officials and promoting independent investments in CBF.
Results of inter-sectoral water allocation

- Actual allocation decision is not efficient. This has to be increased by 25% for rice farming and has to be decreased by 42% for CBF.

- There is a huge potential (threefold) to increase MVP of CBF production at the level of frontier production from the actual level of allocation.

- This water should be re-allocated by reducing the actual allocation by 32% and 53% of water saved can be reallocated for CBF.
Results of intra-sectoral water allocation

- 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 VIS.

- Improvement of collective action and individual field level water management, increases in efficiency of intra-sectoral allocation of water.

- The existing intra-sectoral inefficient volume of water use in tail-end fields and head-end fields can potentially be removed by 10% and 23% respectively of actual usage and re-allocated for middle fields by approximately 63%.

- This re-allocation predicts a twofold increase in MVP of water use for rice farming without reducing existing rice output.
## Results of water re-allocation

<table>
<thead>
<tr>
<th>Production types</th>
<th>Consumer surplus for water demand</th>
<th>Changes of consumer surplus with water re-allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing level</td>
<td>Frontier level</td>
</tr>
<tr>
<td>Rice farming</td>
<td>38756</td>
<td>-26712</td>
</tr>
<tr>
<td>CBF production</td>
<td>-20318</td>
<td>29828</td>
</tr>
<tr>
<td>Total surplus</td>
<td>18438</td>
<td>3115</td>
</tr>
</tbody>
</table>

With the increase in water efficiency by approximately 32%, farmers’ TNB increase by LKR 21,553 (AUD 215) for M/ha of water used for reservoir based agriculture.
Discussion and Conclusions

The total MVP of VIS can be increased by threefold with efficient usage of water. This increases farmers’ welfare.

Increase in technical efficiency of current water use is essential in order to save water in VIS.

The enhancement of institutional capacity of FOs are important for solving inter and intra-sectoral water sharing issues.

Increase in the total reservoir water productivity and farmers’ welfare are mainly attributed to marginal productivity of water used for CBF production. Therefore, promoting CBF activities are an incentive for the efficient use of water in VIS.

Improvement of collective action and individual field level water management can increase efficient intra-sectoral allocation of water by promoting CBF production in VIS.

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.
Policy implications and recommendations

Application of a community transferable quota system (CTQ) which is similar to existing *thattumaru* system, combined with co-management of water resources is a suitable policy that can be employed for promoting transferable water user rights for CBF.

Figure 3. Recommended Co-management settings for reservoir-based agriculture in VIS
Thattumaru is the rotational cultivation of one plot of land by several children within one household.

One of the children cultivates the entire plot for one season, the next season another son / daughter will cultivate the entire plot, etc.

Thattumaru prevents the division of land into smaller and smaller plots.

In each village, Thattumaru is applied on average by 4 or 5 families with small landholdings.

Thattumaru is practiced to prevent conflicts among children. Thattumaru is most likely to be practised when further fragmentation of lands within a family is no longer feasible.
Thank you

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