Green vs modernity and community governance: water allocation and reservoir-based agriculture in village irrigation systems of Sri Lanka

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Abstract

Traditional agriculture in many parts of the world has ensured the sustainability of subsistence economies and its non-commodity contribution has secured environmental sustainability. For example in Sri Lanka, village irrigation systems (VISs) have been managed by the village community. As a result of unplanned modernisation of rural agriculture, integrated sustainable farming systems have collapsed and also weakened community governance. Therefore, existing allocation mechanism for reservoir water fails to achieve the maximum social benefits.

This paper examines the challenges of community governance in order to re-establish green reservoir-based agricultural production in VISs within the framework of a market economy. This paper analyses the issue of water allocation by using primary data collected from of 460 rice farmers and 325 fish farming groups in two administrative districts in Sri Lanka. Technical efficiency estimates are undertaken for both rice farming and culture-based fisheries (CBF) production. The equi-marginal principle is applied for the allocation of water. Welfare benefits of water re-allocation are measured through consumer surplus estimation.

The results show that the estimated mean technical efficiencies (TE) for rice farming and CBF production are 72% and 33% respectively. The most influential factors of TE of rice farming are membership of Farmer Organisations (FOs) and the participatory rate in collective actions organised by FOs. Removing subsidies, improving consultation with extension officials and water user rights were found to be key actions that could improve TE of CBF production. We suggest that integrated forestry, animal husbandry, fishery and rice farming in VISs, no doubt will enhance farmer incomes and community welfare within a market economy framework. With application of co-management of water and a community transferable quota system for CBF development, there is potential for a threefold increase in marginal value product of total reservoir water, while allowing market forces to guide the efficient re-allocation decisions.

Key Words: Reservoir-based agriculture, culture-based fishery, village irrigation systems, co-management, community transferable quota system

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1. Introduction

A critical issue involving water use is to ensure that producers consider the consequences of their decisions, and how such decisions could lead to the depletion of water resources. A solution to this vexed issue is to either allow the relevant institutions to allocate resources systematically or to leave the problem of resource allocation to the market to determine the allocation based on the largest benefits (Bostock et al., 2010). Water transfers between competing sectors have received much attention in the western world, while intra sectoral water management is given higher priority through much of Asia: from China to Viet Nam, the Philippines, Indonesia, and India and Sri Lanka. The diversity of water rights agreements between users and the livelihood strategies adopted by the affected communities make these issues even more complicated. The main drivers responsible for increasing the demand for water use (and hence water allocation) are growing population, expanding urbanisation, ineffective and conflicting government policies, overlapping and often contradictory legislation as well as policies and declining motivation for traditional collective action norms. In addition, policies on investments, agricultural subsidies, and foreign direct investments, which directly target water, have often contributed to the growing demand and re-allocation of water issues and problems (Meinzen-Dick and Claudia, 2006).

In many Asian countries, water ownership, allocation and water rights are not well established (Dennis and Arriens, 2005). This issue is important because water in small-scale irrigation systems is treated as a common property resource. In such situations it is important to consider the value of water and its alternative uses so that it can facilitate re-allocation decisions (Kadigi et al., 2004). Therefore, the development of a water allocation model for reservoir water use is needed to cater to competitive demand (Dudu and Chumi, 2008) especially, where water rights have not yet been established (Dennis and Arriens, 2005). However, increasing scarcity and competition between users are significant determinants (Meinzen-Dick and Bakker, 2001) in the area of water allocation in small-scale irrigation systems. Therefore, the need to develop an optimal water allocation model taking into consideration the full economic and social returns of all water users is significant (Meinzen-Dick and Jackson, 1996). However, little work has been undertaken to demonstrate the potential magnitude of the economic gains of water users in village irrigation systems[1] (VISs) in Sri Lanka.

The VISs are distributed over the entire low rainfall regions of the country. Historically, the rural lifestyle in Sri Lanka has been based on “water culture” based on the concept of “one tank - one village” (Siriweera, 1994). These small-scale water conservation systems are generally referred to as VISs (Figure 4) with paddy fields. According to the Department of Agrarian Development (DAD), of the 12,005 VISs recorded in the country (DAD, 2000), 10,094 of them are in working condition.

This paper examines the challenges of community governance in order to re-establish a efficient reservoir-based agricultural production system in VISs within a market economy. The paper will also show that the existing allocation mechanism for residual water fails to achieve the maximum social benefits. The paper is structured as follows. Section 2 discusses the VISs in Sri Lanka and the legal dimensions of water use. Section 3 deals with community governance and optimal allocation of water and section 4 deals with the methodology (SPF

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[1] Minor reservoirs which have less than 80 hectares of command area, and are managed by the respective FOs are defined as village irrigation systems (DAD, 2000).

model) and the field survey data used. Section 5 discusses the results of the SPF exercise and section 6 undertakes a discussion of the relevant issues. Section 7 considers co-management as a mechanism for water re-allocation. Section 8 deals with policy implications and implementation issues and the final section concludes.

2. VISs and legal dimensions in Sri Lanka

2.1 Village Irrigation Systems in Sri Lanka

A multitude of reservoirs have been constructed in the low rainfall region (Kularatne et al., 2009) in Sri Lanka primarily to irrigate paddy fields. The reservoir density in Sri Lanka is about 2.7 hectares per every km^2 of land area (Fernando, 1993). These reservoirs represent approximately 74.8% of the inland water surface area of the country (NSF, 2000). Based on the capacity and the functions, the reservoirs can be categorised into four types: (i) large (major) reservoirs, (ii) medium sized reservoirs, (iii) minor perennial reservoirs and (iv) minor non-perennial reservoirs. These minor non-perennial reservoir systems are also referred to as VISs. VISs are dependent entirely on monsoonal rainfall and they are not randomly located, but organised in a distinctly cascading manner (Panabokke, 2001; Udawattage, 1985).

As a tradition, a community meeting is held at the beginning of each cropping season to discuss reservoir water management and allocation[2]. During this meeting, planning of agricultural activities takes place and collective decisions are made that cannot be changed by a single or a few individuals. Farmers who own a plot of land in the reservoir command area with or without the membership of the Farmers Organisations (FOs)[3] have access to water use for rice farming[4] (DAD, 2000). The quantity of water received by an individual farmer (or paddy fields) depends on the time which it takes to irrigate his plot of cultivated land. This is because water is supplied via a single unprotected canal that traverses the block from upper fields to lower fields.

The institutional mechanisms of water allocation in village reservoirs facilitate collective decision-making which is based on shared cultivation. The main weakness of these organisations is that it would be less effective for inter-sectoral and intra-sectoral water allocation because they do not include all sectors of users when they make water allocation decisions (Meinzen-Dick, 1996; Dinar, 1997). Therefore, one of the pertinent unsolved problems in reservoir-based agriculture (RBA) in Sri Lanka is that the total volume of reservoir water is not being allocated efficiently among multiple uses (i.e., irrigation, domestic use, fisheries, livestock and cottage industries). A direct market price for the amount of water used by individual farmers does not exist. The main factor responsible for the market failure of reservoir water allocation is the inability to identify the target group of reservoir water users.

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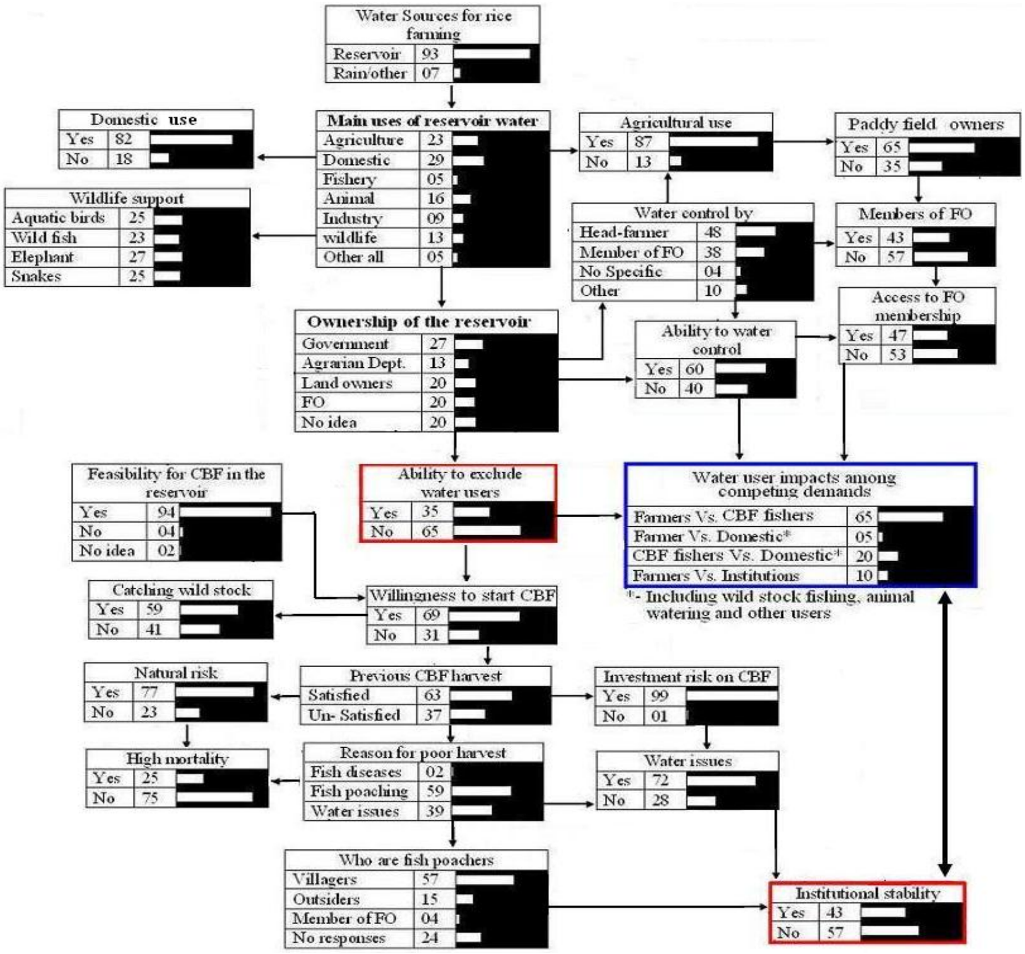
[2] This is called kanna meeting. In addition to the water distribution, there also needs to be agreement about the timing of water issues since once the tank sluice is opened all receive water..

[3] FOs were established under the Agrarian Services Act (No 58 of 1979, No 4 of 1991) and the Agrarian Development Act of 2000. FOs encourage farmers to undertake various agricultural activities that enhance their members' living conditions.

[4] The common term which is used for rice farming in Sri Lanka is paddy cultivation. However, in this thesis these two terms are used interchangeably.

There is no village tradition to exclude those who use residual volumes of water for multiple purposes in the reservoirs (Siriweera, 1994). Out of the competing uses, culture-based fisheries (CBF) are currently being given priority due to the commercial value of fish production. CBF are a form of aquaculture which is practised in inland waters. In situations where CBF has been popular among farmers as an additional source of income, the demand for ‘residual’ water has increased. Under these circumstances, farmers have to use water for rice farming more efficiently in order to maintain a ‘residual’ volume of water for other competing demands. Farmers have private property rights over individual holdings. However, farmers cannot transfer their water user rights to any other productive alternatives because water allocations are made by FOs based on collective decisions with priority given for rice farming. For this reason, the needs of CBF are not considered by the FOs, and as a result, water is always under- allocated for CBF. Therefore, there is a trade-off between the use of water for rice farming and other competing uses such as CBF because the existing allocation mechanism for residual water fails to achieve the maximum social benefits.The existing situation of water use and related issues in VISs, in Sri Lanka is illustrated in Figure 1.1.



Source: Compiled by Author.

Figure1[5]. Water use and related issues in VISs.

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[5] Data related to Figure 1.1 were extracted from a previous socio-economic survey of Australian Centre for International Agricultural Research (ACIAR) project (FIS/2001/030) entitled ‘Management strategies for enhanced fisheries production in Sri Lanka and Australian lakes and reservoirs’.

The majority of landowners are not necessarily members of FOs, but use water for rice farming. On the other hand ownership of reservoirs is a complicated issue. There is no clear understanding among the villagers as to who owns the reservoirs and the reservoir water. However, according to the ACIAR (2001) survey many farmers (27%) believe that the reservoirs belong to the government. Therefore, the public notion is that all villagers can access reservoir water. the main problem of reservoir-based agricultural production is the inability to identify a group of people who have well defined property rights to access water. ACIAR survey results for example, show that fish poaching occurs at a rate of about 59% in Sri Lanka (Jayasinghe and Amarasinghe, 2007).

Fish poaching is assumed to be the group instability of solving water allocation between the different users and lack of water user rights to avoid free riders. The lack of property rights among water users generates external costs among competing water users (e.g., water user disagreements between different users). Disagreements between rice farmers and fish farmers are common. Therefore, two forms of inefficiencies can be identified: (i) those associated with allocating water between the two uses (i.e., water use between rice farming and CBF) and (ii) inefficiencies in allocating water among users for the same activity (e.g., rice farmers). Due to the lack of proper water allocation system between rice and fish farming, farmers realise that they do not receive the maximum net benefits from the reservoir based agriculture.

2.2. Legal dimension of water institutions in VISs

The village council was the earliest known institution that engaged in water allocation rights. In 1815, the British rulers abolished village councils but they were re-established in 1856. The Irrigation Ordinance (No. 32) was first enacted in 1856 by the British colonial administration to both legalise customary irrigation practices and to prescribe the conditions for water extraction, particularly for rice cultivation. Notably, this ordinance does not mandate a planning system nor does it address important issues such as inter-sectoral allocation. Appointment of an irrigation headman by the British administration was the first turning point of collective management into state control in 1856 (Leach, 1961). Following political independence in 1948, cultivation committees were appointed under the paddy land act. However, these committees were abolished and replaced by appointed officers nominated by Members of Parliament in 1977. The Agrarian Services Act of 1979 and subsequent amendments were related to regulations governing the land tenure systems of paddy land and the management of minor irrigation schemes. The latter function was transferred subsequently to provincial councils. At present, the Act provides legal recognition to FOs, stipulates the responsibilities of the FOs including the levying of water fees, and confers the authority on DAD to support the activities of FOs. However, the existing legislation does not adequately address Sri Lanka’s current and anticipated water resources management needs. One of the major shortcomings is that existing laws do not provide a logical basis for inter-sectoral water allocation.

3. Community Governance and Optimal Allocation of Water

The interdisciplinary nature of problems associated with water resource use needs to be integrated into an environmental, technical, social, economic and legal framework. However, introducing any management system for water resources with poorly defined property rights is likely to generate externalities which impose indirect costs or benefits to water users and the environment, leading to an inefficient allocation (Heaney & Beare, 2001).

Failures of efficient resource allocation in production or in the market mechanism generate positive or negative external effects. “External effects” is a confused, concept in economics and it has arisen with the absence of well-defined property rights (Verhoef, 1999). Nevertheless, Demsetz (1967) explained that property rights are used as a primary function to accomplish internalisation of externalities. Furthermore, there is a possibility to solve the external problems when transaction costs are sufficiently small (Coase, 1960). Furubotn (1972) has examined property rights analysis as a new and meaningful way to look at economic problems. Further analysis of property rights by Swanson (2003) has also highlighted that conservation objectives are affected by poorly defined property rights. Externalities have both efficiency and equity aspects. Nevertheless, there is no direct mechanism to measure the difference between the two goals of efficient resource allocation and equitable distribution of the benefits (Verhoef, 1999). Arnason (2008), demonstrated that a theoretically, a mixture of taxes and subsidies for the implementation of property rights could minimise the social externalities in the fisheries sector.

RBA is a collective economic activity. The decision-making on activities such as water allocation, selection of seeds and preparing a cropping calendar are a group activity. Therefore, the demand for water can be identified as the groups’ collective demand. However, individuals are able to decide on the quantity of other inputs used (e.g., seeds, labour, fertiliser, insecticides and herbicides) in rice farming. There are two decision-making units in rice farming, FOs, who operate at a reservoir level DMU, and individual farmers. On the other hand, CBF is entirely a group-based activity. All the decisions in CBF production involve collective agreements. Therefore, the DMU in CBF is for an individual reservoir that also is impacted by groups’ collective demand for water. However, this can vary among individual reservoirs, as group sizes differ.

Many developing countries have begun to decentralise policies and decision-making related to the development, public services, and the environment (Agarawal, 2001). Nevertheless, central government management of water and aquatic resources (e.g., fisheries) often lacks the capacity to enforce property rights and regulations on resource use (Ahmed et al., 2004). In addition to institutional arrangements, market power for allocation of property rights through transferable property rights is discussed in the literature (Hahn, 1984). Wingard (2000) suggests that transferable quotas to the community minimise social impacts and internalise externalities rather than transfer to the individuals. Suitable water allocation policy reforms remain poorly understood. Furthermore, because of increasing competition for water use, water allocation has to be treated in an integrated manner, considering all purposes of water uses (Swanson, 2003).

The subject of water rights is receiving increasing attention from policy makers due to the growing understanding that ill-defined water user rights impairs efficient use because it creates high transaction costs (information search costs, negotiation and monitoring) on decision making on water use (Wichelns, 2004). The main costs of collective decision-making reviewed in the economic literature are the so called transaction costs. Transaction costs are those costs of collective agreement decisions or the costs of making decisions. One of the determinants of the transaction cost is the group size which is involved in decision making. There is a large amount of literature that discusses the effect of group size on net benefits to the group. The early literature (Olsen, 1962) argues that small groups are less likely to be suitable. By contrast, one of the disadvantages of large groups is the difficulty of reaching any agreement. Hence large groups are less likely to contribute to collective decision making than small groups (Oliver, 1998). In the case of CBF production in a VISs it has been found that CBF activities organised by small groups have a positive relationship with the fish yield (Kularatne et al., 2009) and such groups are the most successful in providing benefits to participants (Senaratne & Karunanayake, 2006). Senaratne and Karunanayake (2006) further revealed that large groups have higher information costs (9%), but lower enforcement and monitoring costs (78%) compared to small groups (90%) in CBF production. In the case of a single private owner, the transaction costs are assumed to be zero. CBF activities under private owners are minimal in VISs because of water sharing issues. However, reservoir water is a common pool resource, where more than one user is involved, so the transaction costs are likely to be positive (Senanayake & Karunanayake, 2006). Low transaction costs have been linked to less conflict ridden groups, where agreement is naturally easier to reach. Access exclusion costs are the costs of preventing outsiders from using the resource. In principle, it could be argued that access exclusion costs are likely to be the same for different types of management regimes. However, in CBF production, access exclusion costs of FOs in large groups are less than small groups (Senanayake & Karunanayake, 2006). Nevertheless, it could be argued that for a fixed size of a resource, a larger group implies more individuals are involved in monitoring, so exclusion costs may be lower with common pool resources. Similar arguments arise with regard to enforcing rules about how group members or “insiders” use the resource. A second cause of the decline of VISs management is the declining productivity compared to alternative income sources. This arises when the total economic gains from collective management are less than the costs. A case study in South Africa revealed that small-scale farmers are prepared to pay a higher price for improvement of water right systems while lower institutional trust and income levels lead to lower willingness to pay (Speelman et al., 2010). Similarly, FOs with medium sized groups of farmers (30-40 members) and economically homogeneous members are better for irrigation water management (Thiruchelvam, 2010).

4. Methodology and Data

4.1. Model

A range of potential stochastic production frontier (SPF) functional forms exist, including the translog, Cobb-Douglas and constant elasticity of substitution (CES), where the last two are effectively special cases of the translog. The translog production frontier (Aigner et al., 1977; Meeusen and Van den Broeck, 1977) is given by:

$$(1) \qquad \ln y_i = \beta_0 + \sum_k \beta_k \ln x_{k,i} + 0.5 \sum_k \sum_l \beta_{k,l} \ln x_{k,i} \ln x_{l,i} - u_i + \varepsilon_i$$

where y is the quantity of output produced, x is a vector of inputs, u is a one sided error term ($u \geq 0$) representing the level of inefficiency of the vessel and ε_i is a random error term. The TE of the i-*th* sample farm, denoted by TE_i is given by $TE_i = exp\ (-u_i)$. A distributional assumption has to be made to separate the stochastic and inefficiency effects in the model. In this study, inefficiency is modelled explicitly as a function of known characteristics and exogenous effects, such that:

(2) $$u_i = \delta_0 + \sum_j \delta_j Z_{ij} + w_i$$

where Z is a set of *j =1,…,J* firm-specific variables which may influence the firm's efficiency, δ_j is the associated inefficiency parameter coefficient, and w_i is an iid random error term (Battese and Coelli, 1995).

There is a trade-off between flexibility and theoretical consistency when using flexible functional forms such as the translog (Sauer et al., 2006; Sauer and Hockmann, 2005). Economic theory suggests that for profit maximization, the production function should be monotonically increasing and quasi-concave for all inputs (Lau, 1978). However, (Henningsen and Henning, 2009b) argue that there is less need to impose the convexity constraints when estimating production frontiers as these are based on the assumption that producers aim to maximise output for a given set of inputs rather than profit maximization *per se*, and suggest that only monotonicity is imposed, which requires $\partial y / \partial x_i > 0$ and $\partial^2 y / \partial x_i^2 < 0$. Imposing these conditions requires either the use of Bayesian techniques (Griffin and Steel, 2007; O'Donnell and Coelli, 2005) or implementing a multistage process to correct the model as required (Henningsen and Henning, 2009a).

In this analysis, we have adopted the latter approach of Henningsen and Henning (2009). This involves first estimating the translog frontier and extracting the unrestricted parameters $\hat{\beta}$ and their covariance matrix $\hat{\sum}_{\beta}$. Second, we estimate restricted $\hat{\beta}^0$ parameters through a minimum distance approach, given by:

(3) $$\hat{\beta}^0 = \arg\min\left(\hat{\beta}^0 - \hat{\beta}\right)\hat{\sum}_{\beta}^{-1}\left(\hat{\beta}^0 - \hat{\beta}\right)$$

subject to:

(4) $$\frac{\partial f(x, \beta^0)}{\partial x} \geq 0 \quad \forall i, x$$

This is solved using quadratic programming to find the revised set of coefficients $\hat{\beta}^0$ that conform to the monotonicity assumption. Finally, the stochastic frontier model is re-estimated as

(5) $$\ln y_i = \alpha_0 + \alpha_1 \ln \tilde{y} - v_i + \varepsilon_i$$

where $\tilde{y} = f(x, \hat{\beta}^0)$. That is, the only input is the estimated frontier output based on the restricted parameters. The parameters α_0 and α_1 represent final adjustments to the parameter estimates.

4.2. Marginal value product (MVP) and Technical Efficiency (TE)

Farm-level efficiency and optimum usage of inputs can be measured by estimating the production function. Optimal resource allocation can be measured by deriving the MVP of each resource uses and equating the MVP of each other. Furthermore, the MVP of each input is compared to the marginal factor cost (MFC). Inequality of MVP and MFC shows that inputs are being used inefficiently (Hussain and Young, 1985). The marginal product can be derived from the production function utilising the relationship between the production elasticity and marginal product (i.e., elasticity is equal to the marginal product divided by the average product). This can be shown as:

$$(6) \qquad \varepsilon = \frac{\partial \ln y}{\partial \ln w} = \frac{\partial y}{\partial w}\frac{w}{y} \quad \text{and} \qquad \text{therefore,} \qquad \frac{\partial y}{\partial x} = \frac{\partial \ln y}{\partial \ln w}\frac{y}{w}$$

The frontier marginal value product $(\overline{MVP})$ is equal to:

$$(7) \qquad \overline{\mathrm{MVP}} = \mathrm{P}^* \left(\frac{\partial \ln \overline{\mathrm{y}}}{\partial \ln \mathrm{w}} \right) * \frac{\overline{\mathrm{y}}}{\mathrm{w}} = P\left(\varepsilon \frac{Y}{W} \right)$$

where $\overline{y}$ denotes the frontier level of production. As a result, the relationship between TE of an existing level of production (MVP_i) can be stated as:

$$(8) \qquad MVP_i = e^{-u}\,\overline{MVP} \quad \text{, since } y_i = e^{-u}\,\overline{y}$$

4.3. Equi-Marginal Principle and Marginal Value Product (MVP)

The theoretical underpinnings of optimal resource allocation can be analysed by examining the input side of production technology. This involves an allocation of variable inputs among competing uses.

Limited resources can be allocated considering the equal MVP among several uses with knowledge of the production function and the unit price of output of each use (Doll and Orazem, 1984). In the case of reservoir water allocation, limited water is equally allocated among competing uses. Formally:

$$(9) \qquad MVP_{WA} = MVP_{WB} = \ldots = MVP_{WN}$$

where, MVP_{WA} is the MVP of water used for product A, MVP_{WB} is the MVP of water used for product B and N is the number of users under consideration (Freebairn, 2003).

It was assumed that a fixed volume of water, W (a static allocation problem) is allocated across competing uses and competing users (Grafton et al., 2004) engaged in rice farming and CBF production. As a result, the optimum water allocation between irrigation and CBF can be stated as:

$$(10) \qquad MVP_r = MVP_f$$

Water allocation between rice farming and CBF is illustrated in figure 1. The horizontal axis shows the total volume of water available for use in rice farming and CBF during irrigation season, (t). The vertical axis on the left depicts MVP of water (MVP_r) used for rice farming during the irrigation season (t) and the vertical axis on the right axis depicts the MVP of CBF (MVP_f) during the same irrigation season. "W*" is the optimum level of water allocation.

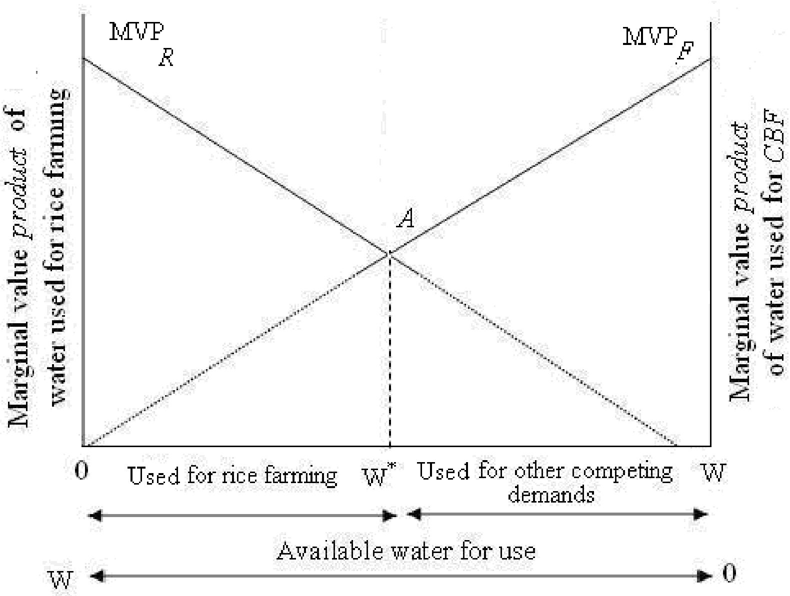

Figure 2. Efficient level of inter-sectoral allocation of water.

4.3. Estimation of Inter-Sectoral Optimal Allocation of Water

The total benefits function of reservoir water use was optimised as follows:

(11) $MaxT = P_R Y_R + P_F Y_F$

(12) S.T. $W_R + W_F = W$

where,

(13) $Y_R = f(W_R)$

(14) $Y_F = f(W_F)$

The Lagranginan under joint maximization is

(15) $T = P_R Y_R + P_F Y_F + \lambda(W - W_R - W_F)$

The Kuhn-Tucker (necessary first-order) conditions are:

(16) $\frac{\partial T}{\partial W_R} = P_R \frac{\partial Y_R}{\partial W_R} - \lambda = 0$

(17) $\frac{\partial T}{\partial W_F} = P_F \frac{\partial Y_F}{\partial W_F} - \lambda = 0$

(18) $\frac{\partial T}{\partial \lambda} = W - W_R - W_F = 0$

Solve for maximum use of W_R and W_F:

(19) $$(15) \Rightarrow P_R \frac{\partial Y_R}{\partial W_R} - \lambda = 0, \qquad \Rightarrow P_R \frac{\partial Y_R}{\partial W_R} = MVP_R = \lambda$$

(20) $$(16) \Rightarrow P_F \frac{\partial Y_F}{\partial W_F} - \lambda = 0 \qquad \Rightarrow P_F \frac{\partial Y_F}{\partial W_F} = MVP_F = \lambda$$

Therefore,

$$P_R \frac{\partial Y_R}{\partial W_R} = \lambda = P_F \frac{\partial Y_F}{\partial W_F}, \qquad (\lambda = \text{shadow value of water})$$

Then,

(21) $$MVP_R = MVP_F$$

4.4. Estimation of Welfare Effect of Water Re-allocation

The economic gains of re-allocating water were measured by estimating consumer's surplus among competing water users. In the context of water, consumer surplus is the net benefits of water use to farmers after they have paid for their water. The price of reservoir water was estimated from the MVP of water used. The allocation of water in village irrigations was assumed to be sub optimal when water usage is inefficient and markets are not present. Two conditions were established for effective water re-allocation between rice farming and CBF production at the optimal and existing levels of TE in production:

(22.) $$TNB^{*} \geq TNB^{a}$$

(23) $$TNB_F^{*} \geq TNB_R^{*}$$

Condition one is that the total net benefits of reservoir water use at the frontier level of production (TNB*) should be greater than or equal to the total net benefits of reservoir water use at the existing level of production (TNB^a). Condition two specifies that total benefits of water use at the frontier level of production for CBF $(TMVP_F^*)$ should be greater than or equal to the total benefits of water use at the existing level of TE in production $(TMVP_R^*)$.

4.5. Study Area and Data

Kurunegala and Anuradhapura districts are the two districts with high reservoir densities are located in low rainfall regions. Current irrigation withdrawals for rice production in these districts account for over 75% of reservoir capacity (Samad, 2005). According to, there are. Kurunegala district has 4,192 working reservoirs out of 10,094 village reservoirs currently being used for rice production in Sri Lanka (DAD, 2000) Anuradhapura district is second to the Kurunegala District. As these two districts are adjacent, they are therefore, homogeneous in morphology, climate, vegetation and all other social and economic aspects.

A multi-stage cluster sampling method (Cochran, 1960) was used for sample selection. Each stage represents the number of reservoirs, based on an administrative hierarchy from national level to village level. The rice farmer study was conducted on 14 selected rice-farming villages, each of which has its own reservoirs in the Galgamuwa Divisional Secretary Divisions (DSDs). Of the DSDs in the Kurunegala district, the Galgamuwa DSD had the highest density of reservoirs used for rice farming and CBF production in the 2008/09 principal agricultural season (*Maha* season). 607 farmer households are involved in paddy cultivation, covering 1,225 ha using the village reservoirs in the Galgamuwa DSD (ADO's Annual report, Galgamuwa, 2009). A sample of individual farmers was selected from each of the fourteen villages to complete the survey. In total, 460 farmers were interviewed. The total sample represented 76% of the total farmers in the study area.

The study area for the CBF farmer field survey was also essentially Kurunegala and Anuradhapura districts, as high numbers of reservoirs in these two districts have been used for CBF production in the country. Data on CBF production was collected in 22 DSDs in the Kurunegala district. In the Anuradhapura district, 29 DSDs were covered in the CBF farmer survey.

A group of fish farmers from each reservoir engaged in CBF production was considered as a sample unit for the CBF survey. CBF is essentially a group activity. For this reason, individual performance of CBF activity is unlikely. Furthermore, as the CBF industry is not well established in all village reservoirs of Sri Lanka, CBF activities are not continuing annually. Therefore, CBF production data were collected during several different culture cycles from 2006 to 2009. In Kurunegala and Anuradhapura districts, there were 165 and 169 reservoirs respectively (a total of 334) where CBF activities had been carried out during the three culture cycles. Data were collected from 325 CBF farmer groups consisting of 165 and 160 reservoirs respectively. This represents 29% of the total reservoirs (1,168) used for CBF production in the country over the last three culture cycles. The purpose of the rice farmer surveys was to collect rice production data from individual farmers. In this context, the most appropriate data collection method was face-to-face interviews with selected rice farmers using a pre-tested questionnaire. The CBF farmer survey was organised as a group discussion. The surveys were conducted from November 2009 to January 2010.

4.6. Data

The rice farmer survey collected information on rice output levels, input use and also characteristics of the farmers. The dependent variable used in the model (collected from the survey) was the level of rice production (Y_i). Data on five key inputs was also collected (or subsequently derived): water (x_1), labour (x_2), mechanical power (x_3), irrigating time (x_4) and pesticide use (x_3). In addition, information on 11 farmer and farm specific characteristics (z) were collected and used in the inefficiency model. Summary statistics of the output and input variables together with various farm and farmer-specific variables used in the analysis are shown in table 1. The survey collected information on CBF output levels, input use and also characteristics of the CBF farmers. The dependent variable used in the model (collected from the survey) was the level of CBF production (Y_i). Data on three key inputs was also collected (or subsequently derived): water (x_1), labour (x_2), total fish fingerlings (x_3). In addition, information on 8 farmer and farm specific characteristics (z) were collected and used in the inefficiency model. Summary statistics of the output and input variables together with various farm and farmer-specific variables used in the analysis are shown in table 2. All input and output data were normalised such that $\ln(\bar{x}_j) = \ln(\bar{y}) = 0$.

Table 1. Summary Statistics of Variables Involved in the Stochastic Frontier Model

Variables	Measurement	Mean	Std. Dev.	Minimum	Maximum
Output Variable					
Y_i Yield	kg	1183.8	904.2	44	5100
Input variables					
x_1 Water	Metres/ha	0.09	0.1	0.01	1
x_2 Labour	Man-days	49.16	61.8	4.00	560
x_3 Power	Minutes	323.46	260.7	15.00	1520
x_4 Irrigating time of fields	Minutes	2185.76	2152.6	120	17280
x_5 Pesticides	ml	728.46	703.0	50	5600
Farm and Farmer specific variables					
z_1 Age of farmers	Years	49.18	12.63	19	90
z_1 Level of education	Years	8.08	3.2	2	13
z_1 Participation rate FO activities	Percentage	80.64	23.5	4	100
z_1 Membership of FO	Dummy	0.86	0.3	0	1
z_1 Field location(head-end)	Dummy	0.34	0.4	0	1
z_1 Field location (Middle)	Dummy	0.33	0.4	0	1
z_1 Locational water issue	Dummy	0.37	0.4	0	1
z_1 Landownership	Dummy	0.64	0.4	0	1
z_1 Use of insecticides	Dummy	0.72	0.4	0	1
z_1 Use of herbicides	Dummy	0.93	0.2	0	1
z_1 Success of field level water mgt	Percentage	77.64	25.3	0	100

Table 2. Summary Statistics of Variables Involved in the SFM for CBF Production

Variables	Measurement	Mean	Std. Dev	Minimum	Maximum
Output (kg)	Kg	2715.48	3739.899	18	20000
Individual volume of water*	Irrigating time	2.03913	1.8876	0.074009	9.62116
Labour	Man days	30	38	2	164
Total fish fingerlings	Numbers	13165.04	11806.69	1000	91500
Group stability	Dummy	0.4154	0.5	0	1
Time spend to meet officials	Hours	17.5262	19.8	0	96
Rain water risk for CBF	Dummy	0.4369	0.5	0	1
Subsidised culture cycle	Dummy	0.6646	0.5	0	1
No of cattle and buffalos	Numbers	185	232.8	0	1300
Slow growth fingerlings (1= yes,0 = no)	Dummy	0.5538	0.5	0	1
Fast growing fingerlings(1= yes,0 = no)	Dummy	0.9200	0.3	0	1
Number of months water use for other	Number	5.2831	3.6354	0	12

A limited number of inputs are used in CBF activities in Sri Lanka compared with other Asian countries (De Silva, 2003). This is because CBF activities are conducted in existing water bodies and do not utilize supplementary feeding.

5. Results

The production frontier approach for estimating MVP is the most appropriate tool to be used for short run water allocation issues. Briefly, this approach estimates the relationship between the volume of water use and output, while other factors of production are assumed at the average level. Based on the estimated parameters of the production frontiers estimated rice-water ($\ln Y_R$) and CBF-water ($\ln Y_F$) frontier production functions are shown in equations 22 and 23.

$$(22)\qquad \ln Y_R = 0.2866 + 0.3231 \ln w + 0.1661 \ln w^2$$

$$(23)\qquad \ln Y_F = 1.5025 + 0.4466 \ln w + 0.1647 \ln w^2$$

$\ln Y_R$ and $\ln Y_F$ represent the natural logarithm of rice output and CBF production. Natural logarithms of individual volumes of water used for rice and CBF production are represented by $\ln w_{Ri}$ and $\ln w_{Fi}$ respectively.

Not all farms are efficient. The estimated mean TE for rice production is 0.73 and for CBF production is 0.33. The production functions that have been estimated at frontier level transform into current levels of input use by mean level of TE. Estimated production function at the Mean TE[10] for rice and CBF are:

$$(24)\qquad \ln y_r = 0.2092 + 0.3231 \ln w + 0.1661 \ln w^2$$

$$(24)\qquad \ln y_r = 0.4958 + 0.4466 \ln w + 0.1647 \ln w^2$$

This pre-assumption was derived due to comparatively higher market price for CBF production. The results of inter-sectoral water allocation are shown in table 7.1 at the frontier and the current level of shadow value of water.

Table 3. Inter-sectoral optimal allocation and shadow value of water

Water allocation levels	Allocation conditions	Shadow value of water (λ), inter-sectoral allocation of water at frontier and current level of production		
		Water for rice (M/ha)	Water for CBF (M/ha)	Shadow value (LKR[6]/Mha)
Actual allocation	WR >WF	3.3881	2.0329	-
Optimal given efficiency	$mvp_r = mvp_f$	4.2338	1.1872	20660
Optimal frontier level	$MVP_R = MVP_F$	2.3100	3.111	71055
The effects of optimal allocation at given efficiency from actual allocation on inter-sectoral allocation		Increased by 25%	Decreased by 42%	-
The effects of optimal allocation from actual allocation to frontier level of production on inter-sectoral allocation of water and to the shadow value		Volume of water can be decreased by 32%	Increase by 53%	A threefold increase in MVP

Notes: Estimated mean capacity of VIS = 5.421M/ha , Mean TE for rice farming = 0.73
Mean TE for CBF production = 0.33, LKR = Sri Lankan Rupees/Currency

The estimated mean capacity of VIS is 5.421 M/ha. The actual allocation of water is decided by FOs. Assuming reservoir capacity is at the full supply level, 62.5% (3.3881 M/ha) of water is allocated for rice farming, while the rest is used for other purposes including CBF.

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[6] Exchange rate AU$ 1 = LKR 100

The volume of water used for rice farming at the optimal allocation of given TE is 4.2338M/ha. This means that the actual allocation needs to be increased by 25% for rice farming. Therefore, the volume of water used for CBF should be decreased by 42%. This is because actual allocation is an ad hoc decision of FOs. However, there is a huge potential to increase MVP of CBF production at the level of frontier production. The estimation shows that the effect of optimal allocation from actual level to the frontier level of production would increase total water productivity three fold. For this to occur, water would need to be reallocated by reducing 32% of the actual allocation. Such inefficient volumes of water can be reallocated for CBF production by 53%.

The estimated shadow value of water (per M/ha) at the given level of TE is LKR 20660 (approximately AU$ 206) per M/ha. This can be increased approximately by five times (up to LKR 71055 per M/ha) by removing the technical inefficiency of rice farming. Empirically estimated MVP of water (per M/ha) use for CBF is higher than the MVP of rice at the frontier level of production ($\lambda_F > \lambda_R$). However due to the low level of TE, MVP for CBF production is lower than the MVP of rice production at the estimated level of TE.

In the re-allocation of reservoir water, for efficient alternatives to materialise as a policy, maximum net benefits (welfare) to the society have to be estimated. Therefore, the empirical approach to policy analysis is to measure the monetary values of efficient allocation compared to the monetary value of proposed new costs. For this, the change in net benefits for rice farming and CBF production has to be calculated. If the aggregate net benefits are positive, then the water re-allocation can be accepted as a useful policy for increasing water productivity of VISs. The condition applied for efficiency-enhancing policy is $\Sigma\Delta NB > 0$ (Griffin, 2006). In connection with welfare effects of reservoir water re-allocation two conditions are measured as:

$$\mathrm{TNB}^* \geq \mathrm{TNB}^a \tag{8.1}$$

$$\mathrm{TNB}_F^* \geq \mathrm{TNB}_R^* \tag{8.2}$$

These two conditions indicate that the total net benefit (TNB) of reservoir water use at the frontier level (TNB*) of production is higher than or equal to the TNB received at the existing level of TE (TNB^a). Further, the total net benefit of water use for CBF at the frontier level (TNB_F^*) of production is higher than or equal to the TNB received from water used for rice farming (TNB_R^*) at the frontier level of production.

Water re-allocation in VISs can be estimated under the policy option of demand shifting. Existing demand for water shifts with re-allocation decisions. Removing inefficient use of water in rice farming is the main factor for the demand shift. Consequently, MVP of water is increased by three times at the optimal allocation of water in the frontier level of production. This huge increase is due to the relative price between rice and CBF fish[7].
With the increase of water demand, the volume of water is increased by approximately 32%. This is because the residual volume of water is increased with optimal water allocation (re-allocation) in the reservoirs. Therefore, removing inefficient usage of water in rice farming increases the volume of water which can be used for CBF production. This means that farmers' TNB increases by LKR 21553 per M/ha of water used for reservoir based

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[7] Average prices for paddy and fish are LKR 30.00 and 100.00 per kg respectively.

agriculture. This effect is shown in Table 9.2 which illustrates the details of estimation of community welfare

Table 4. Consumer surpluses for rice and CBF production with water re-allocation

Production types	Consumer surplus for water demand		Changes of consumer surplus with water re-allocation
	Existing level	Frontier level	
Rice farming	38756	-26712	12043
CBF production	-20318	29828	9510
Total surplus	18438	3115	21553

With the re-allocation of water, net MVP is positive. This estimation is shown in both existing and frontier levels of production.

6. Discussion

It is important for policy makers to know by how much agricultural production can be increased by increasing its TE without altering available water, given the technology involved. It has been estimated in this research that for the same quantity of input, it is possible to increase output by up to 28% in rice farming in VISs. It also has been found that enhancing the institutional capacity of FOs will further improve TE. Furthermore, it has been shown that if it is possible to put in place a system to transfer land ownership and hence water user rights to solve locational sharing issues, this will improve the institutional capacity of the FOs and will thereby help to reduce technical inefficiency. Overall findings of this research show that the total benefits of the reservoir water can be increased by improving water use efficiency in rice farming and improving the TE of CBF production. This study identified five important areas which need to be addressed in order to achieve a higher level of water productivity of VISs in Sri Lanka. The five areas are listed below.

1. Efficient use of irrigation water increases the residual volume of reservoir water, which can be used for multiple purposes.
2. At present, group labour used in CBF is over-utilised. Therefore, there is a need to identify mechanisms for the efficient use of labour in CBF production.
3. Fast growing fish species have no positive impact on CBF production due to inadequate nutrition in reservoir water. Therefore, the possibility of introducing a cost effective integrated farming system.
4. The inter-sectoral water allocation mechanism is made effective by introducing an acceptable transferable water user rights system.
5. Total benefits of reservoir water can be increased by solving two constraints: establishing water user rights for CBF production and by ensuring transferable water user rights are established in rice farming.

Based on the findings of the study, it is clear that these 6 options are ideal for dealing with the water re-allocation issues for green development of reservoir-based agricultural production. Various biological productivity-related problems, such as a lack of an effective means of selecting suitable reservoirs and a lack of guaranteed supply of fingerlings for stocking (De Silva, 2003) have constrained CBF development in Sri Lanka since its beginning in the 1980s. Furthermore, weak institutional linkages, lack of legislation and poorly planned social mobilisation procedures were also responsible for the unsustainability of CBF activities. Some of these constraints, especially at the grassroots levels, have been overcome through concerted efforts of active biological research to some extent and the barriers at the institutional levels can be solved. Therefore, community transferable quota systems (CTQs) are proposed as a possible policy instrument within the framework of the co-management strategy which can be implemented through DAD and NAQDA.

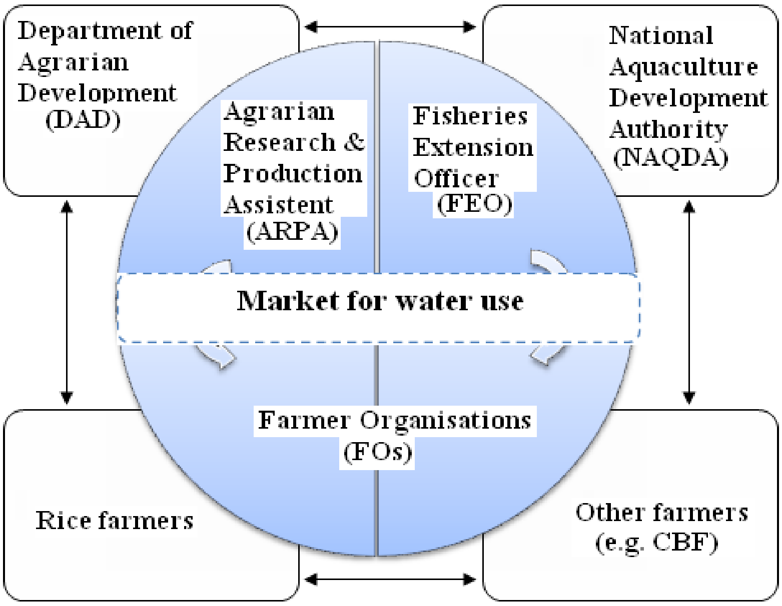
Social capital plays an important role in enhancing trust and co-operation which would reduce the misuse of the available resources among the resource users (Grafton, 2005). As (Teraji, 2008) has stated, a fully protected property rights system can achieve a higher level of trust, while unguaranteed property rights will remain at a low level. Therefore, property rights play an important role in establishing the trust and social capital among communities by increasing cooperation among the resource users. Benefits of cooperation include the avoided costs of social conflict and avoided externalities imposed by others. (Wade, 1987) states that the "Main factor explaining the presence or absence of collective organisation is the net collective benefit of the action." More specifically, Wade (1987) focuses avoiding external costs through cooperation. He argues that cooperation occurs in villagers where the net benefits of cooperation are highest. Since the relative transaction and exclusion costs will be similar for each village, the main cost is the relative benefits of cooperation or the avoided external costs of non-cooperation. The benefits of cooperation are highest and costs are lowest when benefits are equally distributed to all groups gained from collective management. This is often violated in the case of large irrigation systems where some farmers are much closer to the water source (head-enders) while other groups are much further away (tail enders). Cooperation is unlikely to work where the group contains both head-enders and tail-enders since head-enders lose out as cooperation increases and their water use is limited. Therefore, from a social capital point of view, it can be suggested that current top-down resource management should be redirected towards a 'co-management' approach (Grafton, 2005).

It has been shown in many parts of the world that co-management and community-based management of natural resources could provide effective alternatives for natural resources management (Wade, 1987; Hannesson, 1998). Current research suggests that there are emerging characteristics which are central to developing and sustaining institutions that support successful co-management arrangements. Pinkerton (1989) and Ostrom (1990) have summarised and documented some of those key conditions necessary to maintain successful co-management institutions. From their work, co-management is likely to succeed in resource systems where boundaries are clearly defined, membership is clearly defined, the user group is cohesive, the user group has prior experience with the organisation, and the benefits of management exceed costs. Additional criteria are that there will be participation in management by those who are affected, due to the enforcement of management rules under which these co-management approaches are enforced. Also the user group has legal rights to organise, so that there is co-operation and leadership at the community level. Furthermore, there is decentralisation and delegation of authority, and there is co-ordination between the government and the community.

It has been found that participation rates for collective action (FO activities) are a positive factor for increasing TE in rice and CBF production in the case of reservoir based irrigation in Sri Lanka. However, recent studies on major, medium and minor irrigation systems in the Kurunagala and Anuradhapura districts of Sri Lanka have found that the participation rate for FO activities is 38% because of lack of accountability and transparency of FOs (Thiruchelvam, 2010). As a result, Thiruchelvam (2010) recommended establishing strong linkages between FOs (primary level stakeholders) and water authorities (responsible institutions) for successful irrigation management. According to (Khalkheili and Zamani, 2009), the establishment of co-operation with water authority operators will enhance farmers' participation in irrigation management. Furthermore, co-management practices should promote active involvement of immediate actors to the resources for their management rather than relying on institutional hierarchy.

7. Co-management as a mechanism for water re-allocation

Rice production is more popular than CBF production at the village level. However, part of the production of rice is marketed by farmers since rice cultivation is also an income generating activity. CBF on the other hand is mainly produced for the market. Therefore, market is another supplementary factor in the co-management of VISs. Therefore, allocating irrigation water has to take into account the market behaviour of these goods. The value of the water may depend on MVP. Therefore, essentially in addition to institutions and primary level resource uses, market motivation is another factor that should be considered in the decision making process of reservoir water allocation (see Figure 3).



Source: Compiled by Author.

Figure 3. Co-management settings for RBA in VISs

There is a possibility for all farmers in the village to be represented in FOs (See Figure 4). Village farmers and the village level agriculture and fisheries officers, who represent institutions, are identified as primary level actors. The FOs represent the farmers while ARPAs, AEO and veterinary officer are represented by the government officials. Bidirectional arrows in Figure 3 and 4 show the necessary direction of trust and cooperation. Based on the strength of these two institutions and the power of decision-making, it will be possible to implement a successful co-management strategy with water re-allocation. Finally, it can be concluded that the combination of sharing responsibility of water management, between responsible institutions and primary level stakeholders, with the motivation of the market forces for profitable alternative water uses, is a practicable mechanism for reservoir-based irrigation water management which can be achieved for efficient output and higher MVP of water in VISs (See Figure 4). This is aimed at strengthening group participation. Collaboration of these two institutions with FOs would considerably improve collective action of the farmers and will further advance the co-management strategy of production as shown in Table 5.

Table 5. Decision-making of kanna meetings in the framework of co-management strategy

Decisions	Agricultural activities	Activities of CBF production
1. Cleaning canals, bunds and sluices	Cleaning and construction of small canals, bunds and sluices by the relevant farmers	Decide on fish culture and repair reservoir, remove logs, fill pits for brick making and fill the wells dug during the low rainfall season
2. Duration of water supply	Selecting the method of cultivation, type of paddy, place of buying, price, transport & the quantity	Select the group of fish culture, species, place of buying, price, transport, and the quantity
3. First date of water supply	Use rainwater for ploughing fields in order to save reservoir water	Stock fingerlings based on the level of water in the reservoir
4.Broadcasting of paddy and protection rice crop from birds, etc.	Release less water for agriculture to save reservoir water, make fences, remove domestic animals (e.g., cattle), prevent disease, pesticide and fertiliser contamination	Prevent escape of the fingerlings from sluice, outlet, feeder streams, and birds Allow cattle and other animals to graze in the catchment area
5. Last date of water issue	Decide to close the reservoir sluice Decisions can change based on special requests with the approval of FOs and Divisional Office.	Decisions should be flexible

CTQs of CBF production

The CTQs have many potential advantages for addressing social shortcomings of efficiency. Under a CTQ system, a large number of people would be able to remain in the fishery at least on a culture-cycle basis, as a group of farmers to get involved in CBF activities. This may determine the total number of farmers in the group. Under a CTQ system, there are two factors which may maximise the economic benefits while minimising cost impacts

If the group of farmers is considerably large, they can be given a community quota on the basis of the culture cycle. The total group can be divided up into smaller groups. Group one could be given an opportunity in the first culture- cycle and the second group could be given an opportunity in the next cycle and so on. This system could be rotated for each consecutive culture-cycle.

Depending on the spatial MVP of rice farming, one group of farmers with higher MVP of rice farming could cultivate rice, while others who have a lower value of MVP could become involved in CBF, especially during the share cropping seasons. The idea of implementing CTQs is not a new phenomenon in RBA. However, the CTQs need to be reinstated and re-established as formal institutions under the umbrella of a FO system, in order to increase total productivity of RBA. At present most fish poaching occurs due to villagers having no opportunity to participate in CBF production (See Figure 1). CTQ systems facilitate maximum involvement in both rice and CBF production. Furthermore, farmers are likely to be motivated by more efficient intra-sectoral water management due to the increased benefits received from CBF production. This may also solve the problem of inefficient use of water in the MFs of the command areas. Therefore, establishing both water user rights for CBF production and ensuring the existence of a transferable water user rights structure for rice farming can be achieved by establishing a CTQ system in RBA in Sri Lanka.

8. Policy Implications and Implementation

Water re-allocation aims to allocate water for enhancement of the total reservoir water productivity. The preceding analysis of MVP of water shows that the optimal allocation of water between rice and CBF production enables increases in reservoir water productivity. Water supplies for rice production were mainly based on reservoir-based irrigation systems. Nevertheless, it was found that water productivity in VISs were very low (0.07 $/m) compared to other major and medium irrigation systems (Thiruchelvam, 2010). Therefore, the investigation of TE and factors influencing technical inefficiency were important for policy-making on optimal allocation of water in VISs.

The ten year development policy framework of the inland fisheries and aquatic resources sector in Sri Lanka assumes inadequate stocking, low level of social acceptance, religious and cultural prejudices, environmental concerns and the instability of government policies as constraints to the development of the CBF sector. In addition to these constraints, lack of proper water allocation between sectors that is based on well-defined water user rights among multiple users and inappropriate institutional responsibility and coordination between the Ministry of Fisheries and DAD have considerable impact on the development of the sector. Established water user rights and transferable water user rights must be initiated at the existing village level institutions (FOs). The Ministry of Agrarian Services and the Ministry of Fisheries and Aquatic Resources should formulate relevant policies for further strengthening relevant institutions. The responsible legal body for solving water allocation issues with FOs is the DAD network. NAQDA should facilitate the technical aspects of CBF production. Collaboration of these two institutions with FOs would considerably improve collective action of farmers and would advance the co-management strategy further. Selection of farmers for CBF production in particular VISs can cope with the re-introduction of CTQs and as mentioned earlier are already being practised in rice farming A *Thattumaru*[8]. system can be successfully used for the selection of CBF farmers without introducing new selection criteria as it is inherently practised by village farmers.

In addition, there is a possibility to encourage livestock farming in the watershed areas within a framework of integrated agriculture (Prein, 2002) for sustainable organic CBF. As such, a revival and re-establishment of such integration of a crop-animal system as formal institutions under the umbrella of a FO system which is already in existence is useful in order to increase the total productivity of RBA.

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[8] *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.

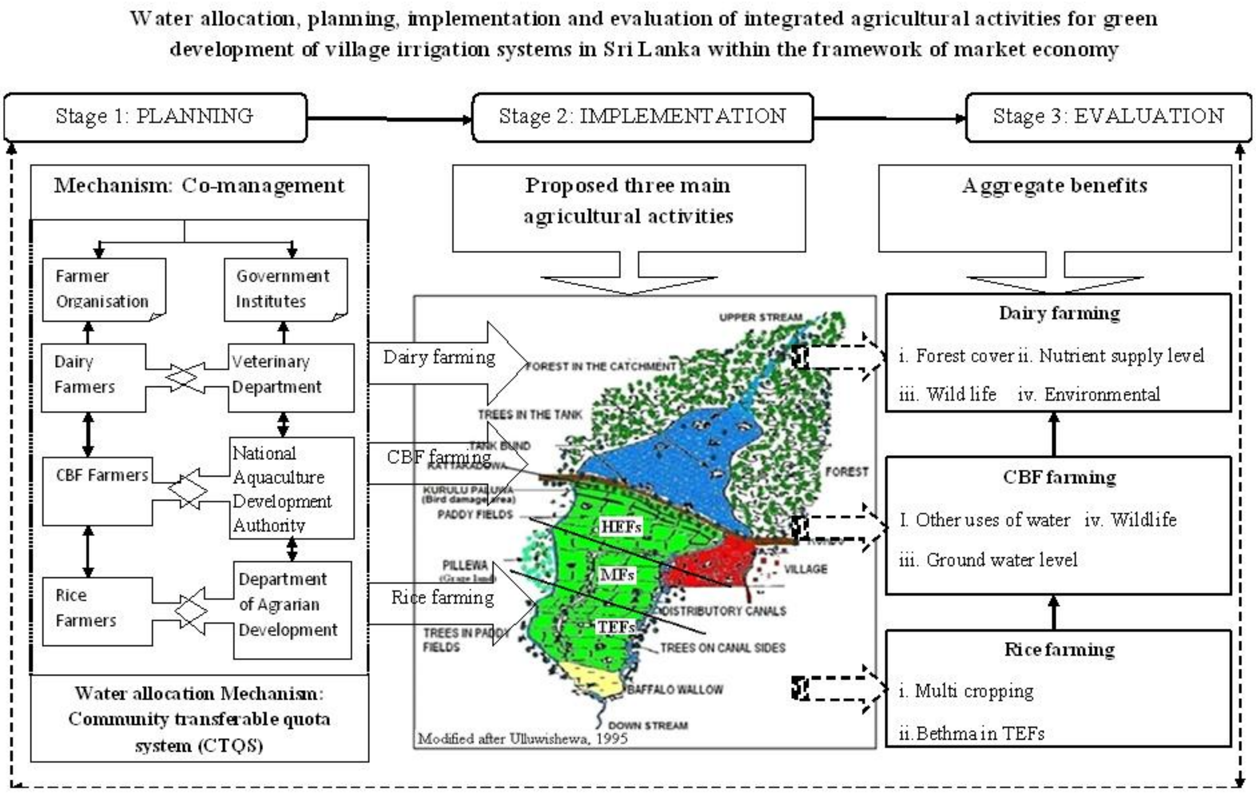

Figure 4. proposed integrated reservoir-based agricultural activities in VISs

Conclusions

Agricultural use has a low marginal value for water (Junna et al., 2006). Re-allocation of water from this sector to others, based on the sectoral marginal values of the resource, has the potential to increase the income of the poorest households. The paper showed agriculture's marginal returns from using water in VISs are not as high as in CBF production. Furthermore, re-allocation of water from agriculture to CBF production increases the MVP of reservoir water. Therefore, the results favour the implementation of inter-sectoral water re-allocation based on TE and support the recommendation that the institution of user rights and inter-sectoral transfer of rights could be a workable policy for promoting CBF production. Co-management of the water resources is the most appropriate mechanism that can be recommended where a combination of both farmers and formal institutions would share the management responsibilities in the market environment.

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