RESERVOIR WATER RE-ALLOCATION AND COMMUNITY WELFARE

Mohottala G Kularatne, University of Kelaniya, kule_econ@kln.ac.lk
Sean Pascoe, CSIRO Marine and Atmospheric Research, Sean.Pascoe@csiro.au
Clevo Wilson, QUT Business School, clevo.wilson@qut.edu.au
Tim Robinson, QUT Business School, Tim.Robinson@qut.edu.au

ABSTRACT

The introduction of culture-based fisheries (CBF) in small scale irrigation systems is increasing the marginal value of water in rice farming. The amount of water that is used in Sri Lanka for rice farming could be utilised to generate more profitable non-crop economic activities such as CBF. This paper examines whether the re-allocation of water to more efficient, high return uses would increase the total economic welfare of farmer community. Primary data was collected from 460 rice farmers in the Kurunegala District and 334 fish farming groups in two districts (Anuradhapura and Kurunegala) in Sri Lanka. The estimation of the value of water used for rice farming and CBF production is derived from the marginal value product by estimating stochastic translog frontier production functions. We then derive benefit calculations on the basis of the water demand functions for rice and CBF. Reducing the inefficient usage of water in rice farming by 32% increases the volume of water which can be used for CBF production by 53%. This greater efficiency can increase, farmers' total net benefits by 17% per Metres/ha of water used for reservoir-based agriculture. But in order to achieve this benefit, it is critical to ensure the water rights of the multiple users of small scale irrigation systems. This paper recommends introducing a community transferable quota, combined with co-management of water resources, to enhance the welfare of fishing and farming communities which use small scale irrigation systems. Key words: Small scale irrigation systems, culture-based fisheries, rice farming, co-management, community transferable quota system. Water re-allocation, Community welfare

INTRODUCTION

Despite agricultural contribution to food security, income and livelihoods, the agricultural sector is responsible for withdrawing water for agriculture approximately 70% of all the global fresh water (Peris et al., 2008). In agriculture, water is allocated for on-storage economic activities (i.e., fishery) and off-storage economic activities (i.e., crop production). When allocation of water is non-profitable in mono-cropping, farmers can engage in multi-crop production. Peris et al., (2008) found that in rice-fish integrated systems, the farmers produce 500 kg per hectare per one cropping season without adding any supplementary feed to the fish stock in their rice fields. This gives 65.8% economic return per annum from the rice fish integrated fields. Increasing water user efficiency, by incorporating multiple uses of fields is beneficial for a number of reasons. Rice-fish integrated field systems are successful where use of pesticides and fertilizer are minimal. The main benefits of rice-fish farming are related to environmental sustainability, system bio-diversity, farm diversification and household nutrition (Peris et al., 2008). However, due to the use of chemicals in rice farming, rice-fish integrated field systems are not practised in Sri Lanka. Furthermore, cultural reasons, such as the Buddhist philosophy which views the rearing and killing of animals as not culturally acceptable, also prevents the establishment of rice-fish integrated field systems. The introduction of CBF activities is a stock enhancement activity with technology innovation in the fisheries sector which tends to increase the marginal productivity of water. The same amount of water that is used for rice farming could be utilized to generate more profitable non-crop economic activities such as CBF. In practice, allocation of more water for rice may be accepted by society. However, allocating more water for CBF production is not a socially optimum answer in ongoing water allocation mechanism in Sri Lanka.

Efficient water allocation has several objectives. First, efficiency and equity of water allocation can be considered. To do this, property rights, transaction costs and water accessibility are used as determents to compare forms of water allocation (Peris et al., 2008). Also, ensuring food security is a social objective of water allocation that can also be prioritised. Allocation of efficient volumes of water for use in rice farming means moving the water for use in areas with higher economic value. According to Molle & Berkoff, (2009), water is often used in economically less efficient, low return uses (usually agricultural). Re-allocation of water to more efficient, high return (non-agricultural) uses would increase the total economic welfare.

LITERATURE REVIEW

Economic efficiency is concerned with the amount of wealth that can be created by a given resource base (Dennis & Arriens, 2005). Decision making on the allocation of resources is one of the most important actions of the planning stage of a firm. Collective decisions taken by groups may have an impact on individual profit maximization. This situation is much more crucial with common pool water resource allocation. In the context of rural agriculture, the investment of peasant households has trade-offs between income risks and the expected profit when they make allocation decisions under weak or missing institutions (Mendola, 2007).

Productivity changes in water aim to increase the incentives of holding more water in order to allocate it for other more productive uses. Clearly, water allocation changes may decrease the quantity of water used for agriculture. However, the reduction of water in one sector, becomes an increase for another sector.

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 internalization 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 theoretically, a mixture of taxes and subsidies for the implementation of property rights could minimize the social externalities in the fisheries sector. Many studies of fisheries problems under various property right regimes have revealed that a lack of property rights and the inability to find solutions to introduce these rights were the main causes for external problems (Arnason, 2008). In this study, the production of CBF is not generally valued in the market system. Village societies like to produce an output that people are willing to put a price on (“desirables”). Or, they expect compensation to leave them with an equitable distribution among individuals (Gough, 1957). Lack of property rights causes externalities and the market system is only efficient if there are no externalities (Debreu, 1959). According to Chou (2002), social capital has mutual links with human capital and financial development. Absence of social capital in a situation with poorly defined property rights leads to resource depletion in both private and communal property regimes (Katz, 2000). Furthermore, collective action, property rights, local institutions, poverty and natural resources management are interconnected (Heltberg, 2000).

Many developing countries have begun to decentralize 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 minimize social impacts and internalize externalities rather than transfer to the individuals. Suitable water allocation policy reforms remain poorly understood, 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; Renwic, 2001).

ESTIMATION OF CONSUMER SURPLUS OF WATER RE-ALLOCATION

To achieve the objectives related to efficient water allocation it is important to understand how to make decisions about water management and allocation in its alternative uses (Peris et al., 2008). In this study, the value of water used for rice farming and CBF development has been derived from MVP by estimating production functions, which is one of the non-economic valuation methods of irrigation water (Peris et al., 2008). This estimation method is commonly used in areas where water rights and the water price have not yet been established (Peris et al., 2008). As a whole, if users cannot utilise the total water supplied by the physical environment, then there is a need to select the right mechanism for water management. This can be done either through demand management of water (such as pricing, technology restrictions and water use regulations) or through supply enhancement strategies (such as efficient structures and appropriately designed rules). However, through supply enhancement strategies new water cannot be materialised (Griffin, 2006). Imposing water pricing was not a successful strategy for demand management of reservoir water in Sri Lanka (Samad, 2005). Therefore, re-allocation of water for more efficient alternatives, within the existing institutional framework, should be implemented when possible.

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:

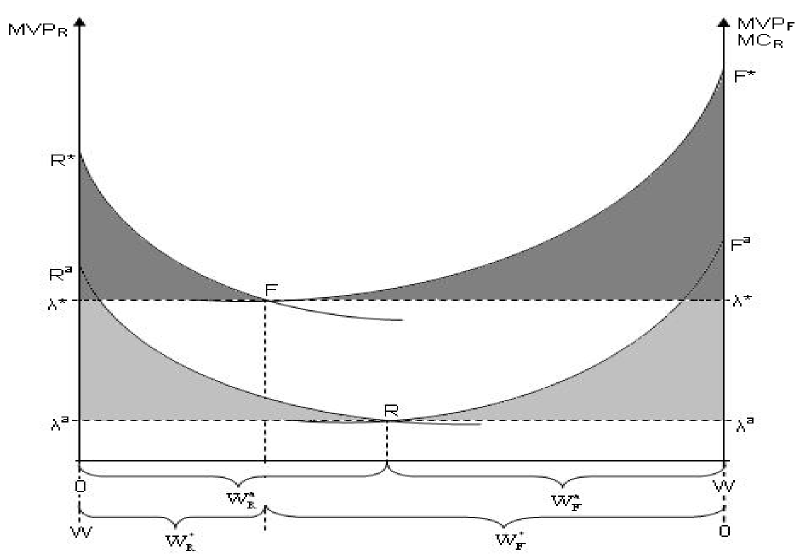
$$TNB^{*} \geq TNB^{a} \tag{1}$$

$$TNB_F^{*} \geq TNB_R^{*} \tag{2}$$

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(TNB_F^*) should be greater than or equal to the total benefits of water use at the existing level of TE in production (TNB_R^*).

These two re-allocation conditions are further demonstrated in Figure 1 MVP curves which are represented by R^a and F^a show production levels of rice and CBF at the existing level of TE respectively. R is the optimal allocation of water whereby W_R^a and W_F^a are the volumes of water optimally allocated for rice farming and CBF production. The area under the two curves is consumer surplus of water demand for rice farmers and CBF farmers. Then:

$$TNB^a = (R^a + R + \lambda^a) + (F^a + R + \lambda^a) \tag{3}$$



Source: Compiled by Author.

Figure 1. Inter-sector water re-allocation.

Similarly, the MVP curves which are represented by R* and F* indicate the frontier level of rice and CBF production respectively. F is the optimal allocation of water whereby W_R^* and W_F^* are the optimal volumes of water allocation for rice farming and CBF production. The area covered by R*, F and λ* is consumer surplus for water demand for rice farming. The area covered by F*, F and λ* is the consumer surplus of water demand for CBF production. Then:

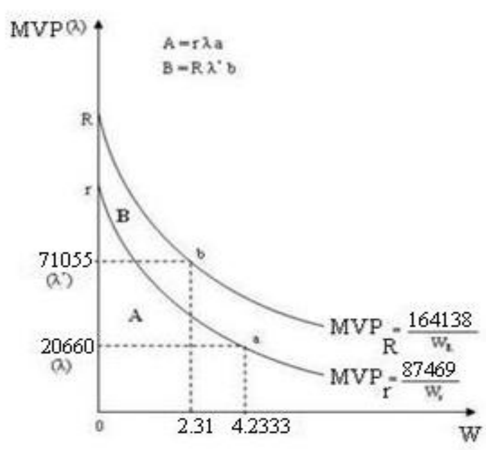
$$TNB^* = (R^*+F+\lambda^*) + (F^*+F+\lambda^*) \quad (4)$$

POTENTIAL GAINS FROM WATER RE ALLOCATION

Most water-related benefit estimations are based on water demand functions. Griffin (2006) demonstrated four primary mechanisms used for estimation of policy changes. They are price rationing, quantity rationing, supply shifting and demand shifting (Griffin, 2006). Demand shifting motivates shifts or rotations of the water demand curve, but in price rationing, quantity rationing policy movements occur along the demand curve. An excellent example of a demand-reducing policy in irrigation is providing low interest loans for advanced irrigation technologies (Griffin, 2006). Demand increasing policies are less common due to water scarcity, but in a situation like the addition of new agricultural land, commercial enterprises, population growth, economic development, demand increases naturally even without policy.

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. Hence, 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 village irrigation systems. 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 in equations 1 and 2.

Water re-allocation in VIS can be estimated under the policy option of demand shifting. 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[1].



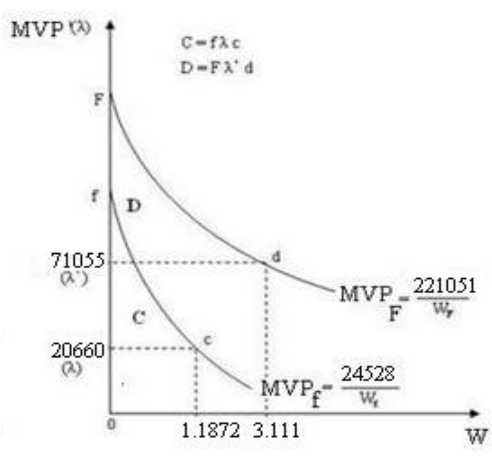


Figure2. Farmers' welfare benefits of reservoir water re-allocation

Figures 2.a and 2.b show the welfare effects of reservoir water re-allocation of rice and CBF production respectively. The area which represents the welfare effects of the existing level and the frontier level of production are presented in Table 1.

Table 1. Analysis of demand shifting due to water re-llocation

Farmers' Wealfare	Rice Farming	CBF production	Total welfare
Farmer welfare at existing production levels	A	C	A+C
Farmer welfare at frontier level	B	D	B+D
Total farmer welfare	A+B	C+D	(A+C)+(B+D)
Net welfare effect of water re-allocation		(A+C)+(B+D)	

Demand increases due to water re-allocation, changes the volume of water used in two ways. The welfare effects that existed before re-allocation of rice farming are shown in area A of Figure 2a. Area B shows post re-allocation welfare effects. In the context of rice farming, water demand decreases by approximately 70% at the frontier level of production. This is because of inelastic demand for water at the frontier level. This means that inefficient volumes of water is one of the determinants of the elasticity of water demand for rice farming.

The illustrative Figure 2.b is associated with CBF production. The areas, C and D show the welfare effects of water before re-allocation and post allocation. With the increase of water demand, the volume of water is increased by approximately by 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 for M/ha of water used for reservoir based agriculture. This effect is shown in Table 2 which illustrates the details of estimation of community welfare.

Table 2.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	120443
CBF production	-20318	250880	9510
Total surplus	18438	3116	21553

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

ISSUES ASSOCIATED WITH RESERVOIR WATER RE -ALLOCATION

According to the analysis of total benefits of water re-allocation, it is possible to make three possible conclusions:

(i) Increases in TE of current water use is essential in order to save water in the VIS.

(ii) The total marginal value product (benefits) of a reservoir can be increased by three times. Consequently, farmers' welfare is increased.

(iii) Increasing the total reservoir water productivity and farmers' welfare are mainly attributed to the marginal value water productivity of CBF production. Therefore, promoting CBF activities is an incentive to efficient use of water in VIS.

Clearly, water must be re-allocated between rice farming and CBF production in order to achieve higher level of reservoir water productivity. Zhou et al., (2009) have revealed that water re-allocation also has impacts on crop production and farmers income in the larger irrigation system. They further revealed that water re-allocation from upstream to downstream areas has reduced agricultural water supply and the area irrigated. There are two key issues which are associated with the water re-allocation: (i) establishing water user rights among the farmers (rice and CBF) and (ii) the establishment of a mechanism to internalise CBF externalities, which are generated by the unequal distribution of the benefits that arise from CBF production. These two factors are discussed in detail in the next two subsections.

ESTABLISHING WATER USER RIGHTS

The interdisciplinary nature of problems associated with water resource use needs 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).

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 cost 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 discuses 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 VIS 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 less 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 village irrigation 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 village irrigation 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 homogenous members are better for irrigation water management (Thiruchelvam, 2010).

INTERNALISING CBF EXTERNALITIES

One of the main outcomes of the welfare effects of the inter-sectoral allocation of reservoir water is increasing village community welfare mainly attributed to increasing CBF production. The recent trend of CBF development in Sri Lanka can be identified as transformation of a common pool resource (village reservoir) into private property (for a small group of farmers). With subsidises for CBF activities (i.e., subsidised fingering supply) reservoirs are facing problems linked to tragedy of the commons documented by Hardin (1968).

In frontier level CBF production, a technically efficient solution has been estimated. However, this estimate may not be enough to argue that on a frontier level production is the most socially efficient solution. This is simply because of the unequal distribution of the CBF benefits among the other water users. The farmers who have no access to CBF production may receive neither private benefits nor compensation for the cost of water allocation for CBF production. Some of the costs arising from CBF development are the combination of other water uses (especially domestic use: bathing, washing clothes in the water deficit period). A key aspect of CBF development is capitalization, which can lead to overcapitalisation with increasing profit margins of CBF farmers. However, application of an individual fishing quota system (IFQ) or individual transferable quota (ITQ) system[2] on CBF resources allocation may not be practical (Arnoson, 2009; Wingard, 2000) as the reservoir water is a common pool regime. Therefore, rather than allocating a transferable quota to individuals, allocating them into communities may capture the benefits of CBF, while minimizing the social impact and internalising externalities of CBF production. In the next section, details will be provided on the applicability of community transferable quota systems (CTQs) rather than allocating CBF activities individually or to a selected small group of farmers (Wingard, 2000).

As a whole, society will benefit when resources are used efficiently. With overcapitalisation, resources tend to get wasted due to overuse. Therefore, property rights are considered as the best way to achieve the most efficient use of the resources. Having a private property rights on resources ensure that the benefits of investment will be received by the investor. Some economists (Arnason, 2009; 2005) argue that the ITQs must generate economically optimal results, but it is a self-centred utility maximizing *Homo economics* practice described in neoclassical economic theory (Wingard, 2000). Especially in the case of CBF production where the allocation of an ITQ system makes entry into the fishery more difficult: some reservoirs accommodate all farmers in the FO in the CBF group in a particular culture cycle. There should be a mechanism which fulfils sustained participation of communities in CBF activities, which will minimise adverse economic impacts on such communities. For this reason, CTQs could accomplish many of the economic and biological goals, while minimising negative social impacts (Wingard, 2000).

Community level agricultural management is very common in Asia. Furthermore, community fisheries management is widespread in many non-industrialised societies (Wingard, 2000). 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.

CTQs of CBF production

Under a CTQ system for CBF, a group of farmers would be able to get involved in CBF activities based on a culture-cycle. Groups of farmers for CBF could be selected among the farmers who are willing 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 maximize the economic benefits while minimizing cost impacts:

(i) If the group of farmers is considerably large (small group favours group stability), 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 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.

(ii) 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.

Selected communities (group of farmers) would provide access rotationally. This would contribute to maintaining and improving social and economic stability and would avoid economic dependency[3] of the whole communities on one form of production. Social capital which is a valuable asset in the context of a village community could be further strengthened through economic independence. In addition to communal stability, other sectors of the rural economy such as agriculture and livestock[4] would also benefit. This would also strengthen social capital throughout the village community. Social capital exists with the form of obligation, expectation and trust (Teraji, 2008; Grafton, 2005). Obligation and trust help farmers to meet their goals. Information is another form of social capital which reduces the uncertainty of CBF production. Norms and sanctions are also part of the social capital. They allow for predictability of behaviour which reduces transaction costs (Grafton, 2005; Coleman, 1988). Improvement of social capital may lead to communal stability and would contribute to the long term social and economic wellbeing of village communities.

Co-management as a mechanism for water re-allocation

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, p.98) 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 (Hannesson, 1998; Ostrom, 1990; Wade, 1987). Current research suggests that there are emerging characteristics which are central to developing and sustaining institutions that support successful co-management arrangements. Ostrom (1990) and Pinkerton (1989) have summarized 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 organization, 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 organize, so that there is co-operation and leadership at the community level. Furthermore, there is decentralization and delegation of authority, and there is co-ordination between the government and the community.

In Sri Lanka, the inland fisheries development programme came to a standstill with the decision of the government to terminate state patronage in 1990, on religious grounds for this important sector which had been contributing 20% to the total fish production in the country. This government policy decision has been reversed and since 1994, development of Inland Fisheries and Aquaculture has been given high priority because of its value as a cheap animal protein for the rural community (Amarasinghe, 1998). It also has the potential to increase income and employment opportunities to the people and to function as a source of foreign exchange to the country (Sivasubramaniam & Jayasekara, 1997) .

After withdrawal of state support for inland fisheries development, annual inland fish production declined dramatically. This decline was shown to be a result of "growth over- fishing" (Amarasinghe & De Silva, 1999). This resulted due to the use of small mesh gillnets in the absence of state-sponsored monitoring procedures. This indicates that under the existing state management procedure, it is necessary to have a Centralized Management Authority for Inland Fisheries management in Sri Lanka (Amarasinghe & De Silva, 1999). In reservoirs with 'organized' fishing, the communities themselves have developed regulations through community based management strategies. In such reservoirs overexploitation of fish stocks was not evident even after state-sponsored monitoring procedures were suspended (Amarasinghe & De Silva, 1999).

Based on these studies, an alternative approach is recommended for the management of reservoir capture fisheries in Sri Lanka. It is recommended that Government and resource-users have equal responsibilities in making decisions for the management of reservoir fisheries (Amarasinghe, 1998). This acknowledges the fact that farmers' involvement is equally important for the successful co-management system as primary stakeholders.

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 participation rates 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 stake holders) and water authorities (responsible institutions) for successful irrigation management. According to Khalkheili & 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.

Markets are another supplementary factor in the co-management of VIS. Rice production is more popular than the CBF production at 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. Hence, allocating irrigation water has to take into account the market behaviour of these goods. The value of the water may depend on MVP t. 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.

There is a possibility for all farmers in the village to be represented in FOs. Village farmers and the village level agriculture and fisheries officers, who represent institutions, are identified as primary level actors. The FOs represents the farmers' while ARPAs and AEO who are represented the government officials. Bidirectional arrows in Figure 3 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 VIS.

POLICY IMPLICATIONS AND LIMITATIONS

Policies are considered as alternative institutions (Griffin, 2006). 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. However, the main constraints are lack of well-defined water user rights for CBF production and the non-existence of transferability of water uses of rice farming for other beneficial water user alternatives. Most of the issues relating to the enhancement of water productivity must be dealt with using the existing WUAs s (i.e. FOs) on an apolitical basis. 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.

Sanctions for the non-cooperation in an irrigation system are difficult, but possible. The common irrigation service is not a pure public good, because one contributor can, with difficulty, be excluded. Even when punishment by exclusion is difficult, it is possible to impose fines. There are rules that are already implemented that arise from crop destruction by animals. Owners of animals are required to pay the cost of the crops damaged by animals. Another example, where collective management is involved takes place when making decisions about allocation. In this instance, those who do not participate lose out. This can discourage free-riding in attending FO meetings. In some irrigation systems in Sri Lanka, non participation or free riding by individuals has led to penalties (Uphoff et al., 1990).

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 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 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 CBF farmers for CBF production in particular village irrigations can cope with re-introduction of a CTQs which has already been practiced in rice farming known as a *Thattumarau*[5] system. *Thattumaru* system can be successfully used for selection of CBF farmers without introducing new selection criteria as it is inherently practiced by village farmers. However, There are two main limitations of the study: MVP analysis does not undertake more than two sectors of water uses (rice farming and CBF production), while reservoir water is being used for many other uses such as domestic use, animal watering and brick making. However, any steps which are taken to increase the residual volume of water will be beneficial for all the other alternative uses. In practice TE may not be possible to increase by one cropping seasons or a culture cycle for rice and CBF production respectively. The important factor for policy makers is realising that the maximum level of TE should be achieved to obtain the maximum benefits. In other words, optimal allocation of water should occur to improve TE. This enhancement can happen in three ways. First, TE of rice farming can increase while TE of CBF production is in existing level of production. Second, TE of CBF production can increase while TE of rice production is at existing levels of production. Third, the TE of both sectors can be increased at the existing level of production. The investigation of the dynamic situation of TE and its impact on optimal allocation is an area that could be examined further.

CONCLUSION

Reservoir water productivity can be increased by five times, by increasing TE up to the frontier level of production. The only necessary requirement for water saving is that water is used efficiently in rice farming. Increasing reservoir water productivity should be undertaken from a practical point of view. It should ensure water user rights of VISs for multiple users. It is important to reintroduce CTQs in CBF production in order to select CBF farmers. Co-management of water resources is the best institution for reservoir water management. Increasing farmers' economic benefits through efficient water re-allocation in reservoir-based agriculture will remove village dependency on external sources (subsidy, political support). The FOs can act as the main village level institution for reservoir water management and decision-making, with the support of relevant formal institutions and the market guidance of reservoir water demand.

REFERENCES

Agarawal, A. (2001). Common property institution and sustainable governance of resources. *World Development, 29*(10), pp. 1649-1672.

Ahmed, M., Viswanathan, K. K., & Valmonte-santos, R. A. (2004). Collective action, and property rights in fisheries management. Focus 11, Brief 7 of 16. CGIAR System-wide Programme on Collective Action and Property Rights (CAPRI), International Food Policy Research Institute, Washington DC.

Amarasinghe, U. S. (1998). Reservoir fisheries management in Sri Lanka: Achievement, mistakes and lessons for future. *International Review of Hydrobiology*, pp. 83,pp. 523-530.

Amarasinghe, U. S., & De Silva, S. S. (1999). Sri Lankan reservoir fishery: a case for introd`uction of co-management strategy. *Fisheries management and ecology, 6*(5), pp. 387-399.

Arnason, R. (2005). Property right in fisheries: Iceland's experience with ITQs. *Review in Fish Biology and Fisheries, 15*, pp. 243-264.

Arnason, R. (2009). On the economics of releasing cultured fish into the aquatic environment. *Review in Fisheries Science, 16*, pp. 135-145.

Chou, Y. K. (2002). Modelling social capital and growth: Department of Economics, Research paper 865. Department of Economics, University of Melbourne.

Coase, R. (1960). The problem of social cost. *Journal of Law and Economics, 3*, pp. 1-44.

Debreu, G. (1959). *Theory of value.* New Haven: Yale University Press.

Demsetz, H. (1967). Towards a theory of property rights. *American Economic Review, 57*(2), pp. 347-359.

Dennis, V. C., & Arriens, W. L. (2005). *Understanding water rights and water allocation.* Paper presented at the 1st NARBO Thematic Workshop on Water Rights and Water Allocation, Hanoi, Viet Nam 5-9 December 2005.

Furubotn, E. G., & Pejovich, S. (1972). Property rights and economic theory: A survey of recent literature. *Journal of Economic Literature, 10*, pp. 1137-1162.

Gough, H. G. (1957). *Manual for the California psychological inventory*: Consulting Psychologists Press.

Rafton, R. Q. (2005). Social capital and fisheries governance. *Ocean & Coastal Management, 48*, pp. 753-766.

Griffin, R. C. (2006). *Water resources economics: The analysis of scarcity, policies, and projects*. Cambridge, London: The Massachusetts Institute of Technology (MIT) Press.

Hahn, R. W. (1984). Market power and transferable property rights. *The Quarterly Journal of Economics, 99*, pp. 735-765.

Hardin, G. (1968). Tragedy of the commons. *Science, 62*, pp. 1243-1248.

Heaney, A., Beare, S., & Bell, R. (2001). Evaluating improvements in irrigation efficiency as a salinity mitigation option in the South Australian River land. *The Australian Journal of Agricultural and Resource Economics, 45*(3), pp. 477-493.

Heltberg, R. (2000). Property rights and natural resources management in developing countries. *Journal of Economic Surveys, 16*, pp. 190-214.

Katz, E. G. (2000). Social capital and natural capital: a comparative analysis of land tenure and natural resource management in Guatemala. *Land Economics, 76*(1), pp.114-132.

Khalkheili, T. A., & Zamani, G. H. (2009). Famer participation in irrigation managment: The case of Doroodzan dam irrigation network, Iran. *Agricultural Water Management, 96*, pp. 859-865.

Khan, A., Huda, F. A., & Alam, A. (2010). Farm household technical efficiency: A study on rice producers in selected areas of Jamalpur District in Bangladesh. *European Journal of Social Sciences, 14*(2), pp. 262-271.

Khan, S., Traig, R., Yuanlai, C., & Blackwell, J. (2006). Can irrigation be sustainable? *Agricultural Water Management, 80*(1-3), pp. 87-99.

Kularatne, M. G., Amarasinghe, U. S., Wattage, P., & De Silva, S. S. (2009). Evaluation of community participation for the development of culture-based fisheries in village reservoirs of Sri Lanka. *Aquaculture Economics & Management, 13*(1), pp. 22-38.

Mendola, M. (2007). Farm households production theories:A review of institutional and behavioral responses. *Asian Development Review, 24*(1), pp. 49-68.

Molle, F., & Berkoff, J. (2009). Cities vs. agriculture: A review of intersectoral water re-allocation. *Natural Resources Forum, 33*, pp. 6-18.

Oliver, P. E., & Marwell, G. (1988). The paradox of group size in collective action: a theory of the critical mass II. *American Sociological Review, 53*(1), pp. 1-8.

Ostrom, E. (1990). *Governing the commons: the evaluation of institutions for collective action*: New York, NY: Cambridge University Press.

Peris, K., Narayana, M., & Wijesinghe, S. (2008). *Ecosystem based indigenous water management* (Vol. 3). Colombo: National Science Foundation.

Pinkerton, E. W. (Ed.). (1989). *Introduction: attaining better fisheries management through co-management prospects, problems, and propositions*. Vancouver: University of British Columbia Press.

Renwick, M. E. (2001). Valuing water in a multiple-uses system, irrigated agriculture and reservoir fisheries. *Irrigation and Drainage Systems, 15*(2), pp. 149-171.

Samad, M. (2005). Water institutional reforms in Sri Lanka. *Water Policy, 7*, pp. 125-140.

Senaratne, A., & Karunanayake, K. (2006). Transaction cost and institutional innovation: Sustainability of tank aquaculture in Sri Lanka. *South Asian Network for Development and Environmental Economics (SANDEE) working paper pp. 18-6*.

Sivasubramaniam, K., & Jayasekara, B. M. (1997). Aquatic resources sector contribution to the GDP and the economy. *Economic Review, 23*(6), pp. 2-4.

Speelman, S., Farolfi, S., Frija, A., Dhaese, M., & Dhaese, L. (2010). The impact of the water rights system on smallholder irrigators' willingness to pay for water in Limpopo province, South Africa. *Environmental and Development Economics, 15*, pp. 465-483.

Swanson, T. (2003). Introduction to property rights and biodiversity conservation: Convergence of conflicts. *Land Economics, 79*(4), pp. 457-459.

Teraji, S. (2008). Property rights, trust, and economic performance. *The Journal of Socio-Economics, 37*, pp. 1584-1596.

Thiruchelvam, S. (2010). *Enhancement of capacity of farmer organizations for sustainable irrigation systems in Anuradhapura and Kurunegala Districts.* Paper presented at the The national conference on water, food security and climate change in Sri Lanka: Policies, institutions and data needs for water managment, BMICH, Colombo, Sri Lanka, 9-11 June 2009.

Uphoff, N. (1985). Experience with people's participation in water management: Gal Oya, Sri Lanka. In J.C. Gracia-Zamor (Eds.), *Public Participation in development planning and management: cases from Africa and Asia.* Boulder, Colorado: Westview Press. pp. 131-178.

Varian, H. R. (1992). *Microeconomic analysis (3rd ed.).* London: W.W. Nortan & Company.

Verhoef, E. T. (1999). Externalities, In J. C. J. M.van den Bergh (Eds) *Handbook of environmental economics.* Cheltenham: Edward Elgar Publishers, pp. 197-214

Wade, R. (1987). The management of common property resources: Collective action as an alternative to privatization or state regulation. *Cambridge Journal of Economics, 11*(1), pp. 95-106.

Wingard, J. D. (2000). Community transferable quotas: internalizing externalities and minimizing social impacts of fisheries management. *Human Organization, 59*(1), pp. 48-57.

Zhou, Y., Zhang, Y., Abbaspour, K. C., Mosler, H., & Yang, H. (2009). Economic impacts on farm households due to water reallocation in China's Chaobai watershed. *Agricultural Water Management, 96*, pp. 883-891.

End notes:

1. Average prices for paddy and fish are LKR 30.00 and 100 per kg respectively.

2. An ITQ is a quota share individual allocated as privilege of the total annual fish catch. Quota shares determined how the total annual fish catch is to be subdivided into individual fishermen. ITQs are usually allocated to individuals and group of fishermen during some designated period of time. ITQ shares can be transferred to other parties (Wingard, 2002).

3. FOs are highly politisised due to economic inter-dependence on the politicians and other people (money lenders). This dependency can be removed by increasing water user efficiency. The CBF farmers paid 5% to 15% of the total income of CBF production in 2009. However this is entirely a decision made by the individual FOs in the *kanna* meeting. This system can be further improved and formalized under CTQs with well defined property rights of intra-sector water allocation.

4. The inefficient sector of the command area could be used for cattle grazing which will generate positive externalities for CBF development of downstream reservoirs of the cascade.

5. *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.