An economic analysis of collective management for natural resources; with case studies of small scale irrigation and fisheries in South Asia

Preliminary Draft

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May 1999

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Acknowledgements:
This paper is part of PhD research assisted by a grant from the UK Economic and Social Research Council (ESRC)

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Abstract

This paper presents an economic model for collective resource management. The model is premised on the assumption that certain factors motivate individual and collective decision-making. These underlying assumptions as well as the robustness of the model are field tested with data from actual resource management systems in Sri Lanka and India. Initial field visits suggest that the model may be robust in explaining some of the important features of common property regimes.

The paper starts from the premise that renewable natural resources in developing countries – forests, fisheries, water resources and so on – are being degraded and depleted at rates which are non optimal. In economic terms optimality would require that resource use continues until the marginal benefit of resource use equals the marginal cost of resource use, where costs and benefits include both private and external costs/benefits.

One important factor in determining whether this optimality condition is satisfied is the nature of the property right regime for managing the resource. It is argued that in certain conditions open access, private property and state property will all lead to sub-optimality. For renewable natural resources with low potential productivity, high natural risk, large potential external effects, large costs of exclusion and more socially cohesive resource users, common property management may be the optimal management regime.

However the concern which motivates the paper is that many existing examples of common property management are breaking down. At the same time, driven by the perceived benefits of common property management regimes, many agencies – governments, donors, non-governmental organisations – are trying to promote new common property type arrangements. In this context, it is important to understand why some common property regimes succeed and others fail. This requires an understanding of why common property regimes develop and then why they persist.

Even more important is to understand whether in some cases the failure of common property is optimal. There may be cases where private property is more likely to lead to optimality. In other cases, resources which were once heavily used are now less important (for example shifting from products harvested from wild forests to products from cultivated plots) and so the costs of collective management may outweigh the benefits.

In order to model the economics of collective management, a simple model is proposed drawing from the club good literature, the environmental economics literature and the literature on inter-locking factor markets. The "club" is the decision to form a collective resource management regime. Individual decisions to form and operate such a group is assumed to be based on cost benefit analysis. Relevant costs include the private costs of membership, transactions costs of forming a club and the avoided external costs of internalising the externality. Relevant benefits include the economic and non-economic (e.g. social gains) from membership.

The decision-making process is described for the costs and benefits of membership for both those who join - club "insiders" - and those who choose not to (or are prevented) from joining

This model is designed to examine four main empirical research questions:

- How much are restrictions on outsiders from access to the club explained by economic factors (costs of punishment versus gains from entry) versus social and other pressures

- How much is prevention from cheating by insiders explained by economic factors (costs of punishment versus gains from cheating) versus social and other pressures

- How much is participation in collective management motivated by economic benefits compared to other factors such as social capital, political advancement

- Are there any collective activities with inter-locking externalities, which group members trade off to achieve some total increase in welfare

Answers to some of these questions are still under research. Initial results are available based on a review of the very large literature on common property as well some field visits. A large volume of data has been gathered for small scale fisheries in Sri Lanka, and for small scale irrigation systems in Sri Lanka and South India. Tentative conclusions suggest that the basic approach of the model is correct in assuming that individuals make decisions about collective management of natural resources based on a cost benefit type assessment. However it also would appear that costs and benefits are viewed in the most general way, covering both economic and non-economic costs and benefits.

Thus economic factors go some way to explaining the success and failure of particular common property regimes, and indeed in many cases, economics may be the most important explanatory factor. However non-economic factors such as social, historical and environmental conditions are also important in explaining which common property regimes persist.

1. Introduction

1.1 Why property regimes are important for improved resource management

Renewable natural resources in developing countries - forests, fisheries, water resources and so on - are being degraded and depleted, at rates which are non optimal. In economic terms optimality would require that resource use continue until the marginal benefit of resource use equals the marginal cost. Since the use of natural resources often imposes costs on others, it is important to include these externalities. Thus the optimality condition requires that resource use continues until the marginal private benefit of resource use equal the marginal social cost (Pearce and Warford, 1995).

One important factor in determining whether this optimality condition is satisfied is the nature of the property regime for managing the resource (Bromley, 1991; Dasgupta and Maler, 1994). With no management where open access prevails, resource use will tend to non-optimality since resource use continues until total costs equals total benefits. This implies a much larger level of use than when the marginal benefits equal marginal social costs. For private property the risks of non-optimality are less since an efficient private owner will ensure that the marginal private benefit of use equals marginal private cost. However the problem is whether or not the private owner takes account of the external impacts which lead to marginal social cost being higher than marginal private cost. Often this does not occur and so the risks of non-optimality remain. In the case of state property, in theory optimality is possible, but in practise weak enforcement leads to a de facto open access situation. Thus many attempts at state control of natural resource use are now deemed to have been failures. The one remaining management regime is what is known as common property or collective management.

Common property has the potential to optimise since unlike private property the externalities are internalised if all the individuals potentially affected by the resource use are members of the management group. Thus in principle, resource use can be controlled by the collective to ensure that use continues until marginal private benefits equals marginal social costs. This internalisation can be compared to two firms who affect each other deciding to merge. Clearly the larger the external effect, the more there is to be gained from collective management that will internalise the externality.

There are added complications to this simple comparison between private and common property (open access and state management, which is taken to be de facto open access are ignored as having certain non-optimal outcomes):. It can be argued that since the benefits of any resource enhancing activities are shared by all members of the group (like improvements to an irrigation reservoir), this will reduce incentives for such investments. Thus it may be that the marginal benefit curve is lower for resources managed collectively than those owned privately. However a very different result may arise from the risk-pooling benefits of common property: individuals have access to a wider set of resource endowments than they would if they were divided up so that each is managed privately. Given the risk associated with many resources (eg potential for water source to dry up, or fishing ground to become unproductive), a larger resource endowment will lower risk. This kind of risk-pooling could be seen as an additional marginal benefit from common property.

Thus lower productivity and risk-pooling work in opposite directions. The question is which dominates. For a low value risky resource, the benefits of common property as a result of risk pooling may be greater than any potential loss of productivity. Thus common property would be preferred. For a potentially high value, non risky resource, risk pooling may be much less of a concern than reduced productivity and hence private property would produce more efficient outcomes.

The other key factor which influences the relative costs and benefits between private and common property is the costs of management, which is taken to include transaction costs, access exclusion costs and internal rule enforcement costs. Transaction costs are those costs of collectively agreeing decisions. In the simplified case of a single private owner the transaction costs are assumed to zero. With common property, where more than one user is involved, the transaction costs are likely to be positive. Lower 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 principal, it could be argued that access exclusion costs are likely to be the same for different types of management regime. This may be the case, but it could be argued that for a fixed size of resource. a larger group implies more individuals involved in monitoring, so exclusion costs may be lower with common property. Similar arguments arise with regard to enforcing rules about how group members or "insiders" use the resource. The issue of individuals not obeying a rule due to so called free riding is addressed later.

This review has demonstrated that common property may be the optimal management regime for renewable natural resources with low potential productivity, high natural risk, large potential external effects, large costs of exclusion and less conflict ridden group membership. However the concern is that many existing examples of common property in developing countries are breaking down. At the same time, driven by the kind of benefits of common property identified here, many agencies - governments, donors, non-governmental organisations - are trying to promote new common property type arrangements. In this context, it is important to understand why some common property regimes succeed and others fail. This requires an understanding both of why common property regimes develop and then why they persist.

Even more importance is to understand whether the failure of common property is economically optimal or not. There may be circumstances which as already demonstrated, private property is more likely to lead to optimality. In other cases, resources which were once heavily used are now less important (for example shifting from products harvested from wild forests to products from cultivated plots) and so collective management is no longer required.

1.2 What is meant by common property regimes

There are a number of key concepts which appear in the growing literature on common property management, which are clarified in this chapter. Such concepts include open access, public and club goods, common pool resources, cooperatives and corporations. These concepts relate to distinctions in the literature between types of resource use regime, types of good, types of resource and type of institution.

While there is still some disagreement over what constitutes "common property", it is assumed here that it is an institution or form of resource use regime. The term common property resources is taken to mean simply those resources subject to common property management. Some authors (eg Berkes, 1989) have taken common property resource to refer specifically resources where exclusion is difficult and there is some degree of rivalness in use. However there are resources, such as land, which in some contexts are managed through common property – yet clearly exclusion is possible. The term common property resource is therefore seen to be confusing and is not used here. As stated by Bromley: "The literature is full of casual reference to common property resources as if this were a universal and immutable classification – almost as if the prevailing institutional form were somehow inherent in a natural resource. Never mind that in one place trees and fish and range forage are controlled and managed as private property, in another setting they are controlled and managed as state property, in another setting they are controlled and managed as common

property and in other settings they are not controlled or managed at all but are instead used by anyone who so desires to use them." (Environment and Economy, 1991)

i. Types of resource use regime

This relates to the distinctions between private, open access, state property and common property. There has in some cases been a lack of clarity between open access and common property resource use regimes. The so called Tragedy of the Commons (Hardin, 1968) actually refers to open access resources and so should be more accurately referred to as the Tragedy of Open Access (Stevenson, 1991). This point was first made by Ciriacy-Wantrup and Bishop (1975): "Common property is not everyone's property. The concept implies that potential resource users who are not members of the group are excluded. The concept of property has no meaning without this feature"

Under open access there is no ownership of the resource and so entry is unlimited. If there is rivalry in consumption which results in negative externalities, these will eventually destroy the resource under the famous result by G. Hardin (1968): "The rational herdsman concludes that the only sensible course for him is to add another animal to his herd. And another . . . But this is the conclusion reached by each and every herdsman sharing the commons. Therin is the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world which is limited. " The other effect of open access modeled by Gordon (1954) in the open access fishery is that extraction continues until all economic rents are dissipated. The final effect of open access is to lead to over-investment in extraction equipment (Stevenson, 1991).

By contrast, common property resources have limited controls to entry. Indeed Stevenson (1991) goes further and states that common property resources must also have limitations on how much each user of the resource can extract. Thus Stevenson summarises private, common and open access resource use regimes based on both the group and extraction limitation.

Table 1: A Trichotomy of Resource User Regimes

	Private property	Common property	Open access	
			Limited user	Unlimited user
Group limitation	One person	Members only	Members only	Open to Anyone
Extraction limitation	Extraction limited by individual decision	Extraction limited by rules	Extraction Unlimited	Extraction Unlimited

Source: Stevenson, 1991

However common property does share some aspects of private property and open access in that in certain situations (e.g. a fishery), users impose negative externalities on one another. The issue is the extent of the externality. Common property through limitations on entry and extraction by users, constrains the negative externality to a non destructive level. In practice, the restriction on extraction may be more varied and complex than simple physicals limits on the quantity extracted.

Common property management must have seven characteristics (Stevenson, 1991):

1. The resource unit has boundaries which are well defined by physical, biological and social parameters.
2. There is a well delineated group of users, who are distinct from persons excluded from resource use.
3. Multiple included users participate in resource extraction (ie group is at least two)
4. Explicit or implicit well understood rules exist among users regarding their resource rights and their duties to one another about resource extraction.
5. Users share joint, non-exclusive entitlement to the in situ or fugitive resource prior to its capture or use.
6. Users compete for the resource, and thereby impose negative externalities on one another.
7. A well delineated group of rights holders exists, which may or may not coincide with the group of users.

A simpler definition is offered by Bromley for common property: "The management group (the owners) has rights to exclude non-members, and nonmembers have duties to abide by exclusion. Individual members of the management group (the co-owners) have both rights and duties with respect to use rates and maintenance of the thing owned." Indeed according to this definition, the main distinction between private and common property is that there is only one owner with private property, but more than one with common property.

Theoretically, the outcomes produced by optimal state, common and private ownership can be the same as explained in the introduction. Indeed a state which allocates optimal quotas to resource users will reach the same outcome as an optimal common property management (Cornes and Sandler, 1992) . Thus the difference between the three regimes arises from the relative costs and benefits in reaching such optimal outcomes and the likelihood that such outcomes will occur under different property regimes.

ii Types of good/resource

There are generally two major types of good: public and private and a range in between. The distinction is that private goods are excludable and rivalrous, while pure public goods are non-excludable and non-rivalrous (also known as jointness of supply). For a pure public good, the value of a good is a function of the number of consumers, whereas the cost of providing the good is constant. Very few natural resources are still pure public goods as increased use has created rivalry in use.

There has been some discussion about the relationship between public goods and common property. There are two main distinctions (Stevenson, 1991). The first is that public goods are a type of good or service, while common property is a resource management method. Thus it is possible for the common property resource use regime to be used to manage both so called private goods, such as lands and goods with more public goods characteristics such as parks or natural harbours. The second distinction is that common property is not applicable to pure public goods since there must be some degree of rivalry and excludability for a common property resource use regime to be possible.

Another distinction between public goods and common property is drawn by R. Hardin (1982) that the theory of public goods as developed by Samuelson was focusing mainly on consumption, while the issue of collective management focuses mainly on the provision of public goods.

In between public and private goods lie a number of other goods with varying degrees of excludability and rivalrousness. Club goods are defined by Cornes and Sandler as an excludable (rivalrous) public good. Club goods are provided by a club which is a "voluntary group of individuals who derive mutual benefit from sharing one of more of the following:

production costs, the member's characteristics, or a good characterised by excludable Cornes and Sandler). Club goods are defined by Bromley as "joint management regimes that control assets and allocate use rights among co-owners or members." Thus the provision of club goods may be one form of common property regime.

Common pool resources on the other hand are generally perceived to be rivalrous, but harder to exclude than club goods. Common pool resources are defined by Ostrom (1990) as: "natural or manmade resource system that is sufficiently large to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use." They have also been defined (Stevenson, 1991) as "physically unamenable to division into individual units prior to capture." However in practice the difference between club goods and common pool resources often breaks down.

This gives the following simple typology:

Table 2: Typology of goods characterised by excludability and rivalrousness

	Non rivalry	Rivalry
Excludable	Club	Private
Non excludable	Public	Common pool

The relationship between common pool resources, club goods and common property is that given the characteristics of common pool resources and club goods, some kind of multiple use arrangements will be required, and in many cases this will be through common property.

Natural resources in this paper are defined to include both natural resources (forest, fish, groundwater, rivers), human infrastructure that uses natural resources (eg irrigation structures, water supply, microhydro generators) and environmental goods/bads (eg. poor drainage, protection from wild animals and landslides).

iii Types of institution/ organisations

There are many different rationales for collective arrangements to arise. The main way economists seek to frame the question is why non market institutions come about. Coase (1960) explains the theory of the firm as a response to high transaction costs of bargaining. While firms reduce transaction costs of repeated bargaining over long time periods, they also have principal agent problems requiring monitoring. The issue is whether the gains in reduced transaction costs outweigh the costs of monitoring to reduce principal agent problems.

In this context, it is worthwhile asking in what ways is a common property institution different from a firm. The main point made by Stevenson is that common property goods are not corporations or private companies in that individuals do not pool their real and financial assets and skills in order to earn a common return. There may be certain inputs which are jointly owned (eg tools, buildings) but in general each common property user earns his returns separately using his own inputs.

Nor can common property be identified as a cooperative. A cooperative will have very different circumstances since as Cornes and Sandler show under a situation where catch is pooled and each of the n exploiters takes home a fraction 1/n of the catch, then the level of exploitation will be below the efficient level. In deciding whether to fish, each fishermen only counts the fishing benefit as 1/n ignoring the n-1/n of the share that goes to the others.

Ostrom (1990) reviews the two institutions – firm and state – to explain why collective arrangements take place. Taking her theory of the state from Hobbes and assuming an entrepreneurial view of firm motivation, she concludes that for both the state and firm, the burden of organising collective action is undertaken by one individual whose returns are directly proportional to the surplus generated. The question is then, in common property regimes, what motivates collective action since there is no one individual who will appropriate any surplus. One answer is provided by Olson (1965) who argues that even with collective action, there are certain "entrepreneurs" who will benefit from collective action and thus help to organise it.

Another comparison between common property and the state is based on Buchanan and Tullock (1962) who model common property type management as voluntary cooperation between private individuals with a unanimous decision rule compared to collective state action based on majority rule.

1.3 A Summary of Common property resource regimes

Based on this selective literature review, common property resource regimes are a resource use regime which restricts entry to the resource (or to the infrastructure which uses the resource) and limits extraction by group members. Such management regimes can be used for all types of good – public, private, common pool or club goods – but are more likely to arise in the context of club goods or common pool resources. Common property regimes require groups of individuals who are neither a private firm nor a cooperative (although they may have some jointly owned assets) to each earn returns from a resource using their own inputs (or from infrastructure) subject to a set of collectively agreed rules.

2. How can common property management be modelled economically

This thesis reviews the micro-economics of collectively managed natural resources to determine what factors explain the success and failure of such schemes. Common property regimes are examined in both Sri Lanka and the Indian state of Tamil Nadu, focusing specifically on small scale irrigation schemes and fisheries.

2.1 Review of earlier economic analysis (theoretical and empirical)

Many authors have pointed out that it is not possible to define a complete set of institutional rules to explain the formation and persistence of common property regimes: "By differing, the rules, take into account specific attributes of the physical systems, cultural views of the world and economic and political relationships that exist in the setting." (Ostrom, 1990) However it is possible to move closer to a generalisable set of charactersitics required to explain common property by identifying the economic parameters within which common property institutions operate. While this economically reductionist approach is applicable only to certain contexts, for these contexts it does allow the various institutional characteristics to be taken as a means to achieving economic objectives, rather than as an end in themselves. For some of the existing lists of institutional characteristics explaining common property (see Wade, 1987, Ostrom, 1990 and Hobbley, 1994) this distinction as to whether institutional characteristics are means or ends is unclear.

An important element of the growing empirical literature on common property resource management has focused on economic cost benefit analysis as an explanation for whether collective management takes place. Empirical studies have focused on both individual returns from cooperation (Acheson, 1988, Stevenson, 1991, White and Runge, 1995; Bardhan, 1994) and collective returns (Wade, 1987, Ostrom, 1990 and Mosse, 1994). The evidence that is currently available suggests that participation or cooperation is positively correlated with increasing economic returns at both an individual level and group level.

The cost benefit analysis for collective management of natural resources can be used to explain three different characteristics of collective management: exclusion achieved, free riding prevented and transaction costs overcome. While all these constraints need to be solved simultaneously, they are analysed separately here. Thus the optimal common property size will be a function of relative costs and benefits of exclusion, versus optimal total size and optimal punishment for free-riding. The complexity of solving all these three constraints simultaneously explains why the existence of common property is threatened world-wide.

This extended approach will be presented here drawing upon examples of various common properties in particular small scale irrigation schemes and small scale fisheries, focusing on the growing body of research available on common property management in Sri Lanka and South India.

Limiting open access through exclusion

The definition of common property requires that open access to the resource has been prevented. As Ciriacy-Wantrup and Bishop (1975) state "Common property is not everyone's property. The concept implies that potential resource users who are not members of the group are excluded. The concept of property has no meaning without this feature". Indeed if "outsiders" to the management group are not excluded, then the situation will revert back to the open access identified by Hardin (1968). Analysis of management systems that exclude outsiders and mechanisms to make "outsiders" insiders have been developed in the literature on club goods (Cornes and Sandler, 1996).

Rules on "membership" of a common property management group can either be determined by quantity controls (eg only fourteen fishermen in the lagoon unless members decide otherwise) or price controls (eg payment of $50 plus three days labour to join the water supply scheme). Quantity controls will be more applicable to common pool resources (eg fisheries), where the resource is largely fixed, while price controls will be appropriate to club goods which can be increased such as members grow (eg rural water supply scheme).

In small scale reservoir (known as "tank") irrigation system, rights of access to the water include criteria based on land, crop share, membership of village and payment of irrigation fee (Gardiner, Ostrom and Walking , 1994). Rights of access to small scale fisheries are more complex, including criteria based on physical aspects of the fishery, residence, organisational and socio-cultural factors and fishing gear (Sen and Nielsen, 1995). Since access to land is relatively difficult compared to ownership of fishing gear, it is often the case that irrigation facilities will experience less conflict with outsiders than fisheries. However even in irrigation, land access is not as stable as might at first appear as governments often seek to expand the area served by an irrigation reservoir (known as the command area of the facility). This has been a common problem in small scale tank systems in Sri Lanka (Leach, 1961).

Overcoming free riding:

The problem of free riding is set out by Olsen in the Logic of Collective Action (1962) who argues that goods with public good characteristics will only be provided if there is one person whose costs of providing all the public good is less than the benefits that he receives. A group who has an individual for whom this is true is privileged, one that does not is latent. Olsen also argues that large groups tend to be latent, while small groups are more likely to be privileged.

This problem of free riding has elsewhere been modelled as the prisoners dilemma where the choices of individual 1 are affected by concerns about what individual 2 may do (see Table 3). Here defection is the dominant strategy.

Table 3: Simple cheating game

Player 2 Player 1	Cooperate	Defect
Cooperate	1,1	-2.2
Defect	2,-2	-1,-1

Note: player 1's pay-offs are given first.

For a collective good, we can compare pay offs to an individual versus pay-offs to the remaining members of the collective (see Table 4). There are ten members and if all members pay 1 unit (for a total cost of 10 units), the benefit to each member will be 2 units (for a collective benefit of 10 units). Payoffs are costs minus benefits. The individual pay-offs are given first and his actions are shown on the left hand column. So again not paying is the dominant strategy.

Table 4: Game theory applied to collective management

Individual Collective

	Pay	Not pay
Pay	1,1	-0.8, 0.2
No pay	1.8, 0.8	0,0

There are a number of ways to solve the problem of cheating:

- It has been shown that in infinitely repeated games the result may be different, with Axelrod showing that the tit for tat strategy works best ie cooperate unless others cheat, and then cheat until others cooperate.
- Another solution has been shown by Runge (1981) that prisoners dilemma is not always the dominant strategy. Rather the dominant strategy depends on co-ordinating a critical mass of agents to ensure cooperation (this is similar to the need to ensure cooperation among k agents as defined by Olsen, 1962). This problem has been labelled the "assurance" problem based on Sen (1967): "If they function optimally, common property institutions can lead to equilibrium outcomes in which each individual is assured that a critical mass of individuals will cooperate, so they too will have an incentive to cooperate. This is in marked contrast to the Multiperson Prisoners Dilemma, in which no one would contribute even if everyone else did. Of course, common property institutions do not always provide this assurance . . . The model says that the free rider problem can be sold - not that it will be solved." (Runge, 1986).

For Runge the incentives to free ride as groups size increases is related to the marginal benefits brought about by one more individual cooperating. Below the critical level of k, individuals expect others to cheat so they themselves cheat. However once k, the critical mass has been reached, people expect others to cooperate, so they cooperate themselves. At this point it is also clear that one's marginal contribution to the public good is high. However at one point so many agents are cooperating that it again becomes advantageous to cheat. At this high level of cooperation one also finds that the marginal benefits of cooperation decline. This may also arise when the goods provided are goods provided in discrete quantities. Once the minimum number required to provide the good has been reached, the marginal benefits of further contributions fall to zero.

- Free riding in public good provision can be overcome by bundling with private goods. The social benefits of group interaction are a private good, which if high enough will overcome the incentives to free ride.
- Another way of overcoming the incentive to cheat is if there is a political entrepreneur who find it in their private interest to work for collective benefits.
- Another route out of the prisonors dilemma is to assume that enforcement through monitoring and punishments takes place such that the benefits of cheating minus the punishment are less than the benefits of cooperating. The problem with this approach is that monitoring itself has public good characteristics that mean there is incentive to shirk. Ostrom (1990) combines this view with the assurance approach to argue that there is a private benefit of monitoring in situations where information is costly and necessary to adopt to a contingent strategy.

Punishments for cheating is the route that has been most observed in actual common property regimes and so it is reviewed further. The incentive to cheat arises in common property management when members of a limited access common property either provide too little supply improvements, or too much demand for the resource. This is the free rider problem in the case of resources that are close to local public goods (eg large reservoirs, protection from wild animals, catchment protection, urban drainage) and the congestion problem for resources that are excludable but rivalrous (eg fisheries, coral reefs, small reservoirs, micro hydro electricity and micro rural water supply). Agreements on inputs and outputs is often assisted by certain institutional characteristics such as numbers of members, homogeneity between members and monitoring and sanctions on members.

In simple economic terms, the benefits of cooperation must be larger than costs.The prisoners dilemma arises if there is big difference in pay off between cooperating and defecting. This may not always be the case. Thus it may be relatively easy to set the fine such that it is higher than the benefits from cheating.

In many actual common property regimes, free-riding can become important. Most traditional fishing systems break down not as a result of invasions from outside, but because of enterprising insiders who have taken advantage of existing technology, markets and capital to improve their income and who are the first to break rules (FAO, 1992). One example is the break-down of the beachseine fishery in Ecuador (Southon, 1989) With the introduction of capital intensive fishing technology, there developed vertically integrated ties between an outside middleman and a group of entrepreneurial boat owners. These ties cut across the horizontal relationships underlying the system of sea tenure.

Sanctions for non cooperation in an irrigation system are difficult but possible. One example is given of an irrigation system in Andhra Pradesh in Southern India (Wade, 1988, p 194): "Free riding on common irrigator services is held in check by knowledge that termination of common irrigator services, when water is scarce, would produce an immediate crisis for everyone with land in a tail end location within a village. Also the people know that non payment one season can be penalised the following season by the common irrigators themselves; it will cost the common irrigators some extra effort, but it is possible for them to interrupt a non payer's water supply until his crops suffer yield reducing stress. So the common irrigators service is not a pure public good, because one contributors can, with difficulty, be excluded."

Even, when punishment by exclusion is difficult, it is possible to impose fines, as happens in some South Indian irrigation systems (Wade, 1988, p 193): "The available sanctions include fines of non trivial amounts - a days field wages for an animal caught at night and much more for water infringements. The fields guards salary are set at less than the daily wage of an agricultural labourer so as to give him a strong incentive to collect the fines, for they keep all of the small fines and a fixed percentage of the larger one. "

Where collective management involves taking decisions about allocation, then those not participating will lose out and this can deter free-riding in meeting attendance. This was found to be the case in some irrigation systems in Sri Lanka: "Under such circumstances, non participation will penalise the free riding individual - to be absent when decisions are taken about how to optimise water distribution and not to contribute information or make claims for one own share is disadvantageous."(Uphoff et al, 1990)

Ensuring the total benefits of cooperation are higher than costs:

Even assuming that outsiders can be kept out of the resource and insiders can enforce rules amongst themselves to prevent free-riding, the total benefits of cooperation need to be greater than the costs. While this may be self-evident, it has received much less attention in the economic literature than the concern with free-riding. The main benefits discussed are the avoided externalities of open access and reduced social conflict, while the main costs are the so called transaction costs.

Benefits of cooperation include the avoided costs of social conflict and avoided externalities imposed by others. Wade (1988) identifies that the " Main factor explaining the presence or absence of collective organisation . is the net collective benefit of the action." (p206). More specifically Wade relates cooperation with the avoided external costs from others. Wade demonstrates this with an analysis of villages in Andhra Pradesh, South Indian villages which cooperate to reducing grazing and water-stealing from irrigation. 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.

In villagers where the external costs of non cooperation are highest as indicated by the unreliability and inadequacy of irrigation water and the density of grazing stock, cooperation is highest. The villages with most unreliable irrigation water and highest density of livestock are the villages at the tail end of the catchment and it is in these villages where institutions to manage water and reduce overgrazing are most developed "It is where the risks of both grazing and irrigation are high that on expects to find a corporate response as strong as Kottapalle's: in villages fed from near the tail end of a more than several miles long irrigation channel, with fine, water retentive soils. In dry villages with fine, water retentive soils there are high grazing risks, which tend to generate only an intermediate level of corporate organisation. On the other hand, in top ended irrigated villages, the risks of both irrigation and grazing are relatively low, and the level of corporate organisation tends to be less than that of may dry villages". (Wade, 1988, p 185)

The basic conclusion is confirmed by Mosse in Tamil Nadu in Southern India (1997)p 490: "It appears almost undeniable that the pattern of collective action in Sarugani basin tanks is an expression of ecological variation; that it is shaped by a structure of pay offs arising from ecologically determined costs, benefits and risks and therefore strongly complies with the predictions of institutional-economic theory. In the one (sandy soil) area, ecological conditions - rice cultivation under sandy soil induced scarcity - are such that benefits from co-operative water management and costs of not cooperating (in terms of both crop loss and social conflict) are high. Moreover land holding patterns give almost all farmers direct interest in irrigation as owner cultivators of wet land. In the other (clay soil) area, risks and benefits of cooperation are low and land interests dispersed through extensive rained cultivation and complex tenure systems."

Interestingly while Wade's general principle is confirmed, Mosse reverses his observations that villages in the lower catchement face greater scarcity and hence are more co-operative. In the basin Mosse studies, it is total water demand related to soil type which is more important than adequacy of water supply. These results for Mosse are confirmed by Begum (1997) with a review of 20 irrigation tanks in Sri Lanka.

The main cost of collective decision making reviewed in the economic literature is the so called transaction costs or the costs of making decisions. Decision making is costly in groups due to strategic behaviour as Buchanan and Tullock explain: "If two or more individuals agree on a single decision, each of them must expect to be worse off or better off or at least not worse off as a result of the decision being carried out." Even if all parties expect to be better off, decision making is still costly since "normally a bargaining range will exist and recognising this, each individual will seek to secure the maximum gains to himself while keeping the net gains to his partners to a minimum. Each individual will be led to try to conceal his preferences from the others I order to secure a greater share of the "surplus" expected to be created from the choice being made."

Transaction costs are crucial since as Bromley states: "It is this transaction costs that can be blamed for the cumbersome nature of common property regimes even assuming that the collective has managed to solve the problem of group size and free riding."(p30, Env & Econ, 1991). The size of transaction costs will also depend on what kind of decision making rule are used, with unanimity rules much more costly than majority rules (Buchanan and Tullock, 1962). This is because transactions costs are related to bargaining. At low levels of equanimity there is less likely to be bargaining since if one member of the group asks for exorbitant terms, the group will simply turn to someone else. However as Buchanan and Tullock conclude;" As unanimity is reached, however, this expedient becomes more and more

difficult. Individual investment in strategic bargaining becomes highly rational, and the costs imposed by such bargaining are likely to be high."

The major factors raised in the literature which influence total costs and benefits of cooperation are the type of good, the size of the group, the distribution of benefits, the extent to which benefits are controlled by the group and alternative benefit sources. These are all addressed below.

i. Group size

There has been a large discussion in the literature of the effect of group size on net benefits to the group. Olsen (1962) argues that small groups are less likely to be privileged (i.e. contain someone whose benefits of public good provision is larger than the costs) and hence unable to provide goods with public good consequences. By contrast, one of the disadvantages of large groups is the difficulty of reaching any agreement (which is reviewed further in the section on transaction costs).

The issue which Olsen is interested is latency (given by k in Table 3.1) - the number of individuals who will have to cooperate to provide all the public good. Thus for some goods, the number required to cooperate increases as group size grows suggesting that large groups will be less likely to provide collective benefits. However for some groups which are non rivalrous, benefits grow with more members such as a large irrigation reservoir or controlling wild animal damage. Thus ignoring transaction costs, there is no reason to assume that large groups will be less able to provide the good than small groups.

ii Type of good

Fundamental to the way costs and benefits vary is whether the good is a pure public good or a good which exhibits rivalry in use. Even where goods are rivalrous, they can be both fixed in size (e.g. an irrigation reservoir) or able to expand as membership changes (like a water supply scheme with the possibility of large conveyance structures). As R. Hardin (1982) demonstrates the effect of increased players on the costs and benefits of cooperation depends crucially on the type of good being considered. This is illustrated in table 2.1 below, where n is the number of members, Cg is total cost to the group of good and r is ratio of group benefits to costs (C), and k is the smallest integer larger than Cg/Vi representing the smallest subgroup who could benefit from providing all the good. Once n, C and r are set the other variables will be determined. Vi is the value of good to individual I, Ci is cost to individual, Bg is the benefit to the group of the good, Vi/C is the return to individual per dollar invested, while 1-Vi/C is the disincentive to pay $1.

Table 2.1 How benefits and costs of cooperation vary for different types of good

	n	Cg	r	Vi= rCg/n	Ci= Cg/n	Bg= nVi	Vi/Cg	1-Vi/Cg	K
Base case	5	5	4	4	1	20	0.8	0.2	2
Cg,Bg fix (fixed quantity, rivalrous)	100	5	4	0.2	0.05	20	0.04	0.96	26
Cg fix, Bg up (public goods)	100	5	80	4	0.05	400	0.8	0.2	2
Cg up, B fix (more quantity, rivalrous good or bad)	100	100	4	4	1	400	0.04	0.96	26

Adopted from R. Hardin, 1982

The important rows are n, Cg and Bg which show how group costs and benefits alter as n the group size changes. The first change is where the total costs and benefits stay constant as n expands to 100 and hence Vi the individual benefits fall. This is like a good which is fixed in quantity and rivalrous in consumption, such as a small (fully congested) irrigation reservoir.

The second case is where Cg is fixed, but benefits increase. This is like provision of a public good where the benefits increase with more members but the costs of provision are fixed. This is like protection of fields from wild animals such as elephants or wild boar, or maintenance on a large (uncongested) reservoir.

The third example is where costs and benefit both increase proportionally as n increases. This is a good which is rivalrous in consumption, but is provided in a larger quantity as n increases, such as a water supply scheme from a limited water source. With the potential of a larger conveyance structure as n increases. Alternatively this may be a bad generated by the group, so its reduction will impose higher costs as n increases, and also higher total benefits. Thus although the good (or eliminating the bad) exhibits perfect jointness, its cost rises as group size increases. An example might be rules to prevent a village destroying their own water catchment area, or prevention of cultivation on steep slopes leading to siltation of the irrigation structures, or rules to control open access to a fishery.

iii. Distribution of costs and benefits

The benefits of cooperation are highest and costs lowest when benefits are equally distributed to all ie all groups should gain from collective management. If one individual loses, or does not gain, why should they bear the costs of organising collective management. This is often violated in the case of irrigation where some farmers are much closer to the water source (head-enders) while another group is 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:

Empirical evidence for this comes from many different irrigation systems. Chambers (1977, GR, p358) notes that: “communities are unlikely to agree amongst themselves that those higher up will take less in order that those lower down may benefit.” This is clearly stated by Hunt (1989): “Those close to the main canal (those at the head of the distributary canal) have ample access to water, and have to perform very little maintenance. Those closer to the tail of distributary canals, on the contrary, have very uncertain access to water, and are potentially faced with performing a great deal of maintenance to keep the distributary working. Those at the head of the system have very little incentive to support maintenance efforts below them on the distributary. Further if demand for water below them increases, their own access to water will be impaired. For those at the tail on the other hand, there is very little incentive to perform the maintenance because even if the maintenance is performed they have no leverage over those at the head to release appropriate amounts of water.”

This was confirmed for some schemes in Andrah Pradesh (Wade, 1988 p 185) where it was found that holdings must be scattered for cooperation to occur: “If holdings are not scattered, the externalities of water use are uni-directional: the actions of irrigators with land at the head of the block impose costs on those towards the trial, but not vice versa. In this case, there is a clear difference of interest between top enders and tail enders, the latter having stronger incentive than the former to agree to strong community organisation and formal rules.” Uphoff reviewing an irrigation system in Gal Oya, Sri Lanka (1985) found that incentives for head enders can be increased yields, but these will only occur if the supply of inputs is increased.

Overcoming the head-ender incentive problem is greater than the traditional free rider problem (Bardhan, 1984): "The need for maintenance of field channels is felt more by the farmer at the tail end, but the work has to be done near the head on someone elses property, and the latter has less incentive to allow this."

Given these problems between head-enders and tail-enders suggests that increasing the sum total of water for all is much easier than redistributing water among existing users. Collective management needs to have ways to increase total water availability. Therefore tank management is much easier than canal management. As Hunt 1989 concludes: "Water user association (WUA) members cannot reasonably be expected to do the work planned for them for free. There has to be some kind of reward for the dirty work. two kinds of payment seem acceptable - a wage for the labour involved in maintenance, or local control over the much of the process, especially control over water. Probably the most effective reward is control over water."

iv Control over benefits

The effect of outside factors other than collective management which influence resource availability is vitally important. If resource availability fluctuates significantly due to manmade factors, such as extraction by outsiders (eg trawlers in artisan fisheries or commercial loggers in forestry) or on natural factors (eg rainfall patterns and irrigation), then the perceived benefits from collective management are low. This explains why the benefits of cooperation are so often higher in small scale irrigation systems than large scale inter-connected irrigation systems, where upstream farmers affect the water availability (see IIMI references).

Similarly if the resource cannot be seen or predicted, then less the perceived benefits from collective management. Thus one fishery with the highest benefits from collective management is where there are relatively sedentary fisheries, such as lobsters. The main form of collective management is some form of rotating sea tenure where fishermen share access to fishing spots in some regulated fashion (either an orderly rotation or random) , for example by casting lots.) This has not given rise to private ownership of the spots for two reasons explained by Ascheson (from Mcay and Ascheson): "Concentrations of lobster are found in different places over the annual cycle and from year to year. A man confined to a small territory would not likely have adequate catches most of the time." This is a form of risk sharing argument also used to explain the presence of communal land management in the dry zones of Africa. The second reason is that the cost of defending such privately owned fishing spots would be prohibitive.

v. Alternative benefit sources

Resource dependence is affected by availability of non natural resource incomes, or substitute goods (eg well water for irrigation water). The importance of reduced dependence on fisheries can be shown to have undermined common management of fisheries in the Philippines (Sunderlin, 1997) : "A time series comparison of fishing households in 1980 and 1983 reveals that in this period: there has been a 19% decline in the number of fulltime fishers in each household; the number of sons who left the household and entered fishing has declined from 51.9% to 37.75; respondents with supplemental non fishing income has almost doubled from 19.5% to 32.4%: respondents receiving remittances has more than doubled from 13.3% to 29.3% and females 16 and older engaged in income earning activities tripled. It is possible that these moves away from fishing are undermining interest in organised efforts to alter resource use patterns, both because there is somewhat less interest in fishing and most of these changes appear not to have resulted from organised efforts."

2.2. Synthesised economic model

Based on the literature reviewed, a simple model is described to explain four important characteristics of successful common property management regimes:

1. Mechanisms must be in place to prevent outsiders using the resource: Whatever, the rules used to enforce exclusion the most fundamental requirement for common property to arise and persist is that the costs of exclusion must be less than the benefits of collective resource use to the group who enforce the exclusion. These benefits will depend on the externality imposed by allowing outsiders free access.

ECi < ExCo

ECi = exclusion costs to insiders of keeping outsiders out
ExCo = External costs caused by outsiders to insiders

If this is not the case then open access occurs and there will be no common property. External costs by outsiders depend on the type of resource. The benefits of exclusion are related to membership size, since it is important to ensure that exclusion is set at a level where membership is not so high as to lead to "crowding" or "congestion". There may also be a minimum number of members required to be economically viable. Some goods are what are called step goods - public goods that can be produced or provided only in discrete quantities, so discrete numbers of members will be required.

Exclusion costs will depend on to costs of monitoring and enforcing exclusion, which will depend on the type of good: as goods become more "public" exclusion costs go up. Thus club goods will have lower exclusion costs than common pool goods. But what it that makes goods more or less "excludable"..

Clearly exclusion costs also depend on the pressure on the resource from non members. Where all potential beneficiaries of the good are members of the group, exclusion costs will be zero. So for certain common property resources, such as small scale irrigation and inland lagoons, G may be equal to P, so exclusion costs are zero and open access is not an issue. Thus exclusion costs (EC) will depend on the extent to which the group of insiders (I) is a share of the potential beneficiary population (P) (where insiders plus outsiders equals the population). I must be less than or equal to P. As I becomes a smaller share of P, EC will rise. Thus exclusion costs EC are related to the size of I as a percentage of P (or I/P)

EC = f (I/P)

EC = Exclusion costs
I = Size of group allowed access to resource (ie number of insiders)
P = Total population who could potentially benefit from resource (insiders plus outsiders)

Assuming that I/P is fixed, then exclusion requires that the total net benefits of resource use by insiders is greater than the total net benefits of resource by outsiders. Otherwise the insiders would have no incentive to prevent the outsiders become insiders. If we assume for the moment that the marginal benefits of resource use by insiders is the same as the marginal benefits of resource use by outsiders (and the groups are the same size), what costs may differ between the two groups. The main difference is that insiders will bear the cost of monitoring and enforcing exclusion while outsiders will bear the costs of being punished for intrusion:

NBRUi - ECi .> NBRUo - CPo

NBRUI = Net benefits of resource use by insiders
ECi = exclusion costs borne by insiders
NBRUo = net benefits of resource use by outsiders
CPo = costs of punishments by outsiders

Where NBRUi = NBRUo then ECi > CPo

Exclusion costs for insiders will be determined by the insiders cost of monitoring (CMi). Costs of monitoring to the management group which will be a function of the physical attributes of the resource, the relative location of the group to the resource and the technology of the outsiders seeking entry. For certain resources such as dense forests, where intruders are hard to observe, the costs of monitoring will be high. Generally the nearer the group are to the resource, the easier monitoring is for them. This is one of the reasons that lagoon and coastal fishermen live on the waters edge. It means they can guard their craft and observe others entering the fishery. Finally the technology of outsiders means that the advent of motorised boats has made it much harder to prevent open access fisheries, as outsiders can exit quickly if spotted. This was observed by Dahl (1988): ""The introduction of modern technology can increase the costs of defending territory because of greater fishing power and increased mobility. Coupled with increases in demand, modern technology may make outsiders more willing and able to encroach on territory and deplete its resources. " (p43)

CMi = f(Pr, Li, To)

CMi = cost of monitoring
Pr = physical attributes of resource
Li = Location of insiders in relation to resource
To = Technology of outsiders

The costs of punishment for outsiders (Co) depend on the effectiveness of enforcement, which may in some cases will be legal, but in others cases may be informal such as violence or damage to property. Unlike enforcement on members of the group, here the punishment has to be much higher as the outsider has nothing to lose from being caught (unlike a group member who could penalise future rights to use) and may have less shared "social capital" by being from another area, or tribe or caste etc. Thus in practice punishment against intruders may have to be fairly brutal, such as destruction of equipment. In many cases, where the outsider is richer or more powerful, then insiders are largely helpless. Thus many small scale fishing management regimes have been undermined by the entry of trawler fleets.

CPo = f(Po)

CPo= cost of punishment
Po = Power (wealth, political connections) of outsider

Returning to our earlier assumption that the total net benefits of resource are the same for insiders and outsiders, this will clearly not be in cases where the relative size of insiders to outsiders changes or where the marginal benefits to insiders differ from the benefits to outsiders.

Factors which change the relative size of insider and outsider groups:

* It is clear that the relationship of insiders to outsiders (I/P) is not fixed. In particular, P the population who potentially benefit from the resource is not fixed but is a function of population growth. If the number of outsiders is rapidly growing, there will be increased pressure to enter the resource. Thus there is the well known phenomen of increased population growth leading to open access.

* The benefits to outsiders of resource use depend on the other opportunitities available. If outsiders are poor, then there may be higher entry.

* Similarly if the value of the resource increases, then the demand for extraction will grow. For example this led to over-exploitation in the Belize lobster industry as increased demand by tourists for lobster overwhelmed the common property regime.

* To join insiders has a cost , which will act to keep the number of insiders down. Thus government policies that subsidise access to these assets - through for example forced land redistribution in an irrigation system, or subsidised credit for purchases of boat and fishing equipment - may undermine exclusion.

* The number of insiders itself is not fixed. Groups may develop procedures to allow new members (ie outsiders to become insiders), where this does not lead to very large externalities on current users.

Factors which changes to the relative net marginal benefits to insiders and outsiders

* The costs and benefits of resource access may be different from insiders and outsiders (and will generally be lower for insiders as this is why they became insiders in the first place). For example to become a member of G may be in terms of requiring an asset (such as land or a fishing boat or an electricity connection to use microhydro). Outsiders may have longer travel costs to the resource (eg further from fishery) or higher costs of connection (eg land further from irrigation reservoir), which reduces the benefits of resource use.

Thus to summarise:

NBRUi (I/P, ACi) - CMi(Pr, Li, To) > NRBUo (ACo) - CPo (Po)

CMi = cost of monitoring
Pr = physical attributes of resource
Li = Location of insiders in relation to resource
AC = access costs to the resource for outsiders
To = Technology of outsiders
CPo= cost of punishment
Po = Power (wealth, political connections) of outsider

2. Mechanisms must be in place to prevent insiders cheating on restrictions on use

This requires that for an individual in the group considering whether to cheat, the benefits of cheating must be less than the costs. The costs of cheating are the demonstration costs of cheating and the cost of punishment times the probability of actually being caught and punished. The demonstration costs of cheating refers to the effect that cheating will have on others behaviour - since the more people cheat, the more likely the whole management scheme will be to collapse leading eventually to open access.

Bc < DCc + (CPc x Prob of Pc).

Bc = benefit of cheating
DCc = demonstration costs of cheating
CPc = cost of punishment (if found cheating)
Prob of Pc = probability of being punished for cheating

The benefit of cheating depends on the share of amount of the resource that can be appropriated before being caught. The discount rate can also be important if the benefits of cheating are available now, but the process of being punished takes place some time in the future, and may involve no longer having access to future benefits. Where the discount rate is very high, in a period of severe resource scarcity (for example a drought), then the gains from a unit of the resource (eg water) may be much higher than normal and the benefits of cheating will increase. (Also at times of resource scarcity, the external costs of others use will increase and it may be likely that the amount of monitoring – and so probability of being caught - and punishments for cheating increase. Whether this is sufficient to offset the increased benefits of cheating can only be tested empirically).

The cost of punishment may be reduced access to the resource, some kind of payment or some form of social disapproval. Clearly social disapproval will work best in closer groups where social standing matters.

Group size can have an impact on the extent of free riding. For example, group size can affect the probability with which an individual is caught - in larger groups, there may be lower probability of being caught. Similarly the demonstration costs of cheating tend to be higher in small groups.

In summary
Bc (dr) < Dcc (G) + (CPc x Prob of Pc (G)).

Bc = benefit of cheating
dr = discount rate
DCc = demonstration costs of cheating
CPc = cost of punishment (if found cheating)
Prob of Pc = probability of being punished for cheating
G = group size

3. Mechanisms to ensure that total net benefits of collective management outweigh the costs

In conjunction with solving the exclusion and free rider problem, it is necessary that the total costs of collective management are less than the total benefits. This calculation applies both to forming institutions (fixed costs of collective management) and maintaining them (operating costs of collective management).

Ben Coop > Costs Coop (fixed and operating)

The benefits of cooperation depend on the resource dependence (Resdep), the variability of the resource by factors which management cannot control (Varres) and by the avoided external costs of others use.

where Ben Coop = f (Resdep, Varres, Aexc)

where
Avextcos = avoided external costs of others unrestricted use
Resdep = resource dependence
Varres = variability of resource

The costs of cooperation include the costs of monitoring and enforcement against both outsider and insider rule breakers, the transaction costs of agreeing rules and the direct costs of maintenance. In most cases costs will be composed of the opportunity cost of time times the value of time inputs in terms of cost of providing labour or attending meetings..

Cost Coop = f (OC t x t)

OC = opportunity cost of time
t = amount of time

It will be necessary to develop more detailed models for different types of good: club goods, common pool resources and almost public goods.

For club goods, such as rural infrastructure, benefits will be those provided by the provision of the infrastructure including direct economic benefits (DB) such as increased returns or other indirect economic benefits (InD) such as time saved in collecting water or savings in kerosene for lighting. For and costs will be capital costs (CC) cost of operation and maintenance (CO&M) and transaction costs (TC) of meeting and costs of monitoring and enforcement (CM&E).

B (DB, InB) and C (CC, CO&M, TC, CM&E)

For common pool goods, benefits will be reduced external costs, and costs will be transaction costs and costs of monitoring and enforcement

B (AExC) and C (TC, CME&F)

Some goods such as infrastructure that depend on a finite natural resource (eg small irrigation structures, micro hydro electricity and rural water supply where water is scarce), there may be elements of both club goods and common pool goods.

B (DB, InB, AExC) and C (TC, CC, CO&M, TC, CM&E)

There are a number of factors which influence both costs and benefits:

* Size of the group. According to club model, there is a trade-off in group size as benefits fall and costs rise. More simply larger groups must share the benefits among a larger number. It is the trade-off between transaction costs, exclusion costs and congestion externalities, which determine the size of the optimal group from one upwards (Field, 1985). Very simply transaction costs increase as the number in the group increase, while exclusion costs decline

* Resource dependence (share of income of group affected by collective action). There are some who suggest that the relationship between resource dependence and the benefits of collective action resemble an inverted U. If dependence on the resource is too low, there are no benefits from management. Similarly if there are alternatives/substitutes easily available for the resource (eg electricity from grid, medicinal plants from retailers, wood from homegardens) this reduces dependence on public good. However if dependence too high, there may be high transaction costs to agree on collective action.

* Resource scarcity (related to above). Relationship between benefits of collective action and resource scarcity may be an inverted U with little cooperation during abundance or excessive scarcity. During abundance, benefits of avoided marginal external costs are low so no need to cooperate. During severe scarcity, less incentive for cooperation if costs to rehabilitate too high. Also as resource becomes scarce, costs of conflict increase (eg water stealing, fights between coral users- fishermen, miners, divers), so higher transaction costs.

* Discount rate and timing of costs and benefit stream. This will influence any calculation of the present net value of discounted costs and benefits.

4. Involvement in natural resource management regimes with inter-linked externalities

Individuals and households may be involved in several natural resource activities with externalities. Managing each common property regime will have different costs and benefits, but individuals may act to maximise net benefits across all different activities. This inter-locked situation may act to create greater stability to the system, since the punishment of being made an outsider would be much greater.

An example is from certain rural areas in Sri Lanka, where there are a number activities with externalities, where common property management would help internalise the externalitities. These include: maintenance of the irrigation reservoir (tank), maintenance of the canal, water use, protection from domestic animals and wild animals, reduced erosion from upstream areas.

2.3 Specific Hypotheses underpinning the model

Building on the four characteristics of successful common property management presented above, four main hypotheses can be derived:

1. Exclusion costs hypothesis: In successful common property regimes, the restrictions of outsiders can be explained by economic factors that ensure that the net benefits to insiders minus the cost of monitoring are greater than the net benefits to outsiders minus the cost of being punished for entry. Where this relationship does not hold, it is expected that open access will have resulted.

NBRUi (I/P, ACi) - CMi(Pr, Li, To) > NRBUo (ACo) - CPo (Po)

CMi = cost of monitoring
Pr = physical attributes of resource
Li = Location of insiders in relation to resource
AC = access costs to the resource for outsiders
To = Technology of outsiders
CPo= cost of punishment
Po = Power (wealth, political connections) of outsiders

This hypothesis can be falsified if there are non-economic factors, such as social rules that explain why exclusion arises. For example it could be that access to a particular fishery is open to only a particular caste or group of descendants, so even if very little monitoring takes place and outsiders are not punished for entry, very little open access occurs.

2. The Free Rider Hypothesis:

In successful common property regimes, the benefits of cheating are less than the costs of cheating. It is expected that if the benefits of cheating are greater than the costs, free riding would occur and the common property regime would collapse.

Bc (dr) < Dcc (G) + (CPc x Prob of Pc (G)).

Bc = benefit of cheating
dr = discount rate
DCc = demonstration costs of cheating CPc = cost of punishment (if found cheating)
Cpc = economic cost of being punished for cheating
Prob of Pc = probability of being punished for cheating
G = group size

The model can be falsified if it is found that free riding is prevented by social sanctions rather than economic rationale. For example, if the punishment of free-riding is fear of social sanctions. To test this alternative hypothesis a variable for active social relationships will be included.

3. The Positive Net Benefit Hypothesis

In successful common property regimes, the total benefits of management must be greater than the costs. With the same assumptions, those who are most active in common property management are those who stand to gain the most net benefits.

Ben Coop (Resdep, Varres, Aexc> Costs Coop (fixed and operating)

Avextcos = avoided external costs of others unrestricted use
Resdep = resource dependence
Varres = variability of resource)

4. The Inter-linked externality hyothesis

In successful common property regimes, individuals are involved in several common property regimes which internalise external effects for members. While individuals may appear to be appearing sub-optimally in one regime, they will seek to maximise the sum of net benefits from all the common property regimes in which they participate.

3. Methodology

3.1 Types of case studies

The hypotheses presented above will be tested by qualitative and quantitative study of selected sites in Sri Lanka and Tamil Nadu. Case studies will include:

1. Rapid comparison of several types of resource in several sites (eg for Sri Lanka: irrigation, fisheries, rural water supply, micro-hydro, forestry and wildlife protection). This would be required to test hypothesis one, and would be useful to test for hypothesis two and three.

2. Comparison of same resources at different sites (existing studies focus on irrigation and total net benefits of collective management. This would be required to test hypothesis one and would be useful to test for hypothesis two and three.

3. detailed study of a single site (such as Wade in AP, Leach in SL). this would be required to test hypothesis four and would be useful to test for the other hypotheses.

As much as possible existing data sets will be used. To be useful these sites will need to provide either:

Individual data
1. Cross sectional data of varied levels of participation by people participating within site,
2. Time series data of varied levels of participation by people participating within site
3. Cross sectional data of positive levels of participation on site and non-participants in a similar site

Site level data
4. Cross sectional data of participatory sites with different levels of participation (Begum data, IIMI large scale irrigation data, rural water supply data)
5. Cross sectional and time series data of participatory sites with different levels of participation (Begum data, IIMI large scale irrigation data, rural water supply data)

The problem may that in many sites participation will be equal for all at site, so no data on participation variation among individuals will be available. This can only be circumvented by approach 3 above comparing those who do participate with those who do not at same or similar site (as in White and Runge, 1994 study). However still this may not provide clear results.

The alternative is then to do a site comparison as in Wade (1988), Mosse (1994)

3.2 Procedures for Data collection

The following data will be required. The data will need to be normalised to a standard measure (eg per ha, White and Runge, 1994). data will be collected on on individual and household level:

* Participation in natural resource management measured by various indicators (days worked per year, financial contributions)
* Net economic benefits (proxy can be amount of land weighted by tenure, average yield of land, position of land (head, middle, tail)
* Active social relationships (no of membership in other groups: death donation, etc, days spent on shremadana per year, contribution to other village infrastructure)
* Income (proxy own land for farmer, boat for fisherman, size of house, other assets eg motorbike, TV),

* Age
* Nationality/caste
* Gender
* Resource dependence (off farm income, access to groundwater, crop type)
* Avoided external costs (night irrigation, guarding/watching crop, water disputes)
* No of years in area

3.3 Data Analysis

From each of the sites data would be collected that support the four main hypotheses either in a qualitative fashion, or in a quantitative manner through simple correlations between variables or more sophisticated multiple regression techniques. For the multiple regression approach, the table below summarises the key dependent and independent variables for each hypothesis.

Table: Summary of multiple regression relationships to be tested

Hypothesis	Dependent variable	Independent variables
Exclusion costs	Rate of entry by outsiders or investment by insiders in preventing entry	Data on insiders and outsiders (eg net benefits of resource, number, income, technology for resource use, location, access costs to resource, political strength)
Free rider hypothesis	Amount of rule breaking	Data on cheaters and non-cheaters (eg discount rate, cost of punishments, income, active social relationships)
Positive net benefits hypothesis	Participation	Data on insiders and outsiders (net economic benefits, active social relationships and other observables)
Inter-locked externalities hypothesis	Participation ??	Data on insiders to multiple common property regimes (net benefits, other observables)

A more detailed methodology is given for the positive net benefits hypothesis which could be applied to all the hypotheses

The objective is to identify the significant causes of participation in natural resource management. An analogy would be to model the decision to participate in the labour force or to participate in a training programme, or to participate in extra schooling - leaving aside for the moment, the collective nature of the decision.

$Pi = bXi + gNEB + fASR + ui$

Pi = participation (measured by a yes/no dummy variable and as a ranked qualitative measure from 1 to 5 ie very high, high, medium, low, very low)

NEB = net economic benefits
Xi = other observable characteristics
ASR = active social relationships (measured by a rank of very high, high, medium, low, very low)

The hypothesis is that participation is positively correlated with economic benefits ie participation is higher if economic benefits are higher. Thus it is assumed that the coefficient g in the above equation will be positive and significant. The alternative explanation of participation is “active social relationships”, at both an individual or site level.

Estimation methods

The yes/no participation result will be measured using logit.

The ranked participation results will be estimated with ordered probit using maximum likelihood??, unless there are a large number of very low Pi observation (ie limited dependent variables or truncated sample in which case maximum likelhood on censored data will be used. For results where the number of participating individuals are given in numbers but no ranking, Poisson regression will be used. Following White and Runge (1995, WD), the Poison model will be fitted to identify which variables were most significant predictors of ex ante participation (measured by ex ante log level of participation 1-5) and which of the variables were the mot strongly associated with action ex post (measured by ex post log level of treatment 1 to 5).

The results are given in log odds ratio and have to be converted to probabilities using the formula prob = e logit/(1+ e) logit

The main problem is the direction of causality and simultaneous equations : Is direction from NEB to Pi or from Pi to NEB, or is the system solved simultaneously. If the relationship between NEP and Pi is simultaneous equation, the OLS gives a biased upward result, and other methods such as instrument variables must be used. However in small samples, as used here, OLS is still preferred. Moreover, it is argued that the direction of causality is from NEB to Pi (ie NEP should be the independent variable) since individuals use a resource individually before they decide to cooperate, thus this is a recursive system and so OLS can still be used.

3.4 Background to Sri Lanka and Tamil Nadu

Sri Lanka (SL) and Tamil Nadu (TN) have been selected both for the very interesting comparisons and contrasts they provide. Very simply, the two countries share a heavy economic dependence on natural resources, due to their relatively low per capita incomes. They also have many agro-ecological similarities as relatively dry tropical countries with short periods of heavy rainfall, so the techniques that farmers and fishermen use to utilise natural resources are similar. SL and TN also have a similar history of a long period of British colonial rule followed by 50 years of an over-extended state currently in the process of economic liberalisation. State involvement in natural resource management has been extensively predicated on a “top down approach”, but with pressure in the last decade to become more participatory.

However their different culture, particularly the effect of the Hindu caste system in TN compared to largely Buddhist Sri Lanka (and a large section of Catholic fisher-people) has led to quite different local level resource management regimes. In addition, SL has had a faster rate of economic growth leading to a faster reduction in the subsistence rural economy. Some of the basic data is summarised in the Table below.

Basic Comparative Statistics for Sri Lanka and Tamil Nadu

Data	Sri Lanka	Tamil Nadu
Population	18 million	58 million
Size	66,000km2	130,000 km2
Average annual rainfall	200-400 cm in Wet Zone 100-200 cm in Dry Zone	80-120 cm
Monsoon period	May-August (Yala) Oct-Jan (Maha)	?
First British colonial settlement	1796	?
Date of independence	1948	1948
Ethnic composition	74% Singhalese, 18% Tamil 7% Muslim, 1% other	100% Tamil?
Religious composition	70% Buddhist, 15% Hindu 8% Christian, 7% Muslim	90% Hindu, 10% Muslim?
Average life expectancy at birth	72 years	60 years
Average population in towns	15%	?
Average adult literacy coverage	89%	50%
Average per capita income	$800	$400

While research between the two countries is very instructive, it has been very limited due to the tensions surrounding the war with Tamil separatists in the north and east of Sri Lank, who have at times been publically supported by the Tamil Nadu state government. As a British researcher able to work in both countries, it seemed to make sense from a substantive as well as logistical point of view to study resource management in both places.

The economic, climatic, historic, political, ethnic and cultural characteristics of the two countries are briefly reviewed below with respect to their effect on how natural resources are currently managed, with a primary focus on small scale irrigation and fisheries.

Economically, both countries have low per capita incomes, although TN is significantly poorer. Over half the population in both countries remains dependent on agriculture for their income. In areas served only by small scale tanks, the main commercial crop is often rainfed, but irrigated rice serves as the staple diet and has a significant cultural importance. Fish provide a large share of the protein intake. This means that in both countries natural resource management is central to broader questions of poverty alleviation and improved nutritional intake. Relatively low economic growth, particularly in TN has been responsible for a rapid population growth. This has added pressure on natural resources.

Both countries suffer from water shortages, although this is much more acute in Tamil Nadu, so irrigation with storage reservoirs for the dry season is widespread. Thus for both countries, the rice paddy crop is constrained more by water than by land. Small irrigation reservoirs for water storage, known as “tanks” are common in both countries, as well as much larger irrigation schemes. The earliest of these small tanks date from before Christ. In contrast to the larger irrigation systems built with royal patronage and now maintained and managed with extensive state involvement, the small scale tanks may well have been developed indigenously by groups of farmers and even today government involvement is much more limited.

The small scale fisheries, in the freshwater tanks, brackish lagoons and near shore coastal areas of SL and TN are based on similar species and use similar fishing methods. Motorisation of craft has increased in recent years, but there is still a widespread use of non-motorised craft and shore nets.

Historically both SL and TN were colonised by the British in the 18th century and both become independent in 1948. Politically, development since independence has been mixed. The power of the vote certainly has led to a greater focus on rural concerns, and in Tamil Nadu has led to challenges to the entrenched caste system with the rise of low caste political leaders and parties. However in both SL and TN a patronage culture has also developed with widespread corruption, politicisation of the bureaucracy and the local member of parliament being a major power broker at local level leading to nepotism and favouritism. These historical and political developments have had a significant impacts on the way natural resources are managed as resource management is one arena where local political elites exercise their power.

Since 1978 in Sri Lanka and the late 1980s in Tamil Nadu, the government has promoted greater economic liberalisation. This has undermined the traditional subsistence economy and while incomes have risen, this has been accompanied by greater inequality. Even the traditional static land markets have become more liberalised and traditional systems of shared land ownership and labour sharing at harvest time have been replaced by market relationships.

The spread of the Green Revolution in the 1970s had a dramatic effect on the way irrigated agriculture was managed (Farmer, 1977). The new improved seed varieties made a reliable source of water even more vital. There has since the 1980s been a rapid increase in the use of groundwater extractions, particularly in the north of both SL and TN where groundwater is deeper and surface water extremely limited. There has also been the advent of surface diesel and electric powered pumps from the water source to the field. These technological developments have been driven by new social and political conflicts, but they are themselves responsible for intensifying pressure on management regimes.

Ethnically, the countries are different with TN having almost 100% Tamils, who are Hindus, compared to the Sri Lankan population which is 70% Singalese, most of whom are Buddhist. Related to this, the two countries are also culturally quite different. In Tamil Nadu, the Hindu caste system meant that land ownership was traditionally controlled by the higher castes in a feudal social structure. It is a matter for controversy to what extent these landowners traditionally acted as benign leaders of resource management, investing in common property resources, as opposed to exploitative feudal overlords. However as new social and political pressures have arisen to challenge this caste system, resources have become the battleground for major social conflicts. High caste landowners have in some cases either lost interest in the land as they have become educated and migrated to urban areas or they have been forced to relinquish control through social uprisings. Resource management conflicts in TN can only be understood in the context of caste and other social conflicts.

By contrast, in Sri Lanka the spread of Buddhism in the 3rd century B.C. led to a significant decline in the pre-Buddhistic caste system. Though caste does exist in SL today, in contrast to India there is no equivalent to the highest caste Brahmins. Indeed in SL the highest caste are the farmer or goigama caste who are also the most numerous caste. So while in India, caste is like a pyramid with a small high caste at the top, in SL it is like an inverted pyramid with the most numerous "farmer" caste on top. Finally in SL there is no equivalent to the harijans, and caste is more a form of group allegiance than a power structure.

One important side-effect of the different culture is the large cattle herds found in TN where cows have a religious significance for Hindus. There are also much larger goat herds in TN although this is for agro-climatic reasons rather than religion. Thus a major issue in resource management in TN is controlling unauthorised over-grazing. While this is a minor problem in SL, there are problems in the SL dry zone of damage to crops by wild animals, particularly wild boar and in some cases wild elephant.

To conclude the following patterns of common resource management can be drawn from the two countries. In both SL and TN, the top down approach to resource management which was inherited from the colonial legacy but then increased by governments focusing on central planning, has been increasingly challenged by government deficits and a general disillusionment with state management. But while more emphasis is now being placed on local management of natural resources often with donor and NGO interventions, the existing institutions have been undermined by the spread of the market and technological developments since the Green Revolution. Natural resources have also become arenas in which local political elites compete for power and patronage.

However it is also possible to disentangle differences facing common property management in the two countries. In SL, natural resources seem more under threat from market developments (Moore, Stirrat et al). In SL natural resource management was prefaced on a homogenous community often of the same caste and even originally the same family group managing the resource together. With new market opportunities and growing income differences since the economy was liberalised in 1978, as well as population growth, this homogenous structure has been undermined. This can be seen in the fact that traditional systems of labour exchange which were widespread even in the 1960s have all but disappeared to be replaced by wage contracts, and in even in rural areas credit sources are no longer family or friends, but private money lenders or the shopkeeper.

The penetration of the market in SL effects resource management either as the entry of outsiders such as entrepreneurial traders for example wishing to buy irrigated land or the exodus of insiders for significant off-farm and non-farm employment opportunities. In the former case, conflicts ensue between the old insiders and the new outsiders. In the latter case, the regime collapses through lack of interest. The general literature on Sri Lanka suggests that in contrast to other countries in South Asia, such as India and Nepal, traditional collective management of natural resources has declined significantly. This applies to all the major natural resources such as irrigation systems, forests, watersheds and fisheries. There is a wealth of historical evidence that traditional management systems did once exist. Land was once held in common (see Obeysekera), fisheries, such as the madel fishery were managed collectively (Alexander, 1982), as were forests resources.

By contrast, in TN, natural resource management remains stronger. But here the challenge is that the feudal dynamic that sustained resource management has been destroyed (which may be a positive development for other reasons). If low caste groups no longer feel allegiance to the high caste, he gains no patronage from investing in collective resources. The revolt by low caste land-owners also leads to a more individual ethic with each farmer investing in more extractive technology such as tubewells or surface diesel pumps which ultimately lead to over-pumping to the detriment of all. It is an open question whether the newly empowered lower caste farmers can re-establish a collective ethic now that the feudal structure is gone.

3.2 Background to small scale irrigation in Sri Lanka

There are two main types of small scale irrigation in SL – reservoirs, know as tanks and weirs known as anicuts. A weir is formed by digging a channel from a river or stream. Tanks are formed by placing an earthen embankment or “bund” across the line of drainage to obstruct the flow of run-off water, which then reaches an average depth of 7 feet behind the bund

(Leach, 1961). Two side bunds are then added which run towards the higher gradient gradually losing height (Shankari, 1991). The tank water is conveyed to the irrigated fields and home gardens (which are below the tank) through a sluice (horovva) and then by channels (vel).

The area irrigated by the tank is known as the command area and is roughly equal to the size of the tank. In many cases, the surplus water leaving the command area of one tank will form the in-flow water for a downstream tank, forming a chain of tanks, known as a cascade. Cascades can have as many as 25 different tanks. This has many additional complications in terms of management of water. Interestingly while in Tamil Nadu, mechanisms have evolved for water trading between tanks, this has not happened in SL, possibly due to the higher availability in SL.

Small scale tanks are located predominantly in the north central and eastern areas of the country which form the so-called Dry Zone with less than 100cm of rainfall per annum, while anicuts which depend on continous river or stream flows are found in the south west area or wet Zone where rainfall is more than 400 cm per annum (Abeyratne, 1990). This paper will focus on tanks.

There are estimated to be about 10,000 small scale tanks in Sri Lanka irrigating about 150,000 ha. Thus the average tank irrigates 15 ha (Abeyratne, 1990). However as rainfall in SL is quite variable and soils are shallow and porous, many tanks fill only 3 out of every 5 years (Sakthivadivel et al, 1997). The irrigated paddy of the tank has to be seen as part of a complex agricultural land use pattern which also includes the home garden (the area around the house, largely of tree crops such as banana) and the rain fed or "
manioc, cow pea etc are grown. These three types of land use: tank (wewa), rainfed farming (chena) and homegarden (gama) have been the basic dry zone land use pattern for over a thousand years. Interestingly, it is the rain-fed crop which is the cash crop, while irrigated rice is largely for subsistence consumption. In many places, the command area of the tank is sown with chillies or other crops during the dry season. In addition, to water for irrigation, tanks provide fish. The houses with their home-gardens are located below the tank where water is more available for the garden and the groundwater is deep enough to allow wells to be sunk.

Managing common property tank water requires not only complex decisions about how to distribute water, but also decisions about the timing of water deliveries. Timing has to take account of the two cropping seasons, the expected rainfall, the requirements for water during the cropping cycle and labour constraints given the simultaneous cultivation of chena during the maha season.

Water is needed initially for land preparation (softening up the fields prior to sowing), and then to water the crop and keep the depth at about 6 inches deep until harvest about 4.5 months later. During the slack time when the rice is growing and before the rice harvest, the chena land is cleared and planted. During yala, the same pattern applies except that fast growing low yielding rice varieties are preferred due to water scarcity. At the start of maha season when the tank is empty, there is a trade-off between starting land preparation early using the rainfall and waiting and using tank water. The perceived benefits of using rainfall is that it leaves more water in the tank which can then be used in the yala season, and much government intervention has sought to encourage this early land preparation using the first maha rains. This careful crop timing requires close coordination with the other water users and it is water timing concerns more than water allocation concerns which have been the strongest force in collective decision-making in tank management in Sri Lanka.

Background to small scale tank management in Tamil Nadu

An estimated 125,000 tanks or about 60% of India's tanks are found in the four southern states of Andhra Pradesh, Karnataka, Kerela and Tamil Nadu. There are an estimated 30,000-35,000 small scale tanks in TN, one of the highest densities India. In TN the water shortage is much more acute than the dry zone of SL. Tanks are both rainfed and river fed. The focus here is on rainfed tanks. In TN the maximum rainfall is 30 days a year. Rice has to be grown in the rainy season as no other crop can cope with clay soils during intensive rainfall (Saktivadival, personal communication).

There has been a steady decline in the area irrigated by tanks. In many Districts of TN, particularly the north, groundwater is now more important. The decline in tank area irrigated has been a long running phenomenon and was already commented on in the 19th century, the main complaint being the lack of voluntary community labour in tank maintenance.

Tank management in its broadest senses includes at least five main issues:

- A distinction has to be made between rules to allocate water and rules for tank maintenance. The former remain quite strong in some areas even as the contribution to voluntary labour has continued to decline.
- Where tank maintenance does exist it mainly refers to weeding and desilting the supply to the tank; very few tanks beds themselves are desilted although it is clear that this a major problem in reducing storage capacity.
- In some cases, there are rules about catchment protection and rules to prevent agricultural encroachment into the tank bed.
- There are rules about rights to the tank resources, such as tank fish, trees grown around the tank and silt from the canals and tank for brickmaking or for fertiliser
- Finally there are rules to prevent over-grazing; such as certain breeds of goat being banned due to the destructive way they graze (Mosse, personal communication).

Background to Small Scale Fishery Management in Sri Lanka

Small scale fisheries in Sri Lanka are concentrated on the south western coast. It is estimated that there are 28,000 small scale fishermen (1996, Min of Fisheries). These include coastal, lagoon fisheries and some inland fisheries. As in many developing countries, fishermen are divided by fishing practices/methods, by whether they are owner operator or not and by the site (e.g. coast versus lagoon).

The economic return on traditional craft is low, but they also have low costs, so they can be less risky than the kerosene powered motorised boats.

While data is lacking, there is growing evidence of overfishing in the near shore coastal and lagoon fishery leading to a decline yield per unit of effort. The fisheries have also been badly affected by the ongoing war in the north and east of the island, which has displaced many fishermen from these areas, and limited the seasonal migration opportunities of fishermen. Fishermen are now confined to the south east since 60% of the coast line belongs to the war torn north and east.

While the cooperative movement remains, its effectiveness varies. In many places, the cooperatives are now dormant as fishermen are unable or unwilling to repay their debts. Each cooperative has a board of directors and more than half of these are appointed based on political patronage and so have little interest in the welfare of the fishermen.

Several studies attest to the lack of "community spirit" in Sri Lankan small scale fisheries. Amerasinghe (1989) explains that this is particularly widespread as migration has increased: "In migrant villages, fishermen from different villages fish together, chasing the same shoals. Since traditional norms guaranteeing harmony and fishermen exploiting the same fish resources, do not operate in migrant villages, friction among fishermen is likely to arise and instances of arson resulting in considerble losses of gear and motors are quite common." (p715). Stirrat (1994) in his study of a Sri Lankan coastal fishery also found very little cooperation.

One of the most interesting fisheries are known as beach seine or "
net laid in inshore waters and hauled in from the shore by pulling two ropes on either side. The nets can only be laid on water where bottom is even and free of stones, known as "
Two reviews of the beach seine fishery in the Southern Province (Alexander, 1982, Amerasignhe, 1989) illustrate that although outsiders were limited from entering the fishery, and there was some controls on the way members used the fishery, there was no limit on the amount of nets that members could use in the fishery. The system however remained relatively stable up until the 1950s due to the low price of fish and subsistence demand. However once access to the urban market become possible the benefits of "cheating" by adding additional nets increased and the system was undermined by such overcapitalisation. Thus in Gahavalla the total number of beach seines increased from 20 in 1920 to 108 in 1967 (Alexander) and in Tangalle from 40 in 1920 to 52 in 1935 to 92 in 1950.

As a recent FAO paper asks "The question then arises as to why the community has not organised itself in such a way that a limited number of nets - corresponding roughly to the maximum number of possible turns per day - would be worked on shifts by the entire workforce available. After all, community management of the adjacent sea area testifies that a capacity for collective action was certainly not lacking among local fishermen. A plausible explanation for this seeming waste of capital can be grounded on transaction cost considerations. The argument would run as follows. Being cotton made and easily damaged in the course of digging operations, a beachseine is a highly delicate piece of equipment that requires substantial repairs and careful maintenance after each use. Failing that, its catching power in future hauls would be seriously impaired. If nets are operated on shifts by successive workers, moral hazard problems in the form of asset misuse are much likely to arise (sic). . . . High costs would therefore have to be incurred by the community to monitor repair and maintenance opoerations and our conjecture is that these would be so prohibitively high that a more cost effective solution for the community would actually be the one applied in the beachseine fisheries of south Sri Lanka: to set a rule that requires every fishing team to acquire its own net before granted rights of access to the resource."

4. Initial Results of Selected Case Studies

No detailed data collection has yet begun, but initial site visits and detailed literature reviews have been conducted for three locations. Three case studies are reviewed below to test the simple model presented earlier. In two of these case studies of tanks, the management regime is declining by different processes, while in the fishing example, the common property regime still remains intact and effective.

4.1 Small Scale Tank Management in North Central Province, Sri Lanka

The most detailed historical study of small scale irrigation in Sri Lanka was of a tank in Pul Eliya, a small village in the dry zone of Sri Lanka, 10 km north of Annuradhapura (Leach, 1961). The book describes an extremely complex locally managed irrigation system, and it is considered a classic in anthropology by challenging the importance of ethnological explanations of community in favour of more ecological factors. Leach argues that farmers are considered part of Pul Eliya not because of who they are related to, but whether they own shares in the oldest irrigated field. While Pul Eliya is a specific village it is an archytype for the kind of irrigation still found in more isolated parts of the North Central province.

Mechanisms exist to prevent entry by outsiders

Access to irrigation water can be effectively controlled by who has access to the irrigated land. This has led to strict rules about the distribution of irrigated land, which have traditionally prevented outsiders gaining access to irrigation water. The land in the tank command immediately below the bund which receives water from the tank outlet channel first and was the first historically to be cultivated is known as the purana wela (or ancient field). This field is generally divided into three bage (or portions): the ihela bage (upper portion), meda bage (middle portion) and the palaha bage (lower portion). The upper portion is the section closest to the tank or the head-end section. (There was also in the traditional layout a kurulu panguwa or share for the birds). Within each baga, land is subdivided into strips or shares known as pangu. Traditionally each farmer owned a pangu or share in each of the three baga. Thus no farmer had a monopoly on the most irrigated land in the uppermost or ihela bage. In Pul Eliya, there were originally three bage each of 6 shares making 18 shares in total.

It is important to note that a pangu is primarily a share in tank water. Indeed the common property of tank water is distributed to pangu holders in the same way as share in a limited liability company (Leach, 1961). Each pangu has an equal length of access to the tank outlet channel. The various strips of land are then extended at right angles from the channel. Traditionally the area cultivated in each strip was allowed to vary in length depending on the relative availability of water. However the whole area of the field or wela was fenced off to prevent animals entering. The dependence of the cultivation area on water availability was misunderstood by the British as Leach explains: “Since 1900 the shape of the field has been “frozen”. Land tenure as the British understood it, necessarily consisted of rights to a particular piece of land rather than rights to a particular quantity of water. Consequently all land not actually under cultivation at the time of the survey was treated as crown property. But it is the emphasis on rights in water, as opposed to rights in land, which explain the many peculiarities of the traditional system . . “ (pp 156).

As Leach explains, identity within the village rests on ownership of a share or pangu of the purana wela. The vast majority of pangu in the purana wela are acquired through inheritance or gift, but in rare cases, sale takes place. There is a general cultural presumption against sale and it is a matter of pride that pangu are inherited. Leach states that of the 107 numbered

plots in the Pul Eliya purana wela more than half have never been sold over 60 years. This leaves 45 which have changed hand by sale at least once between 1890 and 1954.

Not only is sale rare, it is generally to members of the local variga or kinship group. Members of a variga must inter-marry and are strictly forbidden from marrying with another variga. The size of a variga may be quite large and in the case of Pul Eliya included 25 other villages (pp24). The prohibition on sale of purana lands to outsiders had been tightly observed in the case of Pul Eliya when Leach did his study. In 1890 only one of the 107 plots was owned by an outsider or non-variga member, and this position was unchanged over 60 years later in 1954. Even when purana lands are bought by outside traders (usually Tamils or Muslims), often in exchange for gambling and other debts which cannot be paid off, they are soon brought back by variga members often by subtle coercion on the outsider as explained below.

When land does fall into the hands of outside traders, farmers have traditionally used various methods to drive them out. The fact is that economically it only makes sense for farmers to live close to the fields, which outsiders by definition do not. Outsiders can also be effectively excluded from the benefits of shared tasks, as Leach explains: "The complications of the rajakariya obligations (explained below) – such as those entailing a roster of night watchmen – and the necessity for the whole village to synchronise its use of the irrigation system, imply that it is almost impossible for a non-resident "outsider" to work land in Pul Eliya unless he can count on the assistance of some kind of local agent. When land falls into the hands of Tamil traders the village habitually exploit this fact so as to compel the trader to sell the land back on reasonable terms." Now the situation is changing, partly as a result of government policy and this will be reviewed further in a later section.

Mechanisms exist to prevent free riding by members

The main water distribution rules depend, as already explained, on equal access to water based on owning pangu or shares in land at different distances from the tank. Since pangu shares are very rarely sold, land ownership is very homogenous, which helps to prevent free riding. The distribution of pangu did increase as a result of sub-division so that in the case of the Pul Eliya Upper field, the original 18 shares in 1889 owned by 12 individuals was divided up into 65 shares by 1954 owned by 23 individuals. However very little land concentration took place with the maximum owned by any one individual in 1954 was 5 shares or 12% of the water allocation.

The basic water allocation rules, are made more sophisticated during yala when water is more scarce. In some villagers, a water-sharing practice known as bethma is followed. There are two main forms of bethma. Firstly that described by Leach, whereby farmers decide to each cultivate only a percentage of their field area (such as one third), thus allowing more water for those further from the tank. A second, rarer and more egalitarian practice is that the most water abundant land itself is redistributed to allow tail-enders access to head-enders fields. Although the amount of water available for the yala season is less, its amount can be more confidently predicted than during maha since it is largely a function of the amount of water left in the tank after maha (supplemented by some yala rains). This makes the kind of decisions required for bethma less complex.

In addition to the water distribution, there also needs to be agreement about the timing of water issues since once the tank sluice is open all get water. Traditionally the most important date is when the water will be first issued since this is when land preparation will begin. There must also be agreement about the date of first sowing, the type of rice to be sown, the date for harvest and for draining the field. Various combinations of government, farmer and heriditary leaders have been involved in these timing decisions. In addition, so called lucky or auspicious days are generally preferred.

Both the water distribution and water timing decisions are decided at a “
the farmers. The exact composition of the kanna meeting and who takes what role has been a long running issue with changing government policy. For most tanks there have been two main decision making procedures: the committee or single individual (in the latter case, the individual simply uses the kanna meeting to inform farmers on what has been decided).

The earliest known institution was the village council, which took certain important decisions including those relating to water. In 1815, the British abolished village councils only to restore them in 1856. The British also (according to Leach) instituted the vel vidane or irrigation headman, who was appointed by the state (although he was in theory at least also elected by the villagers). He made decisions jointly with the council and had strong enforcement powers and was renumerated with a share of the crop. He was appointed for as long as he was fit to carry out his duties. Operation of the tank sluice was his personal perogative. He was the executive head of the village, even though he had to follow the tulana headman (misleading named the village headman, but more accurately the administrative headman), who was a salaried government official responsible for clerical matters in over 10 villages. As Leach concludes: “So far as village affairs were concerned, it was the latter office (of vel vidane) which mattered most.”(pp29)

Following independence in 1948, Cultivation Committees were appointed under the Paddy Lands Act. However in 1977, these Cultivation Committees were abolished and replaced by appointed officers, nominated by members of Parliament. In the meantime, the vel vidane system had declined and so irrigation decisions were often being made by government officers with little local knowledge. In the 1980s elected farmers’ representatives (who were often again known as the vel vidane) were invited to have a say in water allocation decisions together with the government appointed cultivation officers. Thus despite various legal reforms, the basic tension remains between the need for a strong individual and some consensus among farmers, and the tension between a state appointee and farmer representatives.

At the time that Leach was studying Pul Eliya in the 1950s, the vel vidane system was in operation: “It is an office which entails a large amount of tedious clerical work for which the direct rewards are small, but in a prosperous village the indirect advantages which accrue to the vel vidane through his power of influence can be very great. No vel vidane of Pul Eliya has ever vacated his office except on grounds of ill health or old age”. (pp28).

There are also rules about tank maintenance and other duties. Each pangu or share in the tank water carries obligations set down below (Leach, 1961). These duties were collectively known as rajakariya or kings work:

- Each shareholder shall carry out a certain amount of repair work on the bund annually, proportional to the amount of his holding
- Each shareholder shall build and then maintain that portion of the main field fence which is opposite the ends of any strip which he works
- Each shareholder shall maintain in good condition any irrigation ditches which go past or through the land which he works
- Each shareholder shall take his turn to sit up all night in one of the field huts to ward off wild animals which are liable to attack the field during harvest time

The barbed wire field fence is of paramount importance to stop cattle and wild animals, particularly wild elephants from destroying crops and so even in villages where other forms of ranajkariya have collapsed, the requirement to fence remains. A 1989 study of two villages in North Central Province (de Jong, 1989) found that: “Strong sancations exist against offenders who do not participate in fencing. The vel vidane of Maha Wewa told the story that

he once built part of the fence himself and, and presented the bill to the offender. Backed by the cultivation officer, the offender paid and problems stopped occurring" (pp14).

There are also rules about the distribution of tank fish. These are also the common property of the holders of pangu in the purana wela. Any farmer can fish except for two periods at the end of the irrigation season, when the water level is at its lowest of about 2-3 feet, and so fishing is very easy. At this point, the vel vidane erects a pole in the tank showing that individual fishing must cease. There are strong taboos against breaking this rule (Leach says that those breaking it expect to be eaten by a crocodile) and it is supported by government regulations. As soon as half of the pangu holders can agree a date for fishing, it is set by the vel vidane. Fishing is reserved primarily for pangu holders, but they can introduce their freidns and relatives as assistants. The fishing party of about 30 drive the fish towards the bund in the corner and then they can be scooped out in baskets. This lasts for three days. At the end of each day, the fish are counted. The fishermen can keep two thirds of his fish and one third goes into the pangu pile, which is shared out according to the pangu holdings.

These rules are enforced by mutual social pressure operating through strong social cohesion, since purana land ownership is only by kinsmen of the same variga. In addition these kinsman are relatively economically homogenous. Interestingly this economic homogeneity is itself a function of the system, rather than a precursor: "The principle of fair shares for all which permeated the traditional system did not simply reflect a static fact that the traditional village was a highly cohesive social unit. It is rather that the traditional system of tenure imposed social solidarity on village members." (Leach, 1961).

However despite strong local management, rules, at least during the 1950s, were backed up by state sanction. Thus the management of Pul Eliya tank was not as decentralised as might at first appear (Hunt and Hunt, 1976). The village headman of Pul Eliya was according to Leach a "dictatorial office" (p154) who held his job for life and "His first responsibility was to see that government regulations regarding the fair distribution of water are fully adhered to." As Hunt and Hunt (1976) explain: "Historically as well as at present, the Pul Eliya system is not a local invention, purely locally maintained, nor is it free from impingement from the larger social and political world. The central government of Ceylon provides aid in times of famine (p32), forces the village to keep records (p 28, 47) gives financial assistance in irrigation (p46) and legitimises the types of land tenure possible and therefore water allocation (p20) and subsidises major repairs to the tank (p 45-46). Therefore we conclude that Pul Eliya should not be described as decentralised."

<u>Mechanisms are in place to ensure that total net benefits of collective management outweigh the costs</u>

The economic costs of the traditional system were relatively low with clear rules enforced by all farmers reducing the burden of enforcement and monitoring. The most laborious task of tank and channel maintenance was related to the size of holding, making it fair.

The benefits of collective management are threefold: increased profitability, greater social equity and reduced social conflict. Increased profitability was due to greater water reliability, guarding against wild animals and shared fish catch. Leach concludes that ownership of purana lands was very profitable in Pul Eliya although no figures are given.

The system was also extremely equitable, which is in marked contrast to the situation in Tamil Nadu, which will be reviewed later. As Leach concludes: "It is true that under the old system, the three Gamarala and their immediate kin were privileged in comparison with other pangu holders, but since, every individual's land was necessarily distributed in different parts of the Old Field, all the villagers, rich and poor, has a common interest in maintaining the efficiency of the irrigation system to all parts of the Old Field. There was no tendency at all

of the rich to segregate themselves into the most advantageous sections of the field, leaving only the bad land to the poorer villagers." (pp239)

Interestingly Leach identifies the village trader with his extortionate interest rates as playing an equalising role. Rich men were expected to live very affluently and gamble, which they financed by mortgaging their purana lands to the traders. When bad luck hit or they lived behind their means, their land was lost to the trader who then resold it to a member of the variga. Leach states: "Without some such equalising mechanism the community would quickly cease to be homogenous in terms of economic class, and would probably disintegrate altogether." (pp176).

Finally, by creating clear social rules for water allocation and timing, the system significantly reduced the main cause of tension in the village. Leach concludes that even with the many rules in place: "it was quite clear that blokcing or tapping a neighbour's water channel was still be far the most common cause of village quarrels and inter-compound litigation." (pp165) These quarrels would have been much worse without the system of rules in place.

Mechanisms are in place to allow individuals to gain from inter-linked externalities

Within the scheme already described there are two further complexities. The three highest strips of land with the best access to the tank outlet channel were known as the ihala elapat, the gamvasama and the elepata panguwa. They were all traditionally owned by the gamarala or primary landowner, who also owned the last share or pahala elapat.

However while these shares provided the most water, they also carried additional responsibilities. The palaha elapat carries it with the obligation to fence the entire length of the field (at the top of the field the fence went up to the tank bund) – compared to most pangu where fencing only the width of the pangu is required. The gamarala had to contribute grain to the annual village feasts and must pay for the building of the watching huts - although he is escused the duty of night watching. He is not excused from bund repair work. As Leach concludes :"In Pul Eliya this carefully differentiated system of rights and obligations has been rigorously maintained even though the status of the Gamarala as a specialised class of individual is no longer formally recognised. The rights and duties attach to the land itself, not to the individual who owns it."(pp168)

Decline of the traditional common property management system

The traditional system has been undermined by state sponsored efforts to promote land expansion in the tank command area originally to allow for population expansion. The purana wela has been supplemented by new land developed in nationwide land expansion schemes first started during the 1920s. One acre plots were distributed with freehold, known as sinnakkara which formed the akkara wela or acre field. In 1935, government policy shifted with concern over so called "landless peasants" and the Land Development Ordinance was passed which banned outright sale of crown land in favour of leashold land or badu idam. The LDO rules only became operable after the war. This land could only be inherited not sold and the state had the right to take it back in certain circumstance. The area of the akkara wela and badu idam was generally to the right and left of the purana wela, or below it, with water brought by new channels. There was a fourth category of land which is land privately and illegally encroached by farmers known as nawa asvadam.

Unlike the purana field, sale of the akara wela land following distribution was not confined to the variga. There was also considerable political interference in the allocation of akkara and leasehold land, with the vel vidane of Pul Eliya ensuing that he and his henchmen got the largest share. Although initially the akkara and leasehold land was owned by the same

families of the variga who owned purana wela pangu, sale to outsiders of the akkara wela is now widespread.

The development of the akkara wela and badu idam has caused four problems to arise, which have precipitated the decline of the traditional common property regime. The first two arise even if there is overlap between the owners of the purana wela and akkura wela/badu idam, and appeared in the 1950s, while the latter two arise as the identity of the groups who own purana wela, and akkara wela/badu idam change and have appeared since the late 1970s. First even if the owners of the purana wela and akkara wela/badu idam were the same, doubling the area of the command while leaving the tank the same size will increase to water shortage problems. The unrealistically large command area is a common problem for tanks. Once recent study of 21 tanks in the north western province found that 60% of sample tanks have catchments insufficient to support the planned command area (Ekanayake et al, 1990, pp19). A second and related problem is exacerbated water conflict if the owners and operators of the akkara wela and badu idam are slightly different groups within the variga due to the politicised process of land distribution.

This was the problem that had begun to emerge in Pul Eliya in the 1950s with the akkara land monopolised by a particular group so that Leach concludes in contrast to the equitable position in the purana wela, in the akkara wela: "Progressively the doctrine of "fair shares for all" has disappeared. Although the new lands were mostly laid out in a manner approximating to the traditional scheme, ownership was not distributed throughout the community, but only to the privileged friends of the vel vidane"(pp239).

The next two problems arise as the akkara wela pangu have been sold to non variga members. This has been occurring with increasing frequency in the North central Province over the last two decades since the late 1970s. Water conflicts are exacerbated if the purana and akkara wela pangu are owned by quite different groups who now compete for water rights. Finally as the akkara wela is not part of the rights and duties arrangement of the purana wela, the akkara wela owners may not see themselves as bound by the strict rules of tank maintenance and the arrangements may collapse.

Interestingly there is some evidence that it is the land of the rich which are most likely to be sold to outside traders and not the lands of the poor. The is explained by Leach as follows: "It is never sufficient to be an owner of capital; the successful high status individual must demonstrate openly that he is a person of good fortune favoured by the planetary duties. . . For such a man gambling is not a vice but a social necessity. Consequently it is the "wealthy"rather than the "poor" who need cash loans, just as it is the wealthy rather than the poor who have the credit to raise them. Every story of financial disaster starts in the same way. The rich man took his first step on the downward path towards bankruptcy by mortgaging part of his land to a trader at an impossible rate of interest." (pp175)

A second cause of the decline of tank management in SL, is the declining productivity compared with alternative income sources. This arises when the total economic gains from collective management are less than the costs. This has occurred in several of the smaller tanks in the Dry Zone.

4.2 Case study of small scale tank management in Southern Tamil Nadu

In the southern areas of Tamil Nadu (TN) in the Ramnathapuram and Pasumpon Muthuramalingam Tevar District tanks still supply up to 80% of the irrigation water (down from 90% in earlier periods) (Mosse, 1997b). It is proposed to undertake detailed field studies of selected small scale tanks in the Mudurai District of southern Tamil Nadu. The work will be conducted in cooperation with the International Water Management Institute (IWMI) and the Tamil Nadu Agriculture University (TNAU) programme which will be

collecting data on seclted tnaks in the Madurai District. A brief overview is given below of how tank management regimes currently operate in TN drawing from the extension literature available.

Mechanisms are in place to prevent entry by outsiders

Access to land and hence irrigation water is constrained by caste and other economic and political structures. Mosse argues in his work (Mosse, 1997a) that common property management in Tamil Nadu can only be understood in the context of the prevailing power structure: "Common property resources (in this case irrigation tanks in Tamil Nadu) are not simply sources of physical inputs. They are also repositories of symbolic resources. Tanks like village temples, are public institutions expressive of social relations, status, prestige and honour . . . On the one hand the protection, construction or repair of irrigation tanks long involved investments which generated "symbolic" capital in the form of honour or authority and created domains of influence for individual leaders. On the other hand, tanks themselves provide resources (water, trees , fish) which generate economic capital which is invested in symbolic capital though other public institutions especially temples. (Moss, pp 472)"

Under this traditional system, a few feudal high caste families (brahmins or chettiyars) owned the bulk of the land and employed low caste labourers (often harijans) to work the land. There were also many less wealthy farmers with much smaller plots of land. The few wealthy landowning families acted as the "custodian" of the tank.

However while social and political relationships may be more important in tank maintenance, the rules for water distribution seem to be predicated on economic self interest. Where water management institutions are functioning, mostly in southern TN, they do seem to be following the kind of model presented earlier.

Mechanisms are in place to prevent free riding by insiders

Unlike in SL, the higher water scarcity requires more flexible rules for water sharing, which are policed by water distributors or "nirpaccis" (who are from a specific low caste group, often in southern TN from Pallars untouchables). Indeed the work is considered degrading and of low status with potential negative interactions with spirits at dusk and dawn when the sluices must be opened and close (Mosse, 1997b). A similar system of water distributors known as neerkatti is described in Andra Pradesh by Wade (1992) and Shankari (1991). Nirpaccis are generally paid by farmers in grain or cash on a per acre basis. The post is hereditary. Based on field work in Cakkur and Anjavayal tank, Mosse (1997b) explains that normally water is distributed based on need i.e. depending on the state of the crop. This requires detailed filed knowledge by the nirpacci and avoids the usual conflict between head-enders and tail-enders. Fines for non-compliance are not nominal. Where management is strong, the rules forbid the use of diesel pumps.

In times of scarcity more transparent rules are needed and so each farmer receives water to cultivate a proportionate share (ivu) of their landholding, while in extreme scarcity, a fixed and equal irrigated area per household is agreed.

Mechanisms are in place to ensure that total net benefits of collective management outweigh the costs

The benefits of the management regime are reduced social conflict and a relatively assured source of water. However it should be noted that at all times, even in scarcity, the larger landowner will receive a much larger absolute share of the water even though the percentage share cultivated may be the same. Thus as Mosse (1997b) concludes: "Water use rules describe publicly accepted norms or codes of conduct which invariably express the interests of those in authority who back them. Rules have the capacity to systematically reproduce inequality in access to resources, and often do. Indeed it is common in Tamil Nadu to find

the dominance of local castes, lineages or caste expressed in terms of privileged access to tank water." In times of water plenty surplus water is distributed according to the latter principle of equal household share.

The rules about access to tank fisheries are varied including shares given to each household (although often the higher caste got a larger share), but now fishing rights are often auctioned. Trees are more valuable than fish and many villagers pay watchers to protect them. They are generally auctioned every 3-5 years for charcoal. However what is very startling is that in the 30 villages surveyed by Mosse (1997b) is that 73% of cases, the money from the fish and trees and other income generating activities were invested in temples and festivals and not in tank maintenance and repair. One reason may be that this provides a non transparent way to dispose of funds allowing significant amounts of money to be kept by the wealthy farmers. Another explanation may be that temples and festivals are true public goods, unlike tank investment where access is unevenly distributed depending on access to land (Mosse, 1997b). Although there are also cases where low caste farmers have objective to the use of collective funds for temple purposes which reinforces the hierarchical social order.

However the inequitable nature of the benefits and costs have made the system unstable. The rich have now lost interest in being the main contributors to the cost of management, and the poor have decided to seek greater benefits for themselves. The resulting collapse is reviewed below.

Decline of the traditional tank management system

This traditional system of tank management is now declining in southern TN and has largely disappeared elsewhere in TN. The rich have lost interest in managing the tank and have often been driven out by the poorer farmers. The wealthy have often, in simple terms, opted for a more purely self-interested economic approach taking advantage of the improved road network and agricultural extension for tubewells to increase their income and reduce their dependence on the commonly owned tank. Thus by sinking tubeweels, the rich can afford to opt out of tank management. As Janakerajan (1993) explains: "hence those farmers who have access to groundwater (which is private, more assured and controllable) lost interest in the tank water and its maintenance and so collective effort in the maintenance work and the system of water regulation (murai) get weakened)." In other cases, the wealthy families (or their offspring) have become better educated and been attracted by higher incomes in more urban areas. They have lost interest in agriculture and in some cases sold their land and migrated.

At the same time, the lower caste, poorer farmers have actively sought to obtain land from the high caste farmers. As Jakerajan (1993) explains: "The land transfers (from upper caste to lower caste) have been taking place to a greater extent in all the selected tank ayacuts with a few exception and this has resulted in the breakdown of old power relations . . . Due to changes in the caste-class relations, the TII (traditional irrigation institutions) which were hitherto managed effectively by the old landlords broke down. As a result of land transfers, lots of caste factions have emerged which really stand in the way of effective TIIs." The same pattern is observed even more clearly in Andra Pradesh (Shankari, 1991, pp 106) : "Growth of market forces and the entrenchment of electoral politics in various institutions has atomised the village communitities and undermined village unity. Traditional leadership drawing strength from caste and class heirarchies, does not any more command the same respect and obediance."

Another linked reason for the decline in the old management system is that with the shift from share cropping to wage labour, the large landowners do not have access to free labour to send for tank maintenance (Janekerajan, 1993). Under the old system prevalent across south India, at the onset of the monsoon the feeding tank channels are weeded with collective labour.

The small farmers usually come themselves, but the larger farmers send their labourers (Shankari, 1991).

In some cases, the revolt by the lower castes has included the nirpaccis themselves, who have withheld their labour in response to caste conflict. In other cases, nirpaccis have negotiated for payments in cash rather than kind, or have required other farmers and castes to help them or have insisted on removing the caste specific and hence servile role. As Mosse explains: "The point to stress is that the abandonment of water management systems her i.e. not the result of a passive process of decline or decay, but the result of active strategies to redefine social and service identities." This erosion of the traditional nirpacci structure has led to some interesting developments with nirpaccis in some villagers only working during scarcity , while in others supervisors have been appointed to watch the nirpaccis, especially during a drought. Thus the transaction costs of water management have increased.

Case study 3: Stakenet (Kattudel) fishery of Negombo, Sri Lanka

One fishery where there is evidence of continued traditional management is the kattudel or stakenet fishery of the Negombo lagoon, which illustrates the so called sea tenure management approach. The very strict management regime has allowed the kattedel fishery of Negombo lagoon to prosper as a very profitable example of common property management, while the more prevalent madel fishery is in a state of collapse.

The kattudel net can be operated only in channels of about 3.5 metre depth exist. The net is a minimum length of 15 m and maximum legth of 25m. The net is fixed at the onset of evening ebb tide at about 7 pm and removed as the tide changes after about 4-6 hours at about 11-12pm. The main catch is shrimps. The catch varies significantly over the year depending on the tide and the monsoon.

A detailed interview with the Committee Chairman of Grand Street Katudel Association, K Sebastian Fernando in April 1999 provided an overview of the fishery. There are four Katudel Fishery Associations. The largest is known as St Mary's or Grand Street Association. There are 96 members of the Association who each own one pela or share in the fishery. Each member must own at least one net. The Association has access to 13 fishing sites, with an average of 1-6 nets possible for each site. Thus at any one time, about 25-30 nets can be laid. With 96 members chasing only 30 net places, each member gets access to the fishery about one third of the time or about 10 days per month.

However the relative productivity of the different sites varies significantly (see table).

The productivity of stake-net sites of the Grand Street Katudel Association

Site	Maximum number of nets fixed	Mean daily catch per net (kgs of prawns)
Kongaha	6	12-18
Wellakkalama	3	13-16
Moda Ela	1	11-14
Mankuliya	6-7	10-12
Thummodera	3	8-10
Erakkatuwa	2	3.5-10
Ambalanpiyiya	5	6-8
Keerikaduwa Ela	4	6-8
Maiyapitiya	1	5-6
Thilliadiya	1	5-6
Kawatiya	2	5-8

Eramunkuliya	2	5-7.5
Moya	3-4	5-7

The best site at Kongaha is more than twice as productive as several other sites. Access to each site is decided by a lottery which takes place every 3 days at 9.30 am at the Associations meeting place (a religious shrine) to determine who gets access to which site.

The management regime of the Kattudel fishery conforms well to the model presented earlier.

Mechanisms are in place to prevent entry by outsiders

The Association ensures sustainable levels of access to the fishery by strictly limiting membership through control on the use right, known as "pela" or shares. The pela is a written legal document recognised by the Sri Lankan courts. The Katudel Fishery Associations have also lobbied the government to have their fishing sites legally recognised in the fishery regulations. The first such gazette notification dates from 1956.

Access to the pela is primarily by inheritance and only one male member of the family can own the pela. Sale of pela is strictly forbidden. After death the pela or share goes to the younger son. If there is no male heir, the use right is lost. The logic given for passing to the pela to the younger son and reverting the normal inheritance pattern is that it is the youngest who is left at home to look after his aging parents!

Since some members do not marry or have no male heirs, there is some limited potential for new pela to be issued. But since 1975 only 2 new members have been admitted a year. New members have to be married males who are descendants of an Association member. The applicant must demonstrate his understanding of the fishery by proving ownership of a new katudel, and an outrigger canoe.

The rules preventing open access are tightly enforced by the 96 members of the Association and their families all of whom who live close to the fishing grounds so intruders can be monitored. The collective nature of the fishery also ensures that each member has an eqaul incentive to monitor outsiders. It was recalled that in 1989 a non kattudel member had put a net and this had been spotted by another non kattudel member who informed the Kattudel members. They then went down to the water with about 5 men, but by then the intruder had withdrawn his net and run off.

Two reasons that outsiders respect the kattudel fishery are its long ancestory which has given it legitmacy and the fact that the Association is closely connected with the church and gives a large percentage of the catch each year to the church. Many fishermen in the Negombo area are Catholic and as one of the largest financiers of the Negombo Catholic church, the Kattudel fishery gains considerable political leverage. Fear of hostility from the church would deter many potential entrants.

However while the kattudel fishermen have done well to create a closely guarded resource, they are careful not to alienate other fishermen in the Negombo lagoon. They could lay many more nets but this would limit the amount of prawns available for other fishermen, and thus they keep to the current total number of sites. A few sites have become sedimented and new sites have had to be found, but the total number has remained constant since 1956 and before.

Mechanisms are in place to prevent free riding by insiders

There are strict rules for Association members including the sites that can be used, the rules governing the rotation of access to net sites by lottery and the size of the net. There are also non trivial fines payable in the event of non-compliance.

For example, the maximum length of the net, when other nets are operating is 15m. This can be increased to 25m if there are no other nets. The fine for flouting this is Rs100 for each 0.5 metre in excess of 15m

For serious transgressions of rules, such as fishing out of turn, the penalties are severe and increase for each transgession. The first time, the member will lose two turns to fish (i.e. 6 days no fish) and Rs 500. Then if caught again, he will lose 4 turns and Rs 1000, and so on. It was recalled that the last really major problem was in 1970 – itself a sign of success. An extremely troublesome kattudel member kwown as Jasy Apour was sentenced to no fishing rights for 5 years and a Rs20,000 fine. He appealed to the District Court against this sentence, but the Court upheld it. Jasy was forced to find alternative employment in the public sector and when his son grew up with no experience of the fishery, his pela was lost.

There are two other factors which work to ensure rule compliance. Firstly the already discussed association with the church and secondly the close social cohesion of the Association. Social cohesion is achieved by the shared ancestry of the Association families, their Catholicism and rules which prevent Association members being rent seekers, who hire others to fish. The shared ancestry goes back more than 100 years, probably to the few families who inhabited the area at the time of the Portuguese arrival in the 17th century, and perhaps even before that. Interestingly although the kattudel fishermen are all Catholics, they are both Tamil and Sinhalese. In fact, almost unique in Sri Lanka, there are members who call themselves Sinhalese, but their first language is Tamil. The net can only be placed by the kattudel Association member or one of his household. If you are away from the Kattudel for a period of a year you have to pay Rs1000 per year, and after 2 years you have to buy a new net and boat (which is inspected by the Committee) to be allowed to return to the fishery.

While being relatively fixed, the management regime is not rigid. Any new rule can be passed by the association when it meets every three days to draw lots. For example in May 1999 it was decided by members one morning to increase the number of nets allowed at Keerikaduwa Ela from 3 nets to 4.

<u>Mechanisms are in place to ensure that total net benefits of collective management outweigh the costs</u>

The benefits of common property management to Kattudel fishery members are high. The opportunity costs of time for management are kept very low by using a system of clearly defined, well understood rules. Monitoring costs are shared by all 96 members are undertaken during the laying and removing of nets, so no additional time is needed. On average a member earns about Rs 600 per day of fishing, making about Rs 6000 per month for the 10 days net access. This is almost pure profit as the only operating costs are 2 bottles of kerosene per night at about Rs 20, and the only capital costs are the net and canoe both of which are handmade and have a long lifespan.

Thus the 500 Kattudel fishermen are perhaps the most profitable of the 5000-60000 small scale fishermen currently operating in the lagoon. They also earn their income by only working one third of the time and at night so they have ample opportunitites to supplement this. The current Chairman of the Grand Street Association worked in the civil service. Even when he reached the senior position of the number two civil servant in the Housing Ministry, he would return from Colombo to fish at night as his kattudel earnings were earning than his civil service pay!

The main factor that might damage the kattudel profitability would be declining yield or falling prawn prices. The fishery has been affected by falling yields both as a result of population growth and the lack of access to the productive fisheries on the north and east coasts due to the war. It is estimated that about 20 years ago there were only 400-600 fishermen in the Negombo lagoon, but now there are more than 6000. However fortunately

for the Kattudel fishermen, at the same time as yields have fallen, prawn prices have risen substantially from Rs 20 per kg to Rs 200 per kg. Thus the average profits of the Kattudel fishery have remained roughly static over the last twenty years.

Another benefit to members is that they receive cash income and death insurance. This income comes from one of the 13 sites is generate by auctioning the fishing rights to members. The income earned from the auction in 1998 was Rs 350,000. After a large donation to the main Catholic churches of St Peters and Corpus Christi, payments of Rs 6000 are made to families of members who have died and then the remaining money is distributed equally to all members. In 1998, each member received Rs 3000.

Another benefit of common property management is the internalisation of externalities of competition if too many fishermen competed for the most productive sites. Kohonga is the most profitable fishery by far and at the best time of year, the best net there can earn Rs 30,000 in a single night. Without the management regime, there would be a fight for access at these times leading to major conflicts.

5. Tentative conclusions

The three case studies demonstrate the usefulness of the simple economic model presented here. All three case studies show the importance of keeping outsiders out, of preventing free riding among members with realistic sanctions and of ensuring that total benefits are greater than total costs. In the case of irrigation in Sri Lanka, there were also examples of members trading-off the relative externalities of different activities to increase their total net welfare. Thus it is possibly to conclude that economic concerns are the most important factor explaining the relative success of the three schemes.

In two of the schemes the change in the relative economic context also explains their recent decline. In the Sri Lankan tank irrigation example, the sale of land to outsiders has undermined the management regime, while in Tamil Nadu the out-migration of the feudal landowners and greater land access of the lower caste farmers has had a similar effect.

However this initial overview also demonstrates that non-economic costs and benefits are also important. For example one of the costs to outsiders who break the rules of the kattudel fishery in Negombo is the displeasure of the Catholic chuch, which is very powerful among the Negombo fishermen. While in the case of Tamil Nadu, one of the perceived costs of the old system is the caste injustices felt by the lower caste water operators or nirpaccis.

Thus economic factors go some way to explaining the success and failure of particular common property regimes, and indeed in many cases, economics may be the most important explanatory factor. However non-economic factors such as social, historical and environmental conditions are also important in explaining which common property regimes persist.

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