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Organizational Management of Groundwater by Farmers for the Sustainable Utilization of Water Resource in Jaffna District of Northern Sri Lanka

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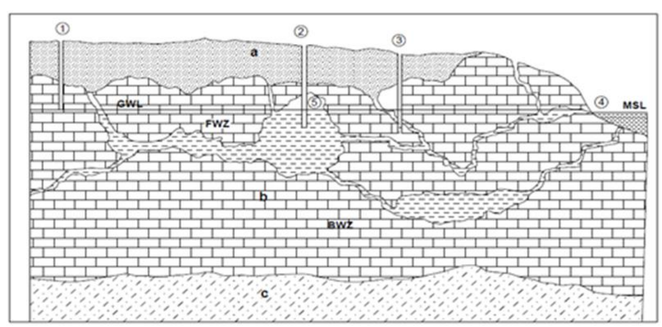
Abstract— *Groundwater is categorized as a common pool resource and is characterized by exclusion and substractbility. Given the nature of groundwater, user exclusion is an extremely difficult task. The cost of exclusion measures could outweigh the benefits generated from the use of the resource. In a finite aquifer system, water withdrawal by one or more persons reduces the water available for others and thus groundwater becomes rival in use. Eventual depletion occurs when water withdrawals exceed replenishment rates over period of time. Groundwater suffers from appropriation and provision related problems. Short term gains often pushes users to over exploit the resource base with minimal or no maintenance. Absence of incentives, institutional structures, and social mechanisms would potentially lead to the destruction common pool resources. Farmer Organizations in Sri Lanka were formed to organize farmer activities at field level. They exist all over the country and formed at the Grama Niladari or Village level. Traditionally the Farmers's Organizations focused on providing membership to farmers, distribution of inputs, irrigation management at local level, and act as a body for collective voicing for farmers. Their involvement in groundwater management had been minimal in the past. Unlike Jaffna, existence of surface irrigation systems in other parts of the country could have contributed to the Farmer Organization's limited involvement in managing the groundwater resources. Given the nature of ground water use at individual level, difficulty of controlling their usage, the article examines potential role social capital could play in such circumstances. The article examines the potential role that the already existing Farmer Organizations could play in conserving and managing the scarce groundwater resources of Jaffna district. Ground water is the life line of Jaffna peninsula and the traditional shallow wells had been used for centuries for domestic and irrigation purposes. Approximately the 0.6 Million population of the district largely depends on groundwater sources for its various needs. The whole Jaffna peninsula is underlain by Miocene limestone formations which are generally 100 to 150 m thick, distinctly bedded, well jointed and highly karstified. Water mounds or lenses found within the limestone formation reach their peak during the monsoon rains of November –December. The aquifer boundary itself expands and contracts through the wet and dry seasons respectively. Various studies has placed the net groundwater recharge rate at an average 37% with Spatial variation of net groundwater recharge ranging from 12 to 69%, of annual rainfall.*

Index Terms— *Common pool resource, Groundwater, Social capital, Farmer Organization, Jaffna peninsula, Miocene limestone.*

1 INTRODUCTION

JAFFNA Jaffna district is located in the northernmost part of the country and connected with the mainland through a narrow strip of landmass. The peninsular Jaffna is surrounded by the Indian Ocean in the North and Eastern side, to the west by park strait and to the south by the Jaffna lagoon. The district has an area of 1203 sq km including that of internal water bodies. The district is largely underlain by limestone which is conducive for the formation of aquifers. According to Panaboke (2007), the easily soluble limestone gives rise to a number of underground solution caverns capable of holding water that had seeped through the above layers. The whole Jaffna peninsula is underlain by Miocene limestone formations which are generally 100 to 150 m thick and which are distinctly bedded and well jointed and are highly karstified. The figure.1 below, provides a schematic view of the groundwater condition in Jaffna peninsula.



Groundwater conditions in the Peninsula (After C.H.L. Sirimanne, 1952)
(a) Red Earth, (b) Jaffna Limestone, (MSL) mean sea level, (GWL) groundwater level, (FWZ) zone of fresh water saturation, (BWZ) probable zone of brackish water ;(1) Dry Well (2) Well of Puttur type, (3) Ordinary successful well, (4) Spring of Keerimalai type , (5) Solution cavern

Figure 1. Schematic view of the groundwater condition in Jaffna peninsula

The Jaffna district falls under the dry climate zone in Sri Lanka and is influenced by the monsoon system. Significant rainfall is experienced during the North East monsoon period. Rainfall is the main source of ground water replenishment and the uncertainty of monsoonal rains greatly affects the recharge of groundwater.

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According to Balendran (1969) water mounds or lenses found within the lime stone formation reach their peak during the monsoon rains of November –December. The aquifer boundary itself expands and contracts through the wet and dry seasons respectively. Monitoring studies have confirmed a significant imbalance between the draw-off and recharge rates as reported by Balendran (1969). The average annual groundwater recharge was 569,624 m^3 (0.57 MCM) from April 2007 to March 2008 and the average annual groundwater withdrawal was 661,635 m^3 (0.66 MCM) resulting a negative water balance of 92,011 m^3 (0.09 MCM) (Thushyanthy and Silva, 2012). The safe yield of groundwater aquifers on a sustainable basis is only the 50% of the annual replenishment or recharge rate. However, in the study area the abstraction has exceeded even 100% of the annual recharge (Thushyanthy and Silva, 2012).

Continuing overdraft exceeding the safe yield may subsequently lead to progressive decline in groundwater table in the study area. This result had been supported earlier by Rajasooriyar et al. (2002) and indicated that excessive extraction of groundwater from wells, particularly from agricultural wells using highly efficient electrical pumps for prolonged periods, was the main course of the reduction in groundwater elevations. Punthakey and Gamage (2006) estimated the total agricultural well usage in the Jaffna Peninsula as 147,000 million liters per year (MLPY), with well usage during the dry season at 88,000 MLPY and wet-season usage at 59,000 MLPY. The above results clearly reveal that over exploitation of groundwater, particularly in the direst months. Due to uneven distribution of rainfall both in time and the space, water resources are dwindling (Thushyanthy Silva, 2012). No effective well monitoring system is in place to gauge withdrawal rates of groundwater for irrigation. Despite available studies on groundwater recharge and withdrawal a comprehensive study is yet to be carried out.

A major water quality issue that was identified as early as in the 1950s was, sea water intrusion in to the groundwater system (Balendran et al. 1968). In the north zone of the peninsula where intensive study carried out during the period of 1973-1976 in an area of 55 sq miles indicate that about 30% of the wells were becoming brine (Shanmugarajah, 1993).

According to the Census of Population and Housing carried out in 2011 Jaffna district has a population of 582,995 and a population density of 628 persons per square kilometer. In terms of population density the district ranks 7th in the country Thadchayini and Thiruchelvam (2005) reports that 65 % of the population still relies on agriculture as their main source of livelihood. High value cash crops are dominant in commercial agriculture and 34.2% of land is used for the above purposes. The paper further states that about 65,400 families and 30,000 farm laborers are involved in agriculture and livestock rearing in the Jaffna District. In addition, a large proportion of the population cultivates their own home gardens. According to the Jaffna district secretariat in 2013 there are 54,417 farmer families and 22,418 farm labourers live in the district. 17,383 agro wells, 375 ditches and 992 small ponds were found to be within the district boundary. Despite a decline in number of people depending on agriculture as their primary source of living it still remains the dominant single sector in the district. Use of water conserving irrigation techniques is minimal and the Jaffna District Secretariat reports that in 2013 only 457 famers were using sprinkler irrigation techniques.

2 Groundwater as Common Pool Resource

Groundwater belongs to the category of common pool resource. According to Ostrom et el. (1994), common pool resources are characterized by,

1. Exclusion and
2. Subtractability

The term exclusion refers to how easy or difficult to exclude users (beneficiaries) from consuming them once they are provided by nature or through the activities of individuals. Subtractability refers to the quality use of common pool resources being rival. That is the use of ground water resources, by one or more person would reduce the resource availability to other users. The following common pool resources, Groundwater, common pasture lands, fishing grounds, are examples for examples for sharing exclusion and subtractability characteristics.

Table 1 Classification of Goods based on Substraction and Exclusion Charecteristics

		Substractability	
		Low	High
Exclusion	Difficulty	Public Goods	Common Pool Resources
	Easy	Toll Goods	Private Goods

Adopted from Ostrom et el. 1994

It is obvious that user exclusion is an extremely difficult task for groundwater resources. The cost of exclusion measures could outweigh the benefits generated form the use of the resource. In a finite aquifer system, water withdrawal by one or more persons reduces the water available for others and thus groundwater is rival in use. Eventual depletion occurs when water withdrawals exceed replenishment rates over period of time.

Hardin's 1968 article was influential in highlighting the plight of common pool resources. The article effectively coined the term tragedy of the commons which had gained traction thereafter. Hardin used the term tragedy of the commons to show how multiple individuals acting on self-interest, independently and rationally will deplete the common resource even though it might be counterproductive in the long-run. As a rational individual, a user of a common pool resource is motivated to maximize his individual consumption by overexploiting the resource base. Such an act carried out collective-

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ly would be detrimental for the sustainable use of common pool resources. In the context of ground water, excessive usage can result in negative externalities such as sea water intrusion and salinity, falling water tables and increased pumping cost etc. to the wider groundwater users. In a worst case scenario the aquifer / groundwater source could be completely depleted beyond renewal.

Ostrom et el. (1994) broadly identifies two major problems related to common pool resources.

1. Appropriation problem
2. Provision problem.

The former is related to the subtractability of the common pool resource and the problem is further subdivided in to appropriation externalities, assignment problems, and technological externalities. Provision problems are related to, creating the resource, maintaining or improving the resource or preventing the destruction of the resource. Short term gains often pushes users to over exploit the resource base and carry out minimal or no maintenance. It is thus evident in the absence of incentives, institutional structures, and social mechanisms would eventually lead to the destruction common pool resources.
Ostrom (1990) cites the example of Cod fish collapse in the late 1980's in the New England fishing ground as a result of over fishing. The tragedy continued until strict restrictions were imposed on fishing which eventually led to the partial recovery. Ostrom et el. (1994) also cite how groundwater users of an aquifer system in California had come together to abide by agreed rules in the face of depleting ground water.

Partha Dasgupta, (2008) argues that trust is also essential in managing the commons. He lists out four conditions under which trusts would become credible.

1. Mutual affection
2. Pro-social disposition
3. The need for incentives to keep promises
4. External enforcement

According to Ostrom et el. (1994), In field settings where individuals with short time horizons, unwilling /unable to communicate, do not trust each other, or do not have access to reliable external enforcers, the outcomes are broadly in consistent with non-cooperative game theory. The following graph shows how two individuals (X, Y) would behave and the resultant equilibrium in the absence of above mentioned aspects and in the presence of it. The below table shows actors' behaviour in the absence of trust, external enforcers, and long term perspectives in a given context.

Table 2 Actors' behavior in the absence of trust, external enforcement and long term perspectives.

	Cooperate	Not- cooperate
Cooperate	**a** / **a**	**b** / **c**
Not-cooperate	c / b	d ★ / d

(Adopted from Ostrom et el. 1994)

a<c, b<d, given the conditions, decision makers are tempted to move to a situation where the resultant equilibrium (*) is the combination (Not cooperate, Not cooperate). Players are motivated to defect to not cooperate since the individual payoffs are higher in the short run.

The below table shows actors' behavior in the presence of trust, strong social capital, external enforcers, long term perspectives

Table 03 Actors' behavior in the presence of trust, strong social capital, external enforcers, and long term perspectives

	Cooperate	Not- cooperate
Cooperate	**a** ★ / **a**	**b** / **c**
Not-cooperate	c / b	d / d

(Adopted from Ostrom et el. 1994)

a>c, given the condition, decision makers are tempted to move to a situation where the resultant equilibrium (*) is the combination (cooperate, cooperate). Players are motivated to cooperate since the adjusted individual payoff is high under the scenario.

Upholf and Wijeyaratna (2000) reports on the collective action by farmers in the Gal Oya irrigation scheme had produced measurable improvements in system performance and efficiency. They further state that a combination of roles, rules, norms and values that supported mutually beneficial collective action had resulted in better than average harvest in 1997 dry period.

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3 Using Farmer Organization as a regulatory mechanism

Establishment of Farmer Organization (FOs) is governed by the Agrarian Development Act (No. 46 of 2000) - Sect 43 which provides a framework for the establishment of (FOs). The act also contains numerous sections that provides clear guidance of FOs roles, establishment federation structures etc.
According to the Jaffna district secretariat the number of FOs established by 2013 was 262 and out of which 231 was registered bodies. Collectively they have 39,434 members out of which 31,983 were male members and 7,451 female members. Number of agrarian service centers in operation was 15. Out of the total number of farmers significant numbers of farmers are represented through FOs.

Traditionally farmer organization are involved in irrigation management usually in established irrigation system, resupplying inputs such as fertilizers obtained from the government at subsidy prices, renovation and maintenance of irrigation and small water holding structures falling within their purview and collective voicing on issues that affect farmers. In the Jaffna district FOs are not directly in involved groundwater monitoring and conservation. FOs contributes indirectly to groundwater conservation trough their engagement in construction and maintenance of water holding structures such as ponds and small ditches in their respective areas.

There is plenty of scope for active engagement by farmer organization in groundwater monitoring and conservation. External enforcement on ground water monitoring and conservation could be costly and ineffective. It requires a sound regulatory environment and enforcing authority which requires effort and resources over a period of time. FOs have the advantage relative ease of access to information at the ground level such as knowledge on irrigation patterns and volume, construction of new open dug wells or bore holes and have the social capital to reward and punish abiders and violators. The role envisaged for FOs to play in groundwater monitoring and conservation includes,

- FOs could actively engage in creating awareness about the status of groundwater in the district. They should educate their members on present and future availability of groundwater, pollution factors and pollution levels, and possible groundwater scenarios
- FOs should promote and adopt crops that are more suitable in the given context. Crops that could yield highest per capita income compared per capita water usage.
- Promotion and adaptation of water conservation techniques such as micro irrigation techniques more vigorously.
- FOs are better positioned for monitoring water withdrawals in tube and open dug wells. FOs access to local knowledge is a considerable asset in this regard. Even if wells were metered to measure their usage FOs role would be still vital in ensuring the system is properly implemented.
- FOs are well placed to effect change and control the behavior of farmers since they could enforce socially binding agreements on members. The social capital available at their disposal could be more effective than costly formal enforcement measures in this context.

4 Conclusion

Groundwater is the lifeline in Jaffna peninsula for nearly its 0.6 million population for drinking, irrigation and other domestic purposes. Evidences exist on the deteriorating nature of groundwater quality. Absence of proper measures could lead in the long run depletion of usable groundwater leaving the population depending on it in a precarious situation. Economists classify groundwater a common pool resource and identifies in the absence of trust, external enforcement, long term perspectives and social capital, the resource base could be depleted. 262 farmer organizations exist in the district with ample scope for engaging in groundwater monitoring and conservation. External enforcement on ground water monitoring and conservation could be costly and ineffective. It requires a sound regulatory environment and enforcing authority which requires effort and resources over a period of time. FOs have the advantage relative ease of access to information at the ground level such as knowledge on irrigation patterns and volume, construction of new open dug wells or bore holes and have the social capital to reward and punish abiders and violators. The article identifies specific roles FOs could play in this regard.

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