

Present Management of Common-pool Resource: Sinnakalapu Lagoon in Alayadivembu Pradeshiya Sabha, Ampara District, Sri Lanka

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Abstract- In order to rectify common problems associated with common pool resource management different types of effective and efficient common pool resource management systems have been developed by experts though seldom published. Sinnakalapu lagoon is a brackish water ecosystem with low salinity and managed as a common pool resource of the five villages in Alayadivembu Pradeshiya Sabha. Flora and fauna present include 35 fin-fish species, four shrimp species, twelve bird species and a significant number of aquatic plants. These identified and biodiversity status of identified flora and fauna of Sinnakalapu was described under two-time periods before tsunami, (1990-2004) and after tsunami, (2005-2017). Ecological importance of Sinnakalapu is described based on biological, chemical and physical features of Sinnakalapu ecosystem. Mean annual income per year by fisheries resources in Sinnakalapu was estimated. Based on this the economic value of Sinnakalapu was described. Mismanagement practices leading to the loss of biodiversity were identified and their impacts were analyzed. Numbers of fin-fishes, shrimps, insects, birds and aquatic plant species have reduced and some of the species have got extinct. Conservation and suitable management systems for sustainable management were identified concurring with the environmental policies and laws in Sri Lanka.

Keywords— Alayadivembu Pradeshiya Sabha, Biodiversity, Common pool resource management, Sinnakalapu, Tsunami.

I. INTRODUCTION

Common property resource (CPR) is a private property of a group and the group may vary in size, nature and internal structure e.g. indigenous tribe, neighbours of village [1]. Common property resource includes fisheries, forests, irrigation systems, and pastures. Global CPR examples include the oceans and atmosphere. Major problems in CPR management is difficulty in excluding users, combined with a CPR's subtractability, creation management vulnerabilities that can result in resource degradation. The importance of such "tragedies" is

evident in anecdotal examples, from the devastation of tropical rainforests to the depletion of local and regional fish stocks and also, at the same time, many examples that suggest that people are capable of averting these tragedies and sustaining common pool resource [2].

Sinnakalapu is situated in Akkaraipattu south, south eastern coastal belt and very close to the Bay of Bengal. The river named as Thillaiaru flows through Panankadu bridge in this area. Sinnakalapu lagoon is located in coordinates 7°11' 31.6" N and 81°50' 54.9" E with an area of about 400 hectares [3]. Only during rainy season, this resource reaches the sea which makes it function as a lagoon. However due to continuous flowing of river water, salinity of water nears that of freshwater.

Sinnakalapu is surrounded by five villages viz., Kolavil, Panankadu, kannakipuram, Alayadivembu and Sinnamugathuwaram in Alayadivembu Pradeshiya Sabha. This lagoon supports the villages in various ways including e.g. economically, ecologically and culturally. Sinnakalapu lagoon is a home for diverse variety of aquatic plants, fishes, reptiles, insects, mollusks, crustaceans, etc. Fisheries resource is the main economically important resource in Sinnakalapu Lagoon. It contains both fresh water and brackish water fin-fish species, which includes both endemic and exotic fish species [Table 2] and also there are about four shrimp species identified in Sinnakalapu [Table-1]. These diverse variety of fish species and shrimps play an important economic role in Alayadivembu Pradeshiya Sabha area. This lagoon supports the villages directly and indirectly. Fisher men are the main stakeholders and the direct economical beneficiaries of Sinnakalapu resource. Farmers, especially paddy cultivators and local people are indirectly supported by cultivating paddy in lands close to river, which depends on this river water. Fish resources play an important role in the diet of local people in Alayadivembu Pradeshiya Sabha. Sinnakalapu lagoon provides fresh, protein rich, healthy and tasty fishes such as *Oreochromis niloticus*, *Channa striata*, *Anabas testudineus*, and cat fishes [4].

Presently, there are several conflicts within the Fisheries Society and between Fisheries Society and Farmers' Society because of mismanagement practices including illegal fishing methods, land degradation and fragmentation of lands for paddy cultivation, human settlements and construction of hotels and timber mills which lead to loss of fish resources and biodiversity in Sinnakalapu lagoon [5,6,7]. There is a need to conserve the biodiversity of Sinnakalapu by identifying the ways to mitigate the mismanagement practices and proposing a well-defined plan of common pool resource management concurring with environmental policies and laws in Sri Lanka.

1.1 Objectives

The main objective of this project is to propose a sustainable common pool resource management plan for Sinnakalapu lagoon.

Specific objectives:

- To study the ecological and economic importance of Sinnakalapu.
- To identify the mismanagement practices which lead to the loss of biodiversity in Sinnakalapu.
- To identify and study the ways to mitigate the mismanagement practices in Sinnakalapu.
- To identify and implement the polices and laws in Sri Lanka to control the mismanagement practices in Sinnakalapu.
- To identify the shadow laws which can be implemented in Sinnakalapu

II. METHODOLOGY

Weekly field visits to Sinnakalapu lagoon for the data collection with respect observation of biodiversity, mismanagement practices, local fish marketing, and small-scale fish marketing to other areas by local people were performed during the period of December, 2017 to April, 2017. Photographs were taken to identify the fish, bird, shrimp and aquatic plant species found in Sinnakalapu with the help of Fishermen and other local people. Several meetings were conducted with the leaders and the members of Fisheries Society and well as Grama Niladhari of Alayadivembu Pradeshiya Sabha to collect details about the mismanagement practices, biodiversity status, conservation and management plans.

III. RESULTS AND DISCUSSION

3.1 Biodiversity of Sinnakalapu

Time scale to explain the biodiversity of Sinnakalapu is divided as period before Tsunami (2004, December, 26) and, after Tsunami. This is because there was a serious impact on biodiversity due to Tsunami and other

development practices after Tsunami, which has led to the reduction of biodiversity in Sinnakalapu.

When the composition of fauna is considered, some needs the movement of the river water to survive, while some have to hold onto the rocks at the bottom in this moving water with the help of differently developed structures. Others thrive in stagnant waters. There are a variety of fin-fishes, birds, shrimps, insects, amphibians, and crustaceans that make Sinnakalapu lagoon as their home. With respect to flora, this lagoon supports diverse varieties of aquatic plants. Most of these plants float on the surface, while some attach themselves to underwater rocks, or even to the bottom. Cattails and watercress grow on the muddy banks, but because of their strong roots, they are not washed away by the water current.

"Field status" is used for the indication of number of the particular species in Sinnakalapu compared to the number before Tsunami according to the observations of fishermen and local people [8,9]. "Very high", "High", "Common", "Less", "Very less", and "Not seen" terms used to explain the field status of identified species in Sinnakalapu.

Table.1: Shell-fish species in Sinnakalapu [10]

Common name/ Scientific name	field status
1.White shrimp/ <i>Penaeus monodon</i>	Common
2.King shrimp	Less
3.Lobster	Less
4.Small shrimp	Very Less

Except *Penaeus monodon* other three shrimp species density have become less, especially the Small shrimp species, which were abundant in Sinnakalapu before Tsunami; but found in very low numbers now.

Table.2: Fish species present in Sinnakalapu [10,11]

Fish species	Field status
1. <i>Anguilla nebulosa</i>	Less
2. <i>Anguilla bicolor</i>	Less
3. <i>Amblypharyngodon chulabhornae</i>	Less
4. <i>Dawkinsia singhala</i>	Less
5. <i>Devario pathirana</i>	Common
6. <i>Devario aequipinnatus</i>	Common
7. <i>Esomus thermoicos</i>	Less
8. <i>Gerres erythrourus</i>	Less
9. <i>Labeo dussumieri</i>	Less
10. <i>Oreochromis niloticus</i>	High
11. <i>Oreochromis mossambicus</i>	Less
12. <i>Cyprinus carpio</i>	Less
13. <i>Channa striata</i>	Less
14. <i>Channa gachua</i>	Less
15. <i>Elops hawaiiensis</i>	Less

16. <i>Mystus ancutta</i>	Less
17. <i>Mystus gulio</i>	High
18. <i>Mystus vittatus</i>	Very High
19. <i>Mugil cephalus</i>	Common
20. <i>Puntius bimaculatus</i>	Less
21. <i>Punitus vittatus</i>	Less
22. <i>Clarias brachysoma</i>	Common
23. <i>Etroplus suratensis</i>	Less
24. <i>Etroplus maculatus</i>	Not seen
25. <i>Anabas testudineus</i>	Less
26. <i>Ctenopharyngodon idella</i>	Less
27. Lady fish (Common name)	Less
28. <i>Gerres</i> sp.	Not seen
29. Emperor fish (Common name)	Not seen
30. Otti (Local tamil name)	Not seen
31. Vannathi (Local tamil name)	Not seen
32. Aaral (Local tamil name)	Not seen
33. Kaalai (Local tamil name)	Not seen
34. White mullet (Common name)	Not seen
35. Uumbakilaathi (Local tamil name)	Not seen

There were 19 fish species, which had become less in numbers including endemic and exotic fish species, 9 fish species which cannot be seen now, 4 fish species, which are found commonly and 3 invasive fish species, which became higher in numbers [12]. Especially most of the endemic fish species have become less in numbers.

Table.3: Bird species found in Sinnakalapu lagoon area [10]

Scientific name/ common name	Field Status
1. King fisher	Very less
2. <i>Tringa tetanus</i>	Very less
3. <i>Lanius</i> sp.	Very less
4. <i>Microcarbo niger</i>	Common
5. Pond heron/ <i>Ardeola</i>	Common
6. Night heron	Common
7. Small Egret	Common
8. <i>Ciconia</i> sp.	Common
9. Mountain sparrow	Very less
10. <i>Passer domesticus</i>	Very less
11. <i>Eremopterix grisea</i>	Very less

There are only about 5 species of birds commonly found in Sinnakalapu and other 6 identified species have become significantly low in Sinnakalapu area.

Table 4: Aquatic plant species in Sinnakalapu [10]

Scientific name/ Tamil name (local name)	Field status
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1. <i>Pistia</i> sp.	High
2. <i>Eichhornia</i> sp.	Very high
3. <i>Nymphaea lotus</i>	Common
4. <i>Nelumbo nucifera</i>	Common
5. <i>Hydrilla</i>	Less
6. Oolaiivaal sallu (local name)	Not seen
7. Karukach sallu (local name)	Not seen
8. Poonaiivaal sallu (local name)	Not seen
9. Veappilai sallu (local name)	Not seen

According to the field status the numbers *Eichhornia* sp. and *Pistia* sp. have become higher in number but both were identified as exotic and invasive species in Sri Lanka [13]. Rooted submerged plants were also found in Sinnakalapu. Local people called it as Sallu which were the places where fishes laid eggs and the reproduction of fishes and other aquatic animals taken place. There are four types of Sallu were found in Sinnakalapu but now none of them can be seen.

3.2. Ecological importance of Sinnakalapu

This area supports diverse groups of plants, Algae and animals. This water body provides favourable conditions for the growth and development of floral and faunal species. Plants and algae found in Sinnakalapu are important to this aquatic ecosystem because they provide oxygen through photosynthesis, and food for animals in this biome such as Yum, delicious algae. In fact, the slimy scum found on the surface of waterbody is relished by many aquatic animals e.g. turtles and snakes. Some aquatic plants have strong roots that keep them anchored securely, while others have stems that bend easily with the movement of the water. Certain mosses are able to cling to the rocks. Plants, which grow in stagnant water of this water body have different adaptations. Water lilies, algae and duckweed float on the surface. Insects feed on fish larvae, while insects and fishes are providing foods for birds. In addition, shrimps and fishes are consumed especially by the local people. All these features have given a great importance to the ecosystem.

Sinnakalapu lagoon has become an important resource in Alayadivembu Pradeshiya Sabha because it provides transportation; recreation, like boating many employment opportunities in fisheries and research. One small dam also has been built across this river named Eaththalaakattu, which provides pollution-free energy, water for agricultural purposes and for aquaculture.

3.3. Economic value of Sinnakalapu

Sinnakalapu plays an important economic role for the surrounding villages. Stakeholders of Sinnakalapu get direct economic benefits and at the same time other

village people are indirectly supported. There are about 7 291 families in Alayadivembu Pradeshiya Sabha which includes 800 of registered fisherman families. But, only about 400 families are continuously fishing and others are part time fishermen. Of the full-time fishermen, 5.5 % of the total families in Alayadivembu Pradeshiya Sabha depend on this waterbody.

There are four main Societies and eleven Sub-Societies in Alayadivembu Pradeshiya Sabha., Using their collected data least average annual income from Sinnakalapu fish resources was estimated [14,15]. Fish resources include only the fish and shrimp species, which were caught regularly and the average weight of fishes and shrimps are calculated for 300 days in a year to estimate average least annual income of Sinnakalapu. Fishermen usually do not go for fishing, on Fridays. Hence, 300 days were considered for the estimation of least average income per year.

According to the estimated least average income per year from fish resources, the economic importance of Sinnakalapu in Alayadivembu Pradeshiya Sabah can be understood, which includes exotic and invasive fish species such as tilapia that had contributed more than the other fishes to the least average income of Sinnakalapu [Table-5].

Table.5: Least average annual income of Sinnakalapu from fisheries

Name of fish species	Average weight of fishes per year (kg)	Average income per year (Rs)
<i>Tilapia</i> sp.	120 000	36 000 000
Cat fishes	90 000	27 000 000
<i>Mugil cephalus</i>	105 000	31 500 000
<i>Channa striata</i>	3 600	1 800 000
Other fishes	45 000	6 750 000
Shrimp	900	90 000
Least average annual income		103 140 000

3.4. Mismanagement practices has led to the loss of Biodiversity in Sinnakalapu

Land degradation and fragmentation are identified as main mismanagement practices in Sinnakalapu. Before Tsunami, the area of Sinnakalapu with Periyakalapu was 1100 ha (SWORD, 2003). However, according to a recent estimation, it is less than 850 ha [3]. Now the area of Sinnakalapu is only about 400 ha according to Google Earth Pro software. Land degradation is mainly due to the settlements of people in the area after Tsunami, filling of Sinnakalapu and using for the industrial purposes and agricultural purposes mainly for paddy cultivation. The land near to the villages are used by the local people illegally. Because of these activities the habitat of aquatic

flora and fauna have been reduced. As the land degradation is still continuing, it is leading to the loss of certain fish and plant species in Sinnakalapu [5,6,7,10,13,16].

During the rainy season river over-flow passes through the Sinnamugathuwaram bridge which was built in 2015. Before this bridge was built, as it was a causeway over-flow of river passes only above the causeway but, after bridge was built, over-flowing river water has been increased. Because of that water carrying capacity has reduced and led to the drying up of river faster than before 2015. Nowadays most of the areas of Sinnakalapu has become dry. Other major problem is paddy cultivations close to the Sinnakalapu lagoon area. When the rainfall is high, farmers immediately cut-open the barmouth of lagoon to pass the water into the sea without taking permission from Fisheries Society to protect their paddy fields. As a result, even during the rainy season also the amount of retaining water is reduced and it speeds up the drying of river in the dry season. Prior to this in every two years fishermen caught large quantity of shrimps, but nowadays income of fishermen from shrimps is largely reduced due to this.

Illegal fishing is also problem. Though the use of monofilamentous nets for fishing is completely banned in Sri Lanka [17], majority of fishermen still used those instead of polyfilamentous nets. Monofilamentous nets are cheaper, freely available and more efficient. Other problem is the use of small-meshed gill nets for fishing, which results in catching large number of small fishes [17]. It leads to the depletion of fish species in this resource. Another important problem is illegal fishing by fishermen in other areas, without any permission.

Pollution is the next major threat to Sinnakalapu due to both point sources and non-point sources. Point sources are those directly contribute to pollution such as washing vehicles, oil containers, clothes, disposal of garbage, household wastes directed to the river [18]. Nonpoint sources of pollution are a combination of pollutants from a large area rather than from specific identifiable sources such as discharge pipes. Runoff is generally associated with nonpoint source of pollution, as water is emptied into streams or rivers after accumulating contaminants from sources like gardens, paddy fields, parking lots or construction sites [18]. Sinnakalapu is surrounded by paddy fields. Thus, paddy field canals which contains water rich in pesticides, insecticides, weedicides, fertilizers and agricultural wastes are directed to the Sinnakalapu. Adding of weedicides into Sinnakalapu water body mainly resulted in the loss of aquatic plants [19] and adding of fertilizers into waterbody of Sinnakalapu has increased the phosphate and nitrate content, which has led to the algal blooming in the river

[5,6,16,21]. Nowadays approximately about 40% of the water body is covered by the *Eichhornia* sp. [3], which indirectly affect fish in Sinnakalapu [21].

3.5. Need for Conservation

Most of the threatened freshwater fishes of Sri Lanka are found outside the Protected Area Network [10] and Sinnakalapu is also one of the lagoons which is found outside the protected area network. In addition, these habitats are under high human pressure. Therefore, they need to be protected; especially because their catchment areas will decide the water yield as well as the quality of water [10]. Any type of development affecting these habitats needs to be clearly assessed before granting approval. Further, species oriented conservation programs and habitat oriented conservation programs should be developed at least for the critically endangered species. As most of the species are found outside the protected areas local communities have to involve in conservation of these species. Conservation action plans should be drawn up for all identified threatened species. Ex-situ breeding programs should also be established with the aim of boosting dwindling wild population. However, translocation or reintroduction programs should be planned with utmost care to prevent imbalances in the ecosystems and introduction of diseases to the population. Thus far, a number of translocations have been attempted in Sri Lanka with the aim of conserving threatened species. Some of these translocation programs have been highly successful while some have failed to achieve the desired objectives [10]. Introducing exotic but, commercially important fish species such as carps and especially *Tilapia* sp. in Sinnakalapu has both positive and negative impacts. Economically it has a positive impact [Table -5] and ecologically it has a negative impact because it has been responsible for the depletion of some endemic fish species in Sinnakalapu [22,23]. Therefore, these programs should be carefully reviewed to document the lessons learnt before attempting further translocations and reintroductions.

3.6. Proposed management plans

3.6.1 Research gaps and research needs

The recent field surveys and phylogenetic studies by IUCN in Sri Lanka have demonstrated that there are still new species to be discovered in Sri Lanka [10]. Therefore, systematic surveys should be carried out to document the distribution and ecological conditions necessary for freshwater fishes in Sinnakalapu. The baseline data generated from such a survey can be used to make proper assessments of the conservation status of species as well as to draw up species conservation plans.

3.6.2. Education and awareness programs

It is important to educate people by organizing rational awareness programs with field visits to impart relevant knowledge about the mismanagement practices and their impacts on Sinnakalapu.

Implementation of different laws, (some of which are indicated below) by various institutes has made it impractical [22].

Law No 1. National Environmental Act No. 47 of 1980 (as amended by Acts No. 56 of 1988 and 53 of 2000) and the Regulations under the Act.

Law No 2. Fauna and Flora Protection Ordinance No. 2 of 1937 (as amended by Act Nos. 49 of 1993, 12 of 2005) and the Regulations under the Ordinance.

Law No 3. Water Resources Board Act No. 29 of 1964 (as amended).

Law No 4. Fisheries and Aquatic Resources Act No. 2 of 1996 (as amended).

Law No 5. Water Hyacinth Ordinance No. 4 of 1909.

Law No 6. State Lands Ordinance No. 8 of 1947. 54 and 83.

3.6.3. Managing the conflicts between Stakeholders.

Fishermen are the main stake holders of Sinnakalapu. There are several conflicts in between Fisheries Society and Farmer's Society because of the illegal fishing and other mismanagement practices in Sinnakalapu. It is better to form a Co-operative Society consisting of poor people of all different stakeholders. Educate and train the members about common pool resource management. Private sector can support the Society by paying for the different assistance provided by members to reduce pollution. Monthly meeting should be held to solve the problems as well as to get their opinions. Based on their opinions, new by-laws and rules which are accepted by all members could be framed for sustainable management of the resource.

IV. CONCLUSIONS

Sinnakalapu has a rich freshwater fish fauna with endemic fish species. However, nearly 19 freshwater fish species are listed as less in numbers and 9 fish species listed as "Not seen" in the Sinnakalapu based on the field status. Therefore, it is important to develop a conservation action plan for the endemic and threatened fish species in Sinnakalapu. Such an action plan should first a priority list of species as well as critical habitats of fishes that require immediate conservation action. This should be followed with preparation and implementation of species specific recovery plans. The implementation of such plans should be performed through co-management and the formed Society should be the nucleus in implementation process. Funds should be raised by the stakeholders

through membership fees and paying a reasonable share for using the resource in addition to what the polluters pay for the society for their assistance.

Therefore, it is essential to conserve the area of Sinnakalapu by reducing or preventing illegal settlements and agricultural practices in resource area by implementing available laws [Law No 1,3 and 6]. Necessary constructions to retain water during dry period should be done through the integrated work offline Ministries with the assistance of the Society. Society members should be used as workers, so that they get the feeling that this resource is theirs. Such constructions will lead to the formation of a healthy biome. Implementation of a polluter-pay system with the assistance of the bureaucrats and the Cooperative Society to control pollution of the resource would lead to develop a proper co-management strategy. Agrochemicals approved for use in Sri Lanka should be assessed for impact on non-target organisms and the environment in general, and the labeling of such products should include information on environmental safeguards.

Further, all future intentional release of exotic fishes should be preceded by an environmental impact assessment involving specific safeguards against invasiveness, and at the same time a rule should be imposed to ban the importation of exotic fish species that are known to be invasive in other countries. We can control the exportation and over exploitation of endemic and endangered fish species by the implementation of Law No 2 and Law No 4. and the aquatic invasive species *Eichhornia* sp. can be controlled by the implementation of Law No 5. Illegal fishing methods can be controlled by implementation of Law No 4.

Create a conservation model involving the Society members for the conservation of endangered freshwater fishes. Development of such a model as developed at Ibbankatuwa, Dambulla will lead to successful management of common pool resources of Sri Lanka. Fishes are renewable resources only if they are sustainably managed. Fresh water resources are most valuable treasures of our motherland.

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