Utilization of Aquatic Plants: A Method to Enhance the Productivity of Water in Seasonal Tanks in the Anuradhapura District

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Abstract

Heavy infestations of aquatic plants in a water body cause considerable economic and ecological losses. Many seasonal tanks in the Anuradhapura District suffer from this problem and cannot be neglected in water resource development and management schemes. This study was focused on the uses of aquatic plants and the problems caused by huge manifestations of aquatic plants in the selected seasonal tanks in the Anuradhapura District.

The study was conducted in four seasonal tanks viz., Galkulama, Thirappane Maradankadawala and Thibbatuwewa in the Anuradhapura District. Information on the utilization of aquatic plants, exploitation level and harmful effects were gathered by using a structured questionnaire to interview people who were residing close to the study sites. The attitudes of the public towards the aquatic plants i.e., conservation of aquatic plants, the potential uses of native plants and harmful effects of invasive aquatic plants were collected.

Twelve species were identified as economically important aquatic plants through the questionnaire survey. Among the 50 respondents, 92 % utilized aquatic plants for food, 58 % utilized flowers for offerings and decorations, 52 % utilized aquatic plants for medicinal purposes, 42 % utilized them as ornamental plants, 30 % used them as bio-fertilizers and 28 % utilized them for weaving.

The edible aquatic plants consumed by the rural community in the Anuradhapura District are Ipomoea aquatica (72 %), Alternanthera sessilis (66 %), Nelumbo nucifera (64 %), Nymphaea pubescens (60 %) and Aponogeton spp. (52 %). Some edible aquatic plants, namely Neptunia oleracea, Ottelia alismoides and Ceratopteris thalictriodes, which are present in the Anuradhapura District, are not consumed, although these are consumed in many other countries. N. nucifera is the most commonly used flower for offerings in the temples and for decorations. In addition, N. pubescens, Nymphaea nouchali are also used for flowers. Bacopa monnieri, N. nucifera, Acanthus illicifolia, N. nouchali and Aponogeton spp. have been recorded as medicinally important plants. Though there are many ornamentally important

aquatic plants, only N. pubescens, N. nouchali, B. monnieri, Nymphoides hydrophylla are used. Salvinia molesta and Eichhornia crassipes are the two aquatic plants commonly used as bio fertilizers.

With reference to the questionnaire survey, there were seven major problems that were discovered to exist due to heavy infestations of aquatic weeds in the water bodies viz., sedimentation and unsuitability for domestic use, interference with navigation, effects on fisheries, blocking irrigation canals and evapotranspiration. The most problematic plants in the Anuradhapura District include E. crassipes, N. nucifera, S. molesta, Pistia stratiotes and Ceratophyllum demersum.

Economically important aquatic plants available in the shallow water bodies of the Anuradhapura District, are marginally utilized, when compared with the utilization of aquatic plants in the global scenario. There appears to be a lack of a well organized action plan to cope with this situation. The public suffer a lot from the problems created by the heavy mass of aquatic plants, which covered the village tanks. The public are, however, willing to get organized and to engage in a participatory approach to restore their water bodies. There is a need for research and development of management strategies for the sustainable utilization of these valuable resources. Awareness programs should be conducted to promote sustainable utilization of aquatic plants. Creating awareness among the people about the nutritional and economic benefits of these natural resources will be useful for Sri Lanka, as a developing nation.

Introduction

The inland aquatic resources of Sri Lanka create a diversity of natural habitats for various aquatic flora and fauna (Jayasinghe 2000). Consequently, a rich aquatic flora is present in the areas of irrigation i.e., reservoirs, natural depressions, swamps, rivers and streams. The aquatic flora of Sri Lanka consists of 11 endemics, 90 peninsular species, and 7 non-peninsular species (Abeywickrama 1955).

An appropriate population of aquatic macrophytes contributes to the general fitness and diversity of a healthy aquatic ecosystem (Flint and Madsen 1995). They would be a direct food source for aquatic animals as well as a source of detritus for saprotrophic organisms (Sastroutomo 1985). In addition, they provide habitats for insects, fish and other aquatic or semi-aquatic organisms (Madsen et al. 1996). Submersed and emergent macrophytes also aid in the anchoring of soft bottom sediments and removing suspended particles and nutrients from the water column (Madsen et al. 1996). Many aquatic plants have played fascinating roles in the life of man since primitive times (Gupta 1987), deriving economic benefits such as sources of food, fiber, paper pulp and green manure (Boyd 1968, 1970 and 1972; Gujral et al. 1986).

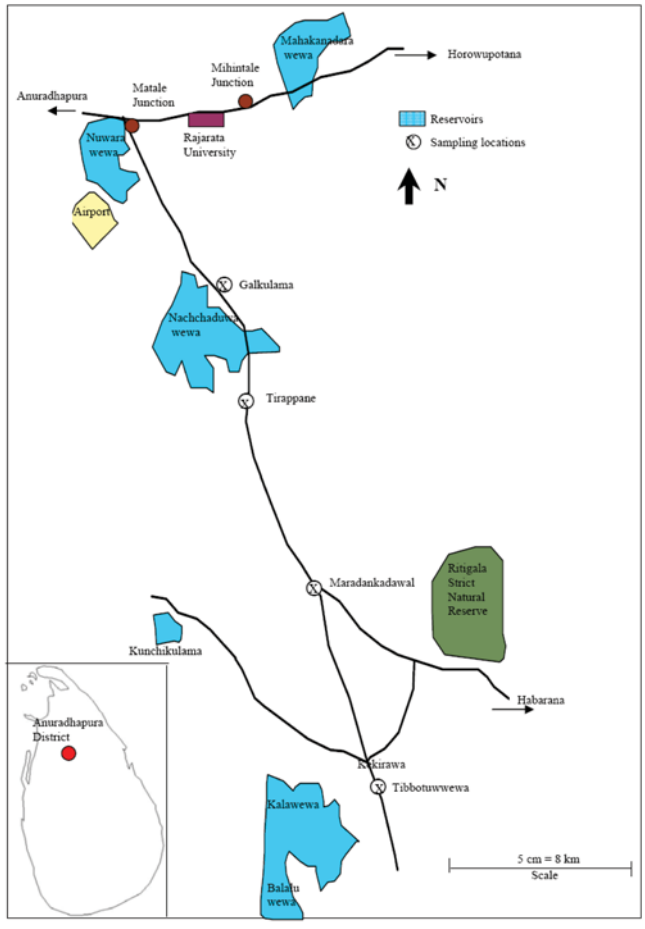
Although there are many benefits in aquatic plants, the excessive growth of water plants is a source for many common water quality problems throughout the world (Chapman et al. 1974; Shireman et al. 1982). Related in particular to the use and management of water resources, these problems include, loss of water storage due to transpiration, effects on fisheries, provision of habitats for vectors of diseases, interference with navigation, slow decomposition leading to decrease in water clarity and increased siltation (Sastroutomo 1985). In some aquatic ecosystems, alien species have grown to such an unprecedented level that they have even resulted in the drying up of water bodies (e. g., Eichhornia spp., Salvinia spp. and Pistia spp).

The vast potential of water plants is only marginally utilized and no scientific approach has been developed for deriving greater economic and ecological benefits (Mohan Ram 1991). The present study focuses on documenting the potential for the utilization of, and problems created by, aquatic plants.

Methodology

The study was conducted in four selected seasonal tanks viz., Galkulama, Thirappane Maradankadawala and Thibbatuwewa in the Anuradhapura District in the dry zone of Sri Lanka. The location of study tanks are shown in Figure 1. Information on the patterns of utilization of aquatic plants, levels of exploitation and opinions on the harmful effects of aquatic plants were gathered using a structured survey schedule. Fifty people residing close to the study sites were interviewed.

Figure 1. Map showing the locations of selected tanks in the Anuradhapura District.



Results and Discussion

Reduction of Productivity of Water in Seasonal Tanks by Aquatic Plants

According to the information gathered from the survey, there are seven major problems that arise due to heavy infestations of aquatic weeds in seasonal tanks. They are: a) increased sedimentation; b) unsuitability of water for domestic use; c) interference with navigation; d) effects on fisheries; e) blocking irrigation canals; f) evapotranspiration leading to increased water loss; and g) damages to the environment. Heavy infestations of aquatic weeds have had impacts on agriculture, fisheries, transportation, health, living conditions as well as the social fabric and the economy of some communities in the Anuradhapura District.

According to views held by the public, sedimentation (caused by heavy infestation of aquatic plants) is the most serious problem prevailing in the Anuradhapura District. The tanks with heavy aquatic plant infestation get silted easily as the dead materials of the plant biomass get deposited on the tank bottom. Sediments lead to a decrease in the depth of tanks, which in turn reduces the water retention capacity of the tanks. This situation has direct influence on the livelihoods of the surrounding communities, who depend on the tank water for their day-to-day water requirements. The shortage of water in the dry period has caused problems for paddy and other cultivations.

Utilization Pattern of Aquatic Plants

Respondents mentioned six current uses for aquatic plants. These uses are: 1) food; 2) flowers for religious offerings and decorations; 3) medicinal use; 4) ornamental plants; 5) bio-fertilizer; and 6) weaving of baskets. Ninety-two percent of respondents used aquatic plants for food, while 58 % used the flowers of water plants. The percentage of respondents reported as using aquatic plants for medicinal purposes and ornamental plants were respectively, 52 % and 42 %.

Comparatively lesser percentage of respondents (30 % and 28 %) reported the use of aquatic plants for bio-fertilizer and for basket weaving, respectively. The present survey revealed that the consumption of aquatic plants was low compared to the available resources in the study area.

As a Source of Food

Table 1 presents the common names, scientific names and percentages of respondents reported using at least one species of aquatic plant for identified uses. According to Table 1, Ipomoea aquatica is the plant used by the highest percentage of respondents.

Leaves and young shoots of both Ipomoea aquatica and Alternanthera sessilis are consumed. Some people consume these plants by harvesting them from the water body, while others buy them from the market. The selling of these plants has become a source of income for some people in the rural community. The price for a stack of plants varies from Rs. 10.00 to Rs. 20.00.

Nelumbo nucifera (lotus) roots are a fiber-rich food for villagers and people elsewhere. The lack of water in water bodies during the dry season facilitates the extraction of lotus roots. As a result, they are mainly consumed in the dry season. Extracting lotus roots and supplying

Table 1. Aquatic plants and their uses.

Common Name	Scientific Name	% reported as using for				
		(1)	(2)	(3)	(4)	(5)
Lotus (Nelum)	Nelumbo nucifera	64	36	54	0	0
Water lily (Olu)	Nymphaea pubescens	60	0	36	42	0
Blue lotus (Nil Manel)	Nymphaea nouchali	0	18	32	28	0
Water hyssop (Lunu-wila)	Bacopa monnieri	0	44	0	18	0
Swamp morning-glory (Kankun)	Ipomoea aquatica	72	0	0	0	0
Joyweed (Mugunuwenna)	Alternanthera sessilis	66	0	0	0	0
Kekatiya	Aponogeton spp	52	38	0	0	0
Ikiliya	Acanthus ilicifolius	0	34	0	0	0
Salvinia	Salvinia molesta	0	0	0	0	12
Water hyacinth (Japan-jabara)	Eichhornia crassipes	0	0	0	0	22
Crested Floating heart (Kumudu)	Nymphoides hydrophylla	0	0	0	12	0
Cattail (Hambu-pan)	Typha angustifolia[a]	0	0	0	0	0
Water mimosa (Diya-nidikumba)	Neptunia oleracea[b]	0	0	0	0	0
Duck-lettuce	Ottelia alismoides[b]	0	0	0	0	0

Notes: Use categories are, (1) Food, (2) Medicine, (3) Flowers, (4) Ornamental Plants, and (5) Bio-fertilizer

[a] These plants are used as material for basket/bag/mat weaving

[b] These plants are, as reported by other researchers, commonly used for the purposes listed. Although such uses were observed by the researchers, respondents to the survey did not indicate any significant uses for these plants

them to the market provides a substantial employment opportunity for villagers. The price per one kg of lotus roots varied from Rs. 60.00 to Rs. 80.00.

Consumption of other parts of Nelumbo nucifera, in either raw or cooked form, is reported in other regions of the world. For example, young leaves, petioles, fruiting torus and flowers are eaten in some regions in India (Pandey 2003; Kio and Ola-Adams (1987). Flowering stalks are eaten as vegetables by the community in the study area. This plant is not exploited to a marketable level. In addition, seeds of Nymphaea pubescens are also eaten as rice, and is said to be beneficial for diabetic patients. In the Aponogeton, flowers, flower stalks and tubers are consumed by the people in the Anuradhapura District. Although Aponogeton is commonly found in many water bodies in the study area (Munasinnghe et al. 2008), its consumption is not popular.

Some edible aquatic plants, namely Neptunia oleracea, Ottelia alismoides and Ceratopteris thalictriodes, which are present in the Anuradhapura District (Munasinnghe et al. 2008), are not consumed by these rural communities, although these are popular and consumed in many other countries (Gupta 2001; Mazid 1983).

Source of Flowers

Nelumbo nucifera is the most commonly used flower for offerings in the temples and for decorations. Flowers of Nymphaea pubescens are also commonly used in temple offerings.

However, the occurrence of Nymphaea nouchali is less when compared to the other two species, and as a consequence are less harvested for offerings. The demand for flowers increases during religious seasons like *Poson* and during wedding seasons because of the increased need for flower offerings and flower arrangements, respectively, during such times. The price of a single flower ranges from Rs. 2.00 to Rs. 5.00 at the place of harvesting and Rs. 5.00 to Rs. 10.00 at flower stalls.

For Medicinal Value

A variety of aquatic plants are used in curative therapy in traditional communities. For instance, Bacopa monnieri is used for stomach disorders and coughs suffered by small children, and is also used for some skin diseases, and to purify the blood stream. Aponogeton has a therapeutic value for diabetes and ailments due to gas. The findings of this study on uses of aquatic plants for curative therapy are consistent with those of Jayaweera (1982).

For the Ornamental Aquatic Plant Industry

Aquatic plants have drawn attention worldwide for their importance in the ornamental plant industry. Although many ornamentally important aquatic plants are abundant in the Anuradhapura District, only four species are used by the fringe community (Table 1).

As Bio Fertilizers

Salvinia molesta and Eichhornia crassipes were reported as used for bio fertilizers by respondents to the survey (Table 1). These are mainly used in their raw form in coconut cultivations, and are sometimes used to make compost. Generally, the average N, P and K contents of aquatic weeds are accepted as 1.5 - 4.0 %, 0.2 - 2.0 %, and 0.15 - 4.9 %, respectively (Mazid 1983). In some regions outside the study area there was evidence of using Azolla as a bio fertilizer. Azolla is an important aquatic plant because of its nitrogen fixing capacity. It can be grown in fish culture ponds to serve as feed and also in rice paddies to add nutrients to the soil.

Use for Weaving

The use of many Cyperus spp. to weave mats, hats, bags, spoon holders and other utensils for their own usage has been a common practice since ancient times. The people collect the requisite weaving materials directly from the marshes and limnetic water bodies. Respondents to the survey pointed out that, there is a drastic decline in Cyperus spp. due to their overexploitation in the weaving industry. However, respondents reported the use of Typha species as the material for weaving. The price of mats weaved using Typha spp. range from Rs. 200.00 to Rs. 500.00 depending on the size of the mat.

Potential to Derive Benefits from Aquatic Plants While Mitigating the Problems Caused by Heavy Infestations

In view of the huge biomass production potential of aquatic weeds, there could be many suggestions for their commercial utility (Gupta 1987). When compared with the utilization of aquatic plants on a global scenario, the usage of aquatic macrophytes in the Anuradhapura District is not at a satisfactory level. Since there are lots of crop cultivations taking place in the Anuradhapura District, the concept of using these aquatic weeds as bio-fertilizers would be an ideal solution to the pollution caused to the water bodies by the use of chemical fertilizers. Making farmers aware of these eco-friendly farming practices will result in a better balance between the economy and the environment. Boyd (1968) says that "utilization of water weeds as food could probably alleviate protein shortages in local populations of many developing nations, but it is doubtful that these plants could contribute greatly to the total food supply of any nation." Moreover, he stated that exploratory research should be initiated to assess the food value of the native aquatic flora. Such utilization of edible aquatic plants and making people aware of the nutritional benefits and economic benefits of these natural resources will be useful to Sri Lanka, as a developing nation.

The ornamental aquatic plant industry, which is a blooming industry worldwide, is neglected in the Anuradhapura District. This should be given more attention as a potential income source. Many ornamentally important aquatic plants are present in a large scale in the natural environment in the study area. The sustainable exploitation of such plants will be a good source of income for the surrounding community and a method of controlling the overpopulation of aquatic macrophytes. In addition, the culture of economically important plants will also provide a good employment opportunity for the villagers residing close to shallow water bodies in the study area in particular, and in other areas, in general. Though this is a novel concept for Sri Lankans, such aqua -culturing of economically significant fresh water aquatic plants is common in many Southeast Asian countries as well as countries like USA, China and Germany. In several developed countries, culturing of aquatic plants is mainly targeted on ornamentally important plants, while the target in Southeast Asian countries is more for food plants.

The use of aquatic plants to derive biogas is another good option to control problematic aquatic weeds. The potential of Eichhornia crassipes should be exploited. According to Casfbow (1967), each kilogram of water hyacinth produces 370 liters biogas containing 70 % of methane. However, this is not practiced in the study area. Appropriate programs should be initiated to harness this potential and to contribute arresting the excessive growth of weeds. Other aspects of use of Eichhornia crassipes include food for animals, raw materials for industry and a source of gases, proteins and other chemicals. In addition, some species can be used for making paper pulp, fish food and other live stock food.

Heavy infestations of Nelumbo can be controlled by a greater consumption of Nelumbo roots. Popularizing the use of Nelumbo leaves as food wrappers will reduce the leaf surface area in the water bodies, which in turn would block light penetration for the submersed plants. Pistia is another commonly problematic plant and mechanical harvesting is done by the surrounding community to control the overgrowth of the plant. Regular production of bio-fertilizer from this weed will mitigate the severe problems caused by this plant.

The public suffer a lot from the problems created by heavy aquatic plant covers present in their village tanks and they are interested in knowing how to overcome these problems. They are willing to get organized and engage in a participatory approach to restore their water bodies. In some villages, people organize themselves and practice mechanical harvesting using ropes, baskets etc. After harvesting, some use Salvinia molesta, Eichhornia crassipes as biofertilizers, while others pile up the harvested plants close to the tank, which lead to the spread of those plants again. Some people burn and remove aquatic weeds. These people are not aware of the benefits they can derive from Eichhornia. These weedy plants can be turned into useful industrial crops and people can earn from these weeds, while cleaning their water bodies. However, most people do not have the requisite knowledge to resolve their problems in this way. Local communities in this area are unaware of such industries. The provision of government incentives and helping with the necessary facilities for the relevant industries, such as energy production and paper industry, will promote the surrounding community to engage in the exploitation of heavily infested aquatic plants in the water bodies. Meanwhile, people must be aware of the importance of not exceeding the limits of sustainable utilization of these fresh water aquatic resources.

At present, using village tanks for day to day water requirements have been reduced as a result of supplying pipe-borne water. This undisturbed situation has also favored the growth of aquatic macrophytes in seasonal tanks. Promoting people to use the aquatic resources in the village tanks will be beneficial to the village community as well as for the sustenance of the tank itself.

Conclusions and Recommendations

Heavily infested aquatic plants create problems in water usage in many seasonal tanks in the Anuradhapura District. The magnitude of sedimentation is getting worse and people are willing to take measures to control this situation in order to conserve water bodies and to increase the water-holding capacity of these tanks. However, they are not aware that they can control this situation through the sustainable utilization of aquatic weeds.

Although there are lots of economically important aquatic plants available, those are marginally utilized. There is a high potential to develop industries related to aquatic plants in this area. The provision of government incentives to develop and to practice novel methods in the utilization of aquatic weeds will be greatly helpful in controlling aquatic weeds in a nonpolluting way, and restoring water bodies to their intended uses.

Many employment opportunities can be provided by industries related to the use of aquatic plants in these remote areas, which can in turn resolve the prevailing unemployment problems in the rural villages. Research should be directed to find new methods of harvesting and processing aquatic weeds for better exploitation of these resources. It is recommended that the public be made aware of the potential industries that can be used to improve the livelihood of those using aquatic macrophytes, while conserving their village tanks.

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