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Jaffna Peninsula Water Resources Challenges

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When we talk of the water resource of an area, we really refer to the resource availability/requirement for use by the people of the area. How many people are likely to have a stake in it and what they wish to do with the resource are relevant issues. None of us know the answers to these questions pertaining to the Jaffna Peninsula today. All we can do is to assess the present nature of the resource, the problems being faced today, how more of it can be made available in a sustainable manner should the need arise, and what the limitations are.

Water Resources of the Peninsula

The area of interest consists of the peninsula trisected by two large lagoon systems, and a number of islands to the west of the peninsula, see Figure 1. The short duration monsoon rains between September and December and the karstic limestone aquifer that underlies the peninsula providing storage for the rainwater, are the principal fresh water resources of the peninsula. Figure 1 also shows the water bearing aquifers in the area. The annual average rainfall is 1 255 mm but is highly variable, spanning a range of 630 mm to 1 780 mm. The monsoon rains are of high intensity, irregular and unreliable. Maximum recorded rainfall intensity was 539 mm in one day. On average 75 to 80% of the annual rainfall is brought about by the north-east monsoon between September and December and the balance 20% falls during the south-west monsoon season of April and May.

The topography of the peninsula is flat, with the highest land elevation being around 11 m above MSL. There are no major streams in the peninsula and surface storage on a large scale is not feasible. The limestone that underlies the whole of the peninsula and the surrounding islands does provide storage. It is Tertiary rock of the Miocene age. It has a vertical thickness on average of around 50 m and underneath the limestone is a layer of sandstone of about 130 m in thickness. The soil overlaying the limestone varies in thickness from no soil cover to 2 m of soil in most of the peninsula, and around 20 m of dune deposits along the eastern edge.

Due to the karstic nature and the presence of innumerable joints, fissures, solution channels and chambers in it, the limestone is the predominant source of groundwater. Extended fresh water lenses exist, recharged entirely by direct infiltration of rainfall, overlaying the saline water derived from the sea. The maximum level of permanent saturation of groundwater is about 0.6 m above MSL. The depth of the freshwater zone varies from 1-25 m. The groundwater storage is largest in December and reaches its lowest level in August. Towards the end of the dry season, with extensive abstraction of fresh water, the static equilibrium appears to breakdown and, in approximately 50% of the area, the water table falls below sea level.

The fresh water lenses are broken up by a major depression in the middle forming two lagoon systems, one joining the sea in the north and the other in the south; see Figure 1. The lagoons,

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while providing some limited fisheries potential, affect the region negatively in a number of ways. The presence of brackish water in the middle of the peninsula has the effect of breaking up the fresh water lens into smaller units and salinising the water in the dug wells for some considerable distance from the lagoon edges. During the monsoon season the levels in the lagoons rise and water spreads over cultivated lands thus damaging the soil and destroying the crops. Thirdly, during the dry season the wind blows the salts deposited on the extensive lagoon banks, destroying crops and polluting the atmosphere.

In addition to the two lagoons, the Vadamaradchchi Lagoon and the Upparu Lagoon, there is a third much smaller Lagoon to the west, in Araly, at the mouth of a seasonal stream, the Valukai Aru. The Valukai Aru, approximately 15 km in length, drains a catchment of 57 km^2, most of which is fertile land suited for rotational cropping including paddy rice in the wet season. This catchment has a preponderance of percolation ponds, usually of about a hectare in extent and one to two metres in depth. These percolation tanks, some 1 000 spread all over the peninsula, are ancient in origin. They detain flood waters by providing intermediate storage thus reducing the flood peaks and enhance percolation into the aquifer for use during the dry season.

Another feature of potential interest to the water resources of Jaffna is the Elephant Pass Lagoon at the South East corner of the peninsula. Extending over 7 500 ha in extent, the lagoon has been rendered saline by seawater entry from the west during the South West Monsoon through the bridge at Elephant Pass. Seawater also enters from the east during the North East monsoon by the collapse of the sand bar opening at Chundikulam. It receives fresh water from a number of streams in the mainland to the south. The total catchment area of these streams is 1 228 km^2, some 30% larger than the total land area of the peninsula.

To the west of the peninsula lie a number of small islands that support farming communities. Like the peninsula, they also rely on freshwater lenses that float on saltwater underneath for fresh water during the dry season.

Water Use

When we discuss water use in the context of planning for development and management, it is usual to base the projections based on the present use and any planned developmental targets. In the case of the Jaffna Peninsula, perhaps it will not be safe or prudent to do so. The present is no indication of the norm and as regards the future, little can be said. The conditions in the year 1981 may be a reasonable datum for a number of reasons, not the least of which is that a fairly comprehensive study of the water resources of the peninsula was undertaken around that time.

The economic activity in the peninsula is predominantly agricultural. The pattern of rainfall imposes the need for irrigation during a good part of the year and the source of water for this irrigation is the aquifer.

The pattern of water use for agriculture is unique to Jaffna, dictated by the special conditions prevailing there. The necessity to lift water from the wells five to eight metres acts as a self-regulating mechanism increasing the efficiency of water use. The field application efficiency for dry foot crops is high as percolation losses are minimised through frequent irrigation. The rice cultivation relies entirely on the direct rainfall, the exception being in very limited areas where irrigation is used for seedbed preparation, transplanting and possibly one irrigation during crop growth, if the rains fail. In most of the paddy areas, particularly in the marginal lands bordering the lagoons, irrigation of the rice crop is uncommon.

In 1981 before the mass migration of the people started and the agricultural activity in the peninsula was at its peak, the population of the province was 73 8791. The amount of water extracted from the aquifer during that time may be summarised as follows:

Domestic use	16.00	million m^3
Home gardens	56.00	million m^3
Irrigation	167.40	million m^3
Deep rooted trees	51.10	million m^3
Total extraction	290.50	million m^3

The need thus appear to be for some 400 m^3 of water from the limestone aquifer.

Challenges

The land area of the peninsula is 951 km^2 and the lagoon system covers another 86 km^2. The principal water resource being rainfall with an annual average value of 1 255 mm, the total water resource available to the 73 8791 people who lived in the peninsula in 1981 is on average 1 615 m^3 per head per year. It is generally accepted by water resource planners that when the availability of water falls below 1 700 m^3 per head per year, the conditions need to be categorised as one of scarcity and appropriate water conservation measures adopted. In the case of Jaffna with its short duration rainfall and the high intensity of monsoon rains, the resource per head of population falls well below the accepted figure defining scarcity. Resource conservation is therefore of paramount importance to the people.

The lagoons in the area impose environmental consequences; the well water in the proximity of the lagoons and even beyond are brackish if not saline. The evaporating salt water in the lagoons leaves salt deposits on the surface only to be blown on to the land area during the dry season damaging crops and causing untold misery.

The principal urban centre for the peninsula is the Jaffna Town situated at the South Eastern corner of the peninsula. The land is low lying and the ground water quality in a good part of the town is brackish. Disposal of the sewerage from this low lying area adjoining a shallow tidal lagoon poses additional problems. The challenges facing the development of water resources for the peninsula may thus be summarised as:

- Water Resource Conservation
- Improvement of the Marine environment
- Enhancing the water availability and sanitation facility of the Jaffna Town
- Providing for the expected increase in Population

We consider these and other related issues below.

Enhance rainwater collection, groundwater recharge and quality as a means of combating salinisation of ground water and providing additional water for small scale irrigation

Shallow hand dug wells provide nearly all of Jaffna's water needs except for direct rainfall that provide most of the crop water requirements during the rainy season. Most households incorporate a home garden, on average about 0.05 ha in extent, and a domestic well. In few instances up to half dozen families may share the water from a common well. While for domestic use, private wells are the norm and shared wells the exception, for irrigation of agricultural lands, the opposite is true. In all there are some 100 000 dug wells in Jaffna of which 25% are in agricultural land.

The quality of the well water varies from place to place, in some instances within short distances of the order of a few metres, depending on the limestone fissures they tap. For instance, of the 11 844 wells in the Thenmaradchchi Division in the south of the peninsula, bordering the Upparu lagoon, 4 628 are salty, 2 408 are saline, 1 244 are brackish and only 3 564 provide good drinking water. Generally, deeper wells of around six to eight metres in depth, found often in red earth formations, produce good quality water. Shallower wells of around 3 to 5 m in depth found on the lagoon basins and paddy areas yield water of variable quality. These also display more pronounced seasonal variations in level, some going dry during the dry season. In shallow well areas it is not uncommon for people to use their private wells for washing, cleaning and irrigating home gardens, but walk to a shared sweet water well a kilometre or so away for drinking water.

The increasing population coupled with increased prosperity and the advent of motor driven pumps fuelling increased agricultural production had contributed to increased water use in the District. While direct evidence is difficult to come by, anecdotal evidence indicates that the resource availability has deteriorated by 1980. A number of well owners had resorted to drilling boreholes at the bottom of the dug wells to cope with the wells drying up during the dry season. In addition, water in a number of wells was said to have become more brackish.

The cause of these problems is readily seen when the annual water balance of the aquifer is considered. The peninsula receives on average around 1.2 billion m^3 as rainfall. Of these around 470 million m^3 evaporate during the 120 days of the rainy season. A further 420 million m^3 goes to the sea as runoff, leaving 310 million m^3 to recharge the aquifer. It is estimated that around 50 million m^3 of this recharged water is lost to the sea from the aquifer leaving on average 260 million m^3 per year for exploitation. The average extraction from the aquifer on the other hand is 290 million m^3.

Although the above figures are based on rough calculations not backed by detailed observation and analysis, the adverse difference between total extraction and total recharge is obvious. It is also obvious in the field. Wells have gone dry and fresh water wells have become saline. The impact on the life of the people is evident with some people having to travel kilometres to obtain drinking water.

In addition to the anecdotal evidence, well water levels monitored by the Water Resources Board in 1972 show (Nandakumar, 1983) that in about 50% of the area, the water table falls below mean sea level from about March to August. These low levels, spread over most of the lagoon fringes and coastal areas, indicate overexploitation of the groundwater resource and are conducive to a substantial ingress of seawater into the aquifer during six months of the year. While the database is insufficient to confirm that there has been deterioration in the resource base with time, the existence of conditions favourable to seawater ingress is sufficiently disturbing to warrant concern and timely action.

Two conservation measures have been implemented in the peninsula. The first is the enhanced percolation into the aquifer through some 1 000 ponds that was referred to earlier. The second conservation measure is the "Jaffna Lagoon Scheme" initiated in 1879 but implemented in part during the 1950s and 1960s discussed in the next section.

The total surface area of the 1 000 ponds in the peninsula is estimated to be around 1 975 ha. Their contribution to the recharge of the aquifer is dependant on the infiltration rates and also the number of days in the year the ponds are not dry. Siltation is the major problem as it reduces the depth of water retained thus reducing the number of days that the recharge occurs and also it reduces the percolation rates. Assuming a percolation rate of 10 mm per day and that the ponds are not dry for 250 days of the year, it turns out that the percolation pond system could recharge the aquifer by some 50 million m^3 per year. Recognising that the total water abstraction from the aquifer during an average year is around 290 million m^3 per year, the contribution that the pond system can make is not insignificant. Maintenance of these ponds to increase the percolation rates and reduce the number of days they are dry, by regular de-silting can certainly enhance the contribution that the aquifer makes to the prosperity of the people of Jaffna. Construction of new ones at strategically chosen locations will add to this.

Prevent saltwater intrusion, local flooding and wind blown salt pollution at critical river/lagoon and beach areas

The source for the salt ingress into the peninsula were identified as the two lagoon mouths in the north and the south at Thondminar and Ariyalai and to a lesser extent at the mouth of the smaller opening at Araly on the south-west coast. By way of minimising this salt ingress four structures were constructed. Three other structures were also constructed to enhance the performance of these structures and hopefully to import additional fresh water into the peninsula.

a) Ariyalai barrage at the mouth of the Upparu Lagoon on the south coast;

b) Araly barrage at the mouth of the Valukai Aru on the south-west coast;

c) A number of salt water exclusion bunds around the barrages and extending well inland totalling more than 50 km in length;

d) Thondminar barrage at the mouth of the Vadamaradchchi Lagoon on the north coast;

e) A spill/causeway at Chundikulam at the eastern side of the Elephant Pass Lagoon;

f) A 4 km canal linking the Elephant Pass Lagoon with the Vadamaradchchi Lagoon,

g) A 4.5 km bund at Elephant Pass on the western side of the Elephant Pass Lagoon.

The last four relating to the Elephant Pass and Vadamaradchi lagoons have never functioned fully as an integrated unit in a manner the designers intended. The design intention was presumably to channel fresh water from the mainland through the Elephant Pass lagoon on to the Vadamarachi lagoon and reduce/prevent saltwater entry at Thondaminar thus making the lagoon area a fresh water environment. The link canal (item F) and the spill/causeway at

Chundikulam (item E) collapsed the year after construction. The Thondaminar barrage (item D) was completed in the 1950s but this also never operated as intended.

The likely effectiveness of these structures, even when properly maintained and operated is a matter for discussion. In an idealised situation where the slat water in the lagoons are replaced by fresh water, then we can expect to have increased storage in the aquifer by an enlarged lens encompassing the three existing smaller lenses. Such a ground water lens will not only provide a cushion form inter-seasonal variations in water availability, but also provide for annual variations in rainfall thus helping to cope with the dry years. The salt water menace will be kept outside the borders of the peninsula.

Is such a scenario feasible? Will it be possible to maintain the present levels of water in the lagoons with freshwater? Since 80% of the rainfall falls in the short period of four months and the annual evaporation rate is in the region of 1 500 to 2 000 mm, any stored water in the lagoons will evaporate during the balance eight months thus reducing the level of water in the lagoons. Such a reduction has the inevitable effect of drawing in freshwater from the aquifer. This question appears not to have received much attention in previous investigations. Clearly a detailed reservoir balance computation needs to be carried out. In the absence of such a detailed study one may only conceptualise what the likely consequence of preventing salt water flow into the lagoons through the two lagoon mouths.

A few numbers are of some use. The total volume of the two lagoons to MSL is estimated at 170 million m^3. The runoff into the lagoons during the 120 days of rainfall would be around 217 million m^3 during an average year. The evaporation from the lagoons from the 86 km^2 surface area of the lagoons would be 115 million m^3.

How much of the runoff of 217 million m^3 will be retained in the lagoons after the end of the rainy season of course depends on the way the barrage gates are operated. It is conceivable that all of this runoff could be retained, by maintaining the level above MSL after the rainy season. There is of course the risk of flooding. With the increased surface area the rate of evaporation will be high but falling rapidly with the rapid reduction in surface area. If this should prove insufficient to maintain the draw on the aquifer water, then one needs to consider other alternative ways of preventing the draw down from the aquifer.

One would be to let some sea water flow into the lagoon during the dry season sacrificing the quality of lagoon water, letting it go brackish, in order to minimise the loss of freshwater from the aquifer. Another way would be to reduce the lagoon surface area utilising and if relevant augmenting the existing lagoon bunds.

The other alternative would be to import freshwater from the neighbouring area. The "Jaffna Lagoon" Scheme was designed to import water from the mainland to the peninsula. Six small streams draining an area of around 1 250 km^2 flow into the Elephant Pass lagoon. The project was conceived to protect the Elephant Pass lagoon from seawater intrusion and to channel the floodwaters of the mainland streams through the northern lagoon, the Vadamaradchchi lagoon.

The mainland streams are at present used to irrigate agricultural lands within their own catchment and the quantity of water that can be released to flush the lagoon system is not known. The catchment area of the steams flowing into the Elephant Pass lagoon downstream of the storage structures on the streams is estimated at 580 sq. km yielding a runoff during an average year of around 187 million m^3. The volume of the lagoon at full capacity is 103 million m^3. The design assumptions are not in the public arena and thus it is not possible to comment on exactly how much of the water was expected to reach the peninsula. Nor is it possible to say what use this water will be put to for according to the design the water would have been diverted into the Vadamarachi lagoon only. The Upparu lagoon would not have benefited according to the design.

As a source of water this is a potential resource and it is feasible to augment the water resources of the peninsula. How best to use it and what benefits it would bring to the population needs detailed investigation. The principal doubt stems from the fact that this water is available during the rainy season in Northern Sri Lanka. This is the time that the lagoons are full and additional water is not needed.

Evolving a viable strategy to improve the lagoon environment, to increase the recharge to the groundwater, and if needed, to use the water from the mainland catchment effectively in a sustainable fashion is a major challenge to the people of Jaffna.

Improve environmental sanitation and protect surface and ground water quality in Jaffna Town

The Jaffna Municipal area lies on the edges of the shallow sea to the south. The water table in the southern part of the area, close to the sea, is high, within a metre of the land surface. The water is brackish making it unsuitable for drinking purposes. Drinking water to this area is supplied through standpipes with water pumped from wells some ten kilometres north of the area. In the northern half however, well water is usable for domestic use although the wells are shallow. The system is fragile in that it depends on a delicate balance between recharge and abstraction. The 24 percolation ponds and the associated channels within the Municipal area have therefore an important role to play in the development of this town.

The Jaffna Town had a population of 118 000 people in 1981 and was then projected to have a population of around 170 000 by the turn of the century. Though the population levels reduced during the war years, it is now increasing rapidly and is likely to reach the projected figures in a few years. Every house in the Municipal area depends on pour-flush latrines and septic tanks for sewerage disposal. The sewerage from the Jaffna Hospital is discharged into the sea to the south. With the assistance of the UNDP, plans were well developed some ten years ago to treat the sewerage from the hospital and pump the effluent to the sea. Increase in the population levels has meant an increase in the density of septic tanks and this along with high water tables implies an increase in the biological pollution levels of the groundwater. There is at present no coherent approach to dealing with the sewerage from the town. The land is flat and the level only a few metres above sea level. In addition a substantial population depends on fishing from the neighbouring sea. These different factors coupled with a number of different institutions having responsibility for managing the conservation, use and disposal of water, makes the sewerage disposal and environmental management of the sanitation in the Jaffna Town area a challenging task.

Evolve effective water management strategies

The principal method of accessing fresh water in the peninsula is through dough wells and these are mostly privately owned. The ground water source being so fragile, it is very sensitive to overexploitation. Once the water in an area becomes brackish or salty through upconing, it would take a number of years for the quality of water to return to safe limits. Also irresponsible action by one individual could cause harm to many in the neighbourhood. The neighbours will in general be helpless to determine their own fate unless there is some mechanism to control the action of individuals overexploiting the resource. The control measures needs to be on the amounts of water abstracted from existing wells and the number and locations of new wells. How much abstraction could be permitted? Does it need to vary from place to place? What is the mechanism for licensing the construction of new wells? How does one implement the proposed measures?

The ownership, and hence the management responsibility of the groundwater is not clearly defined in legislation. While the responsibility for investigation and monitoring the resource rests with the Water Resources Board, they have no institutional authority of controlling or regulating the use of groundwater. There is no groundwater planning system and there is no legal basis for groundwater allocation. There is also no public information and awareness programme regarding groundwater. This absence of any form of planning or regulation has the potential to cause immense harm to this resource base and consequently to the overall economy and well being of the peninsula.

The Water Resources Secretariat has for the first time in Sri Lanka included groundwater management as an issue that needs consideration in policy formulation and legislative programme development. It has in its draft policy and institutional recommendations prepared in the late 1990s included awareness building and demand management as principal instruments in managing the water resources of the country. The present project includes two items, Specific activities E5 and E6 in Section 3.1 to initiate constructive debate and follow up action that institutions like the Water Resources Secretariat can take up in pursuing effective and sustainable management of the groundwater resource in Jaffna. Will this be effective enough or should more effort be put in to evolve a system of management and control?

Improve and re-establish, after war losses, the knowledge base of lagoon hydraulics and its interface with ground waters on the peninsula

The Water Resources Board has been collecting data from the peninsula to monitor well water levels and water quality data. This effort had more or less stopped during the disturbances. Even the data collected has been subjected only to sporadic analytical efforts. Yet there are a number of issues relating to the resource needs to be answered. How effective are the percolation ponds? How much freshwater from the aquifer is lost to the sea? What would be the effective operation of the lagoon structures and what should be the objective? Data needs to be collected, targeted to specific purposes and analysed, and these analyses made to influence developmental efforts.

Capacity building

It is clear that a great deal is unknown about the water resources of the peninsula and with the expected increase in population there is also a great deal of urgency to evolve strategies for resource development. There is clearly a need for knowledge base and the technical and managerial capacity to evolve and implement developmental strategies.

The sole dependence on groundwater is a situation unique to Jaffna in the context of water resource management in Sri Lanka. Development of this resource requires professionals with institutional backing willing to devote time and effort to understand the issues involved and the vision to evolve a strategy for the future.

Conclusions

In 1981 when the population was around 750 000, the rate of water use was around 400 m^3 per head of population. The recharge to the aquifer during an average year is around 260 000 m^3 and this can sustain a population of around 650 000. If the population is to increase above this figure, serious attention should be given to augment the resource base. Technically it seems feasible to increase the resource base through increased percolation and by controlling the salt ingress through the lagoon mouths. A number of issues remain unresolved. These needs to be resolved and development activities initiated as a matter of urgency, for the rate of increase in population (475 000 in 1999) now and in the near future is expected to be very high.

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