Geographical Aspects of the Northern Province

XV Governors' Conference - 2012

Geographical Aspects Of The Northern Province – Sri Lanka

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GOVERNOR'S OFFICE
JAFFNA
NOVEMBER, 2012

This publication has been released on 15th November 2012 to mark the XV Governors Conference which was held in Jaffna with the participation of all nine provinces' Governors in Sri Lanka.

Message of the Hon. Governor, Northern Province

The XV Governors' Conference could be considered a very special event for the peoples of the Northern Province, especially for those in the Jaffna peninsula as they would play host to the Hon. Governors of the different provinces of Sri Lanka, their Secretaries and the respective families.

The three decades of war devastated the Northern Province. However the leadership of His Excellency, President Mahinda Rajapaksa brought about peace to the country and development is now taking place at a rapid pace.

On this accord, the Northern Province is presently experiencing the fruits of development that has never been seen earlier. Thanks to the guidance provided by Hon.Basil Rajapaksa MP, Minister of Economic Development, and Chairman, Presidential Task Force for the Development of the Northern Province whereby "Uthuru Wasanthaya" was executed.

This has given rise to the people to freely involve themselves in their cultural activities without restraint. Similarly their Livelihood, Agriculture, Fisheries and such enjoys a boost.

Amidst all these, being host to the Hon. Governors of all the Provinces of Sri Lanka is an Honour and necessitates the issuance of a brief resume on the Geographical Aspects of the Northern Province of Sri Lanka.

This exclusive publication would no doubt be of value to most of our distinguished and valuable guests, if not all of them, as it dwells into the afore mentioned areas in as brief a manner as presentable.

Thank you.

GA Chandrasiri
Governor
Northern Province.

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SECTION 1

GEOGRAPHICAL ASPECTS OF NORTHERN PROVINCE

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1.0 Introduction to the Northern Province.

1.1 Brief History of the origin of the Provinces of Sri Lanka.

In Sri Lanka, provinces are the first level administrative division. They were first established by the British rulers of Ceylon in 1833. Over the next century most of the administrative functions were transferred to the districts, the second level administrative division. By the middle of the 20th century the provinces had become merely ceremonial. This changed in 1987 when, following several decades of increasing demand for a decentralization, the 13th Amendment to the 1978 Constitution of Sri Lanka established provincial councils. Currently there are nine provinces. (fig.1)

After the British took control of the entire island of Ceylon in 1815 it was divided into three ethnic based administrative structures: Low Country Sinhalese, Kandyan Sinhalese and Tamil. In 1829 the British established the Colebrook-Cameron Commission to review the colonial government of Ceylon, including its administrative structures. The Commission recommended that the existing three ethnic based administrations be unified into a single administration divided into five geographic provinces. Accordingly on 01 October 1833 five provinces under one administration came into being:

- Central Province
- Eastern Province
- Northern Province
- Southern Province
- Western Province

Over the next fifty years four additional provinces were created, taking the total number to nine:

- North Western Province
- Uva Province
- Sabaragamuwa Province
- North Central Province

Figure: 01- Province of Sri Lanka

1.2 Location of the Northern Province.

The Northern Province is located in the north of Sri Lanka, and lies between latitudes 8°46’N and 9°30’N, and longitudes 80°21’E and 80°38’E, and is just 22 miles (35 km) from India. It is connected with the Indian mainland by the mythical Adam’s Bridge. It has an area of 8,884 square kilometers (3,430 sq mi). (fig.2,3)

The province is surrounded by the Gulf of Mannar and the Palk Bay to the west, the Palk Strait to the north, the Bay of Bengal to the east and the Eastern, the North Central and the North Western provinces to the south.

Figure: 02-Relative Location map of the Northern Province

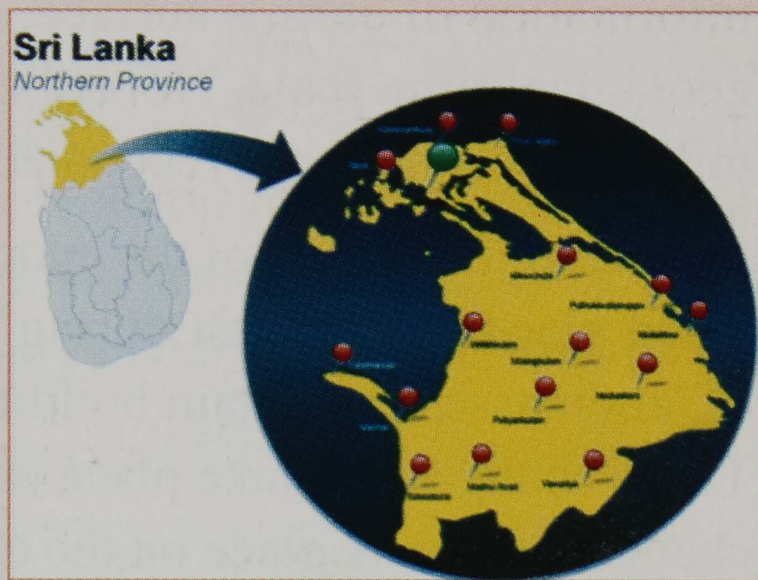


Figure: 03 -Location Map of the Northern Province

LAND AREA OF THE NORTHERN PROVINCE BY DISTRICTS

District	Total Area		Land Area		Inland Water	
	Sq.Km	Percent	Sq.Km	Percent	Sq.Km	Percent
Northern	8848.21	100.00	8545.31	96.58	302.90	3.42
Jaffna	1025.20	100.00	983.60	95.94	41.60	4.06
Kilinochchi	1237.11	100.00	1192.81	96.42	44.30	3.58
Mannar	2002.07	100.00	1991.00	99.45	11.00	0.55
Mullaitivu	2616.90	100.00	2516.90	96.18	100.00	3.82
Vavuniya	1967.00	100.00	1861.00	94.61	106.00	5.39

The province is divided into two distinct geographic areas:

1. Jaffna peninsula
2. Vanni.

1.3 Brief Description of the Geological Base of Sri Lanka.

1.3.1 Physical Setup of the Northern Province of Sri Lanka.

Introduction

Since the inception of the origin of the planet earth, its surface, having become subjected to various impacts has got changed up to now by endogenic and exogenic processes. But man is able to acquire information of earth's surface, of only 600 million years from the geological time scale. Nevertheless geological history of only 100 million years has been recognized to be trust worthy.

Due to the effects of the endogenic processes, great changes had taken place on the crust during the geological periods (movements of landmasses, mountain buildings and formation of sea floor etc.). These changes still take place on the earth. As the evidences of such changes that took place on the earth, have gone to rack and ruin. An explanation of morphological aspects has been given on the basis of some fresh evidences obtained later on.

In the meantime geologists and geomorphologists have shown their interest in investigating into matters relating to various geological, morphological aspects and its complex processes throughout the geological periods.

In this respect, the geographical setup of the Northern Province of Sri Lanka has been described in relation to the geological base of Sri Lanka.

The Geological base of Sri Lanka. Sri Lanka's insularity and morphology have been determined largely by its geological history, rock types and structures. Broad regional relationships may be interpreted in terms of plate tectonics.

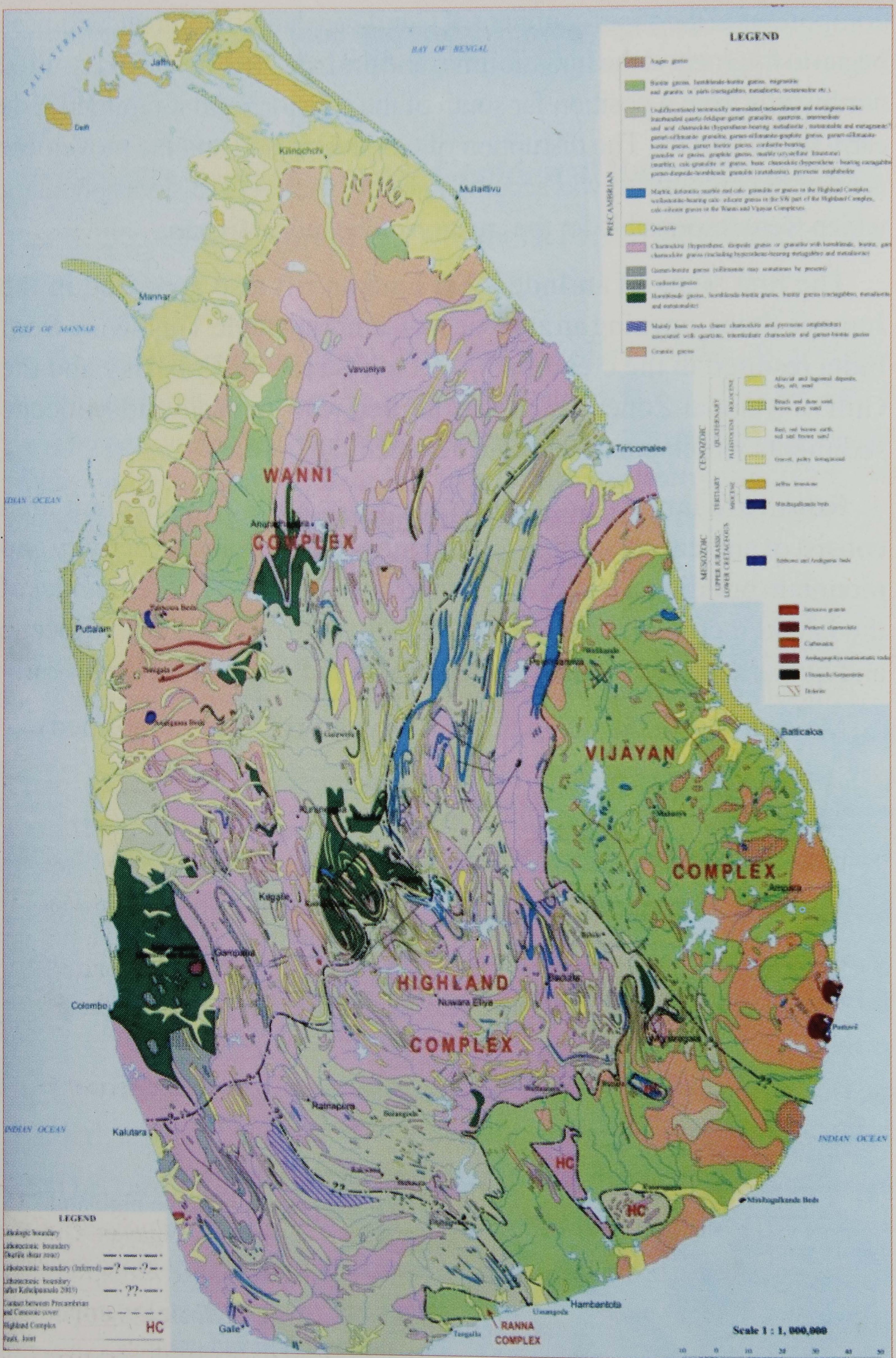
Structurally, Sri Lanka is related to India to which it was united through the greater part of geological time, when both were a component of the super continent of Gondwanaland. This great landmass began to fragment in the Jurassic times and the Indo-Sri Lankan mass rafted northwards from a position far south of the equator, until it rammed Asia early in the tertiary. The disruption of Gondwanaland and the movement apart of its components was accompanied by phases of sea-floor spreading which were responsible for the creation of the Indian Ocean.

The first signs of an Indo – Sri Lankan rift also appeared in the Jurassic times, opening an ancient pre Cambrian fault. This swing from India resulted in the creation of the Palk Strait, the Palk Bay and the Gulf of Mannar Zone, which was infilled with Jurassic and Miocene sediments which attain thickness exceeding 1000m.

Rocks are largely pre-Cambrian. Over 80% of its present area consist of ancient crystalline rocks unaffected by volcanic activity and mountain building for over a thousand million years. The remainder of the Island includes sedimentary deposits which are mainly Miocene and quaternary and located principally in the North and Northwest.

Major event in the geological history of Sri Lanka (simplified)

Geological Era or period	Millions of years	Event
Pre - Cambrian	>3000	Sedimentation on floor of ancient geosynclines
	3000-2000*	Major metamorphism: rocks of highland series and Kataragama complex emplaced
	1700-1500*	Some rocks of highland series emplaced or altered
	1250-1100*	Major metamorphism: transformation of some highland series rocks into the Vijayan. Older rocks of southwestern group appear.
	1000-950*	Emplacement of Tonigala granite and some Vijayan granites



Geology of Sri Lanka

Palaeozoic	Cambrian-Ordovician	700-650* 520-450*	Minor, but widespread metamorphisms
	Devonian-carboniferous	390-345*	local alteration or crystallization of some minerals in southwestern and Vijayan regions
	Permian	280-230	Continental drift underway; erosion
Mesozoic	Jurassic	195- 141	Signs of Indo – Lankan rift; sedimentation on margins of ancient land mass: Tabbowa and Andigama beds
			uplift and erosion
	Cretaceous	141- 65	Rapid breakup of Gondwana land; continental drift continues
			Deposition between S.India and Sri Lanka
Cainozoic	tertiary	22.5 – 5	Submergence, separation from India, Jaffna limestone beds, Minihagal kande sandstone
		5 – 2	Uplift & erosion
	quaternary	<2	
		.01 To date	Post – glacial sea level rise, drowning of continental shelf, younger raised beach & dune deposits, beach rock, recent alluvium, lagoons

1.3.2 Geology and Morphology of the Northern Province of Sri Lanka.

The Northern Province of Sri Lanka can be divided into two solid geological regions. Tertiary sediments are Miocene and is one of the solid geological region that occurs in the North and Northwest of the Province; known as the Jaffna lime stone. These sediments consist of thick, nearly horizontal beds of coralline lime stone, calcareous sand and mud. Overlying the sedimentary rocks are quaternary materials which are unconsolidated or partly consolidated. They include clays, sands, gravels, organic materials and weathering products.

The Other solid geological region falls under then Vijayan series. The rocks and structures of Vijayan are markedly different. Rocks are both igneous and metamorphic types, and include banded greisen's, granites and migmatites. (fig.4,5)

Rocks are highly contorted and evidence of bedding is rarely seen.

Rivers radiate from the high lands to coastward and carry with them the product of erosion which are deposited in plains or carried out to sea. Catchments are relatively small and discharges are correspondingly low.

fig.5 -The simplified geological map of the Northern Province

The Northern Province has been classified into several geomorphologic elements the Major geomorphologic elements are as follows. (fig.6)

a) Undulating plains
b) Old beaches (Pleistocene)
c) Fluvial &Deltaic plains and associated water bodies.
d) Holocene Beaches and dunes
e) Limestone platforms.

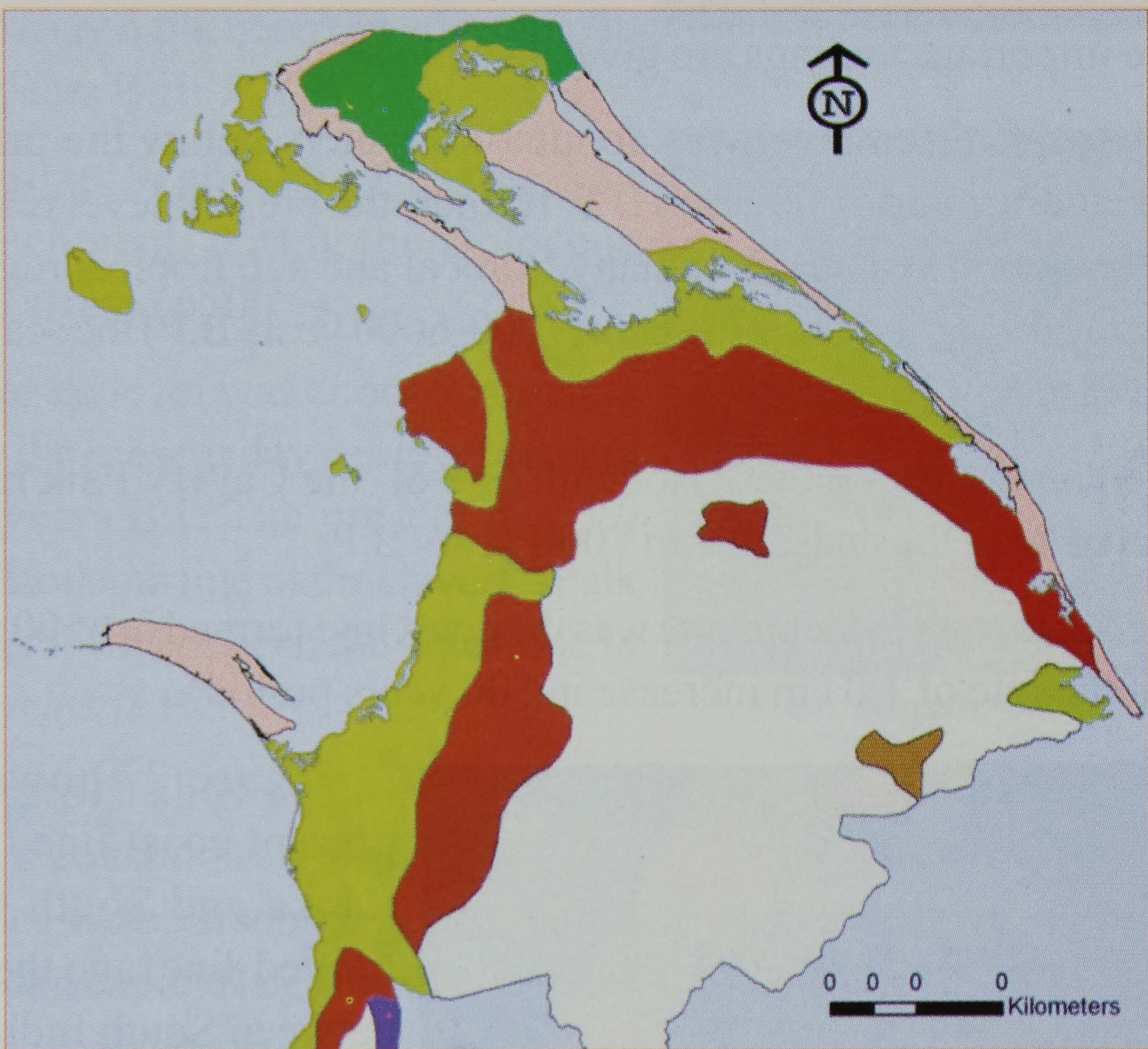


fig.6 -The important morphological elements of the Northern Province

LEGEND

1	Undulating plains
2	Old Beaches (Pleistocene)
3	Inselbergs, rock-knobs, rock plains, rock ridges
4	Holocene beaches and dunes
5	Limestone, platforms, low laying
6	Fluvial and deltaic plains and associated water bodies
7	Lateritic hills, rises and terraces

Recent researches in relation to sea level rise around Cavery-Palk Bay and tropical regions reveal some important findings in view of morphological features development of South India and the North and the North Western part of Sri Lanka, especially formation of the Palk Bay, the Cavery basin, and the continental self region of both south India and Sri Lanka.

These developments took place during the Holocene period (10000 years before the present)

The important findings are given as fellows.

a) The tropical sea level was about 10.0 meters below the present sea level around 7000 years B.P. further; the present level reached around 6000 years B.P. in many tropical and sub tropical regions. During the period of 1000 years (7000-6000 years B.P) the sea level increased by 10.0 meters.

The present 10.0 meters Isodepth line of the Cavery Palk region may have been the coast line in 7000 years B.P.

The 5.0 meters Isodepth line was the coast line formed in 6500 years B.P (at the rate of 1.0 cm increase in 500 years period).

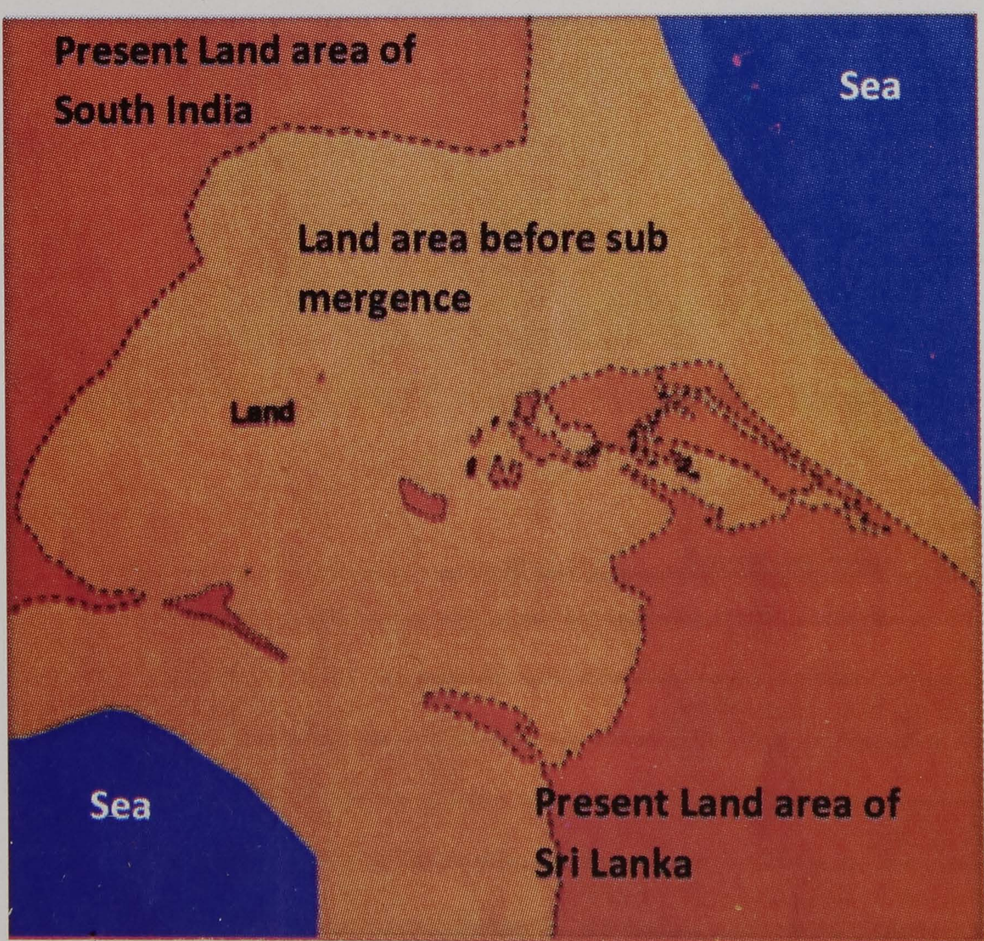


Fig. 07

Figure 7 shows the present coast line of Sri Lanka and South India (dotted line) and the area between South India and Sri Lanka were found as land during that period of 18000 to 17000 years before present. The present day 80 meters Isodepth line of the Cavery – Palk region may have been the coast line during the 18 000 17000

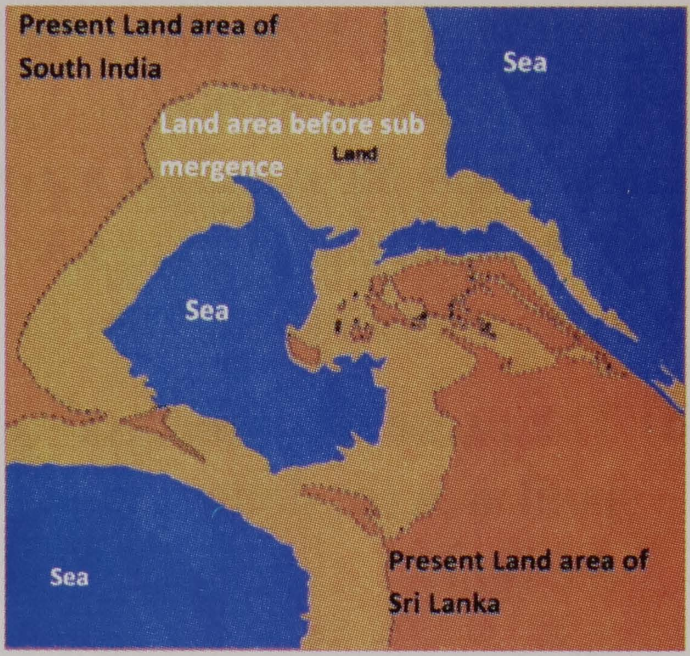


Figure: 08

years before present (B.P) The shows the encroachment of sea into the land during the period of Holocene time (around 7000 years)

The sea level was about ten meters below the present day sea level around 7000 years B.P. The present day 10 meter isodepth line of the Cavery - Palk region may have been the coast line in 7000 years B.P. (Fig.8)

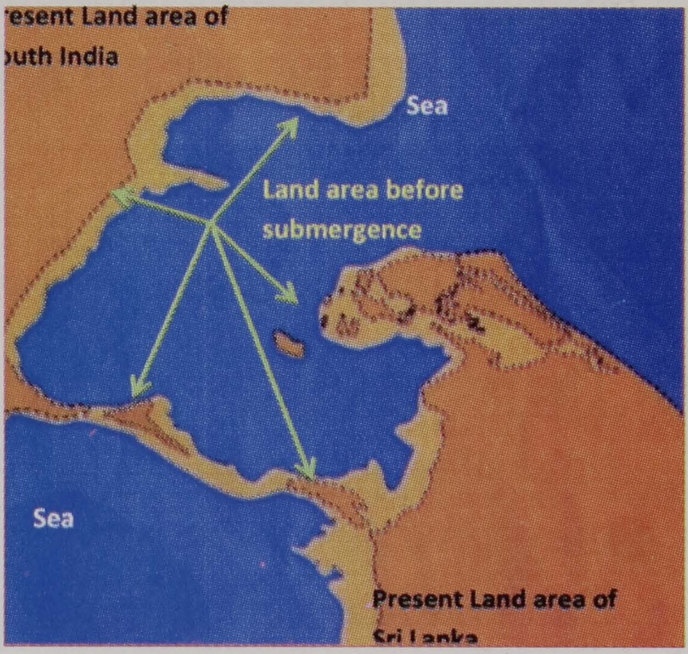


Figure: 09

Figure 9 shows further sea encroachment during the Holocene period around 6500 years.

The sea level was about 5.0 meters below the present day sea level around 6500 years B.P. The present day 5.0 meter isodepth line of the Cavery - Palk region may have been the coast line in 6500 years B.P

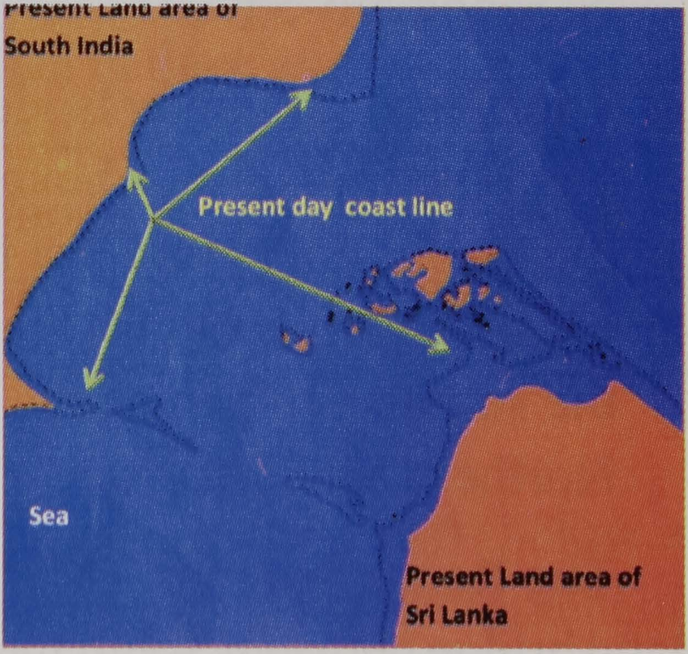


Figure: 10

Figure10 shows that most of the present coastal area of the Northern Province had been submerged during the mid Holocene and late Holocene period.

b) According to figure 8 the present Palk Bay would have come into existence like lake between South India and the North Western and North Sri Lanka. The rivers from South India and Northern Sri Lanka flowed into this lake. Both the present delta regions of the Cavery region and larger portion of the present sea beds of the Jaffna regions, and the North Western part of Sri Lanka would have been land.

c) During this period there must have been several river valleys formed in the Cavery Palk region. One or more of which from South India seems to have rushed across the elongated depression which was formed in the West to East and North West to Southeast direction of the present Northern, and Eastern coast of the Jaffna Peninsula.

d) The present submerged 'Pedro Bank' region may have been the land area (or delta region) which was parallel to the river valley at the time.

e) The present rivers of the dry zone of Sri Lanka (including the Northern Province) may have flown through their former valleys which were formed in the Cavery-Palk region at that time and the present Jaffna lagoon. Also part of the former river valley. The river valleys of Southeastern part of South India also may have extended further into the present continental shelf region.

f) The preset Islands of Jaffna including Delft seem to be an integrated land area. Several low-lying ridges, well marked troughs, deltas may have developed on the land area. The area around Mannar, Pam Ban Island and Rameswaram would have been a band of land with intermittent river valleys which were in the direction of NW-SE, N-S, and NE-SW.

g) The present 5.0 meter Isodepth depth line in Cavery Palk basin was the over limit of the above mentioned basin in 6500 years B.P. In this stage, rivers had lost their own valleys further, sea level rise caused the rivers to fill their valleys and discharge their load over the submerged pen plain. The Island \Delft" was separated from Northern Sri Lanka.

The Rameshwaram – Mannar band of land seems to have been a land bridge between South India and Sri Lanka with some intermittent river valley.

h) The present sea level of both south India and Sri Lanka reached it heights around 6000 years B.P. Afterwards sea level was rising continuously. But the rate of rise varied from time to time (figure 10.)

Some researchers suggest that the sea level in the Indian Ocean has risen from 1.0 – 6.0 meter in the period of 6000 – 2000 years B.P. Some studies suggest that the mid Holocene sea level in Sri Lanka was at least 1.5 meter above present level with three episodes. These episodes were as follows

(i) 6240 – 5130 B.P (High sea level)

(ii) 4390 – 3930 B.P (High sea level)

(iii) 3280 – 2270 B.P (High sea level)

In view of the above findings certain conclusions can be made.

1. The present configuration of Cavery Palk basin and adjoining Jaffna Peninsula with Islands, Rameshwaram Island, Mannar Island etc. have been formed during the mid – Holocene sea level rise episode (around 6000 years B.P).

2. Following these high sea level episode, the former drainage basin sub merged and bays and lagoons were created. The Jaffna lagoon was created during this episode. The former coastal plains have been changed into continental shelf regions.

3. Between mid – Holocene and late Holocene (6600 – 2270) years B.P. Periods further sea level rise took place in the Cavery Palk region and its surroundings. During this period, most part of the present Jaffna peninsula and its adjoining Islands were submerged and also a part of the North Western part of present Sri Lanka, a coastal region of Southern part of south India including Rameshwaram – Mannar link were submerged.

4. As far as Northern Sri Lanka is concerned the lower part (below – 5.0 meter) of the Valigamam, Vadamarachchi and Thenmarachchi would have sunk into the sea then.

The present inland lagoon area also may have been formed during this period.

5. The well known red soil presently found in Jaffna seems to have been the residual soil of some type of formerly existing red soil in the same region.

During the sea level rise between mid – Holocene and late Holocene period most of the red soil deposits were washed away. The present boundary of D

The spatial distribution of red soil in Jaffna region may have been the Holocene maximum sea level boundary of this region.

The Thenmarachchi, Vadamarachchi, Poonakari sand deposits may have been brought and deposited by the sea and wind during the Holocene periods.

1.3.3 Coastal morphology of the Northern Province – Sri Lanka.

The coasts of the Northern Province may be divided into several sectors, each with distinctive physical attributes which distinguish them from those adjacent.

1. **Point Pedro – Thiruvadiniliym**

This stretch of coast occupies the Northern Flank of the Jaffna peninsula. It faces seas that are less than 13 meters deep and for this reason is not affected by medium and long period Ocean Swell.

The coast is low lying and composed of coralline limestone, capped with red Calciclatosols which are weathered beach and Aeolian deposits. Raised Holocene beach deposits lie within 3m of the high water mark.

The coastline is devoid of indentations, excepting for the inlet of Thondaimannar lagoon. In plan, it is multi convex and without prominent headlands. The coast is undergoing slow retreat. Cut back, mainly during the Northeast monsoon, has produced low cliffs and causes in places, an extensive intertidal shore plate form, veneered with coarse calcareous debris which constitutes the beach materials. A coral refflies off shone.

Fig.11

	1	Jaffna islands
	2	Lagoon of Jaffna
	3	Poonerya peninsula
	4	Pallikulam – Mantai
	5	Mannar island
	6	Adam's bridge
	7	Mantai –mkudremalai point
	8	Nayaru – pepara putti
	9	Poonerya peninsula

Coastal morphology of the Northern Province

2. The Jaffna Island

Islands of low level limestone, beach deposits and marine alluvium lie west of the Jaffna Peninsula. Seven cluster together, with shallows of less than 4m between them. They were part of the Jaffna Peninsula until the mid Holocene submergence.

Aloof from others, and separated from them by a channel less than 12m deep, is the Island of Delft, girdled by limestone shores and low cliffs. On some exposed sectors of the Islands facing southwest are sand sheets and dunes, blown in by the Southwest monsoon.

3. The lagoon country of Jaffna

Between the Jaffna coast and the Islands, are shallows, less than 2m deep. These are the beginning of an extensive system of lagoons collectively known as the Jaffna lagoon.

The larger southerly extensions separate mainland Sri Lanka from the Jaffna Peninsula. The system owes it origins to submergence in the Holocene, and to the growth of low barriers and spits of sand and silt that subdivide and delimit it.

The two principal entrances to the lagoon are in the Northwest at Thiruvadiiliyam and between the Island of Mandativu and Kalmunai point on the Poonariyam Peninsula.

The lagoon system is affected by the tides, which flow through at these points bringing in sediments. In addition, fluvial deposits are contributed by rivers, such as the Kanakarayan Aru and Akkarayan Aru, from the main land.

Tidal currents determine the direction of spit and bar growth. Winds whip up wavelets during monsoons, especially during the Southwest monsoon. These have given rise to beaches and low sand dunes in places. Such beaches face either Southwest or Northeast. Most extensive are the shores of silt and Calcareous clays, materials readily transported to parts of the lagoons more distant from the major entrances.

Mangroves and halophytic vegetation occupy the tidal flats.

4. The Pooneryn Peninsula

A Belt of low sandy terrain extends from Pooneryn on the mainland, Northwest wards. This is the Pooneryn peninsula, which adjoins the Jaffna lagoon.

The feature has been built in response to tidal currents, and more particularly to the influence of small waves and wavelets associated with the dry windy Southwest monsoon. These have brought in sediment and have mounded the Palk Bay flank of the peninsula into a stable barrier coast of sand, actuate, facing southwest.

The lagoon side of the peninsula carries depositional features, which include sandbars, offshore islets and fine textured accumulations of alluvia in the inter-tidal zone, shaped by tidal currents which parallel this sector. Mangroves and salt marsh are widespread.

5. **Pallikulam – Manthai**

From the Pooneryn peninsula to the Mannar Island, along the Eastern margin of Palk Bay, the coast is one where depositional features predominate, because of the low wave energy conditions experienced.

Terrain consists largely of wave and wind worked sands, reddened by weathering. These overlie limestone, which outcrops near the low water mark at Devil's point, where a low cape terminates.

The shores of this cape are lined with marine alluvia, worked into spits and bars growing North wards, the direction of the dominant drift.

South of this tract tidal flats and alluvial terrain increase in widths.

The supply of fluvial sediments increases south wards.

Deltas, bordered by mangroves and salt marsh, have developed where rivers enter the sea. Where reddened sand occur, inactive, vegetated duress makeup the landscape.

An inter-tidal offshore barrier of five textured alluvium, which supports a mangrove forest, has been formed by wavelets and tidal currents between Vidattlativu and Illupaikaavai. It is backed by lagoon. Further South, the tract prograded with alluvium widens, as the delta of the Aruvi Aru is approached.

Mantai was an important part in early historical times, but today is completely sediment.

6. Mannar Island

The Island of Mannar consists of multiple sand barriers of Holocene age, thrown up by waves of the Southwest monsoon and Indian Ocean Swell, covering the limestone beneath.

The earliest barrier on the Northeastern side of the Island appears to have been added to from the Southwest, the direction of maximum wave intensity and fetch.

Winds of the Southwestern monsoon have built systems of frontal dunes which have supplied transgressive secondary dunes, that extends most of the Island.

The shores facing the Gulf of Mannar are concave seawards. Those on Palk Bay are convex. Vegetation on this Island is mainly thorny shrub, Palmyra palm and Baobab. Mangroves occur in the intertidal flats between the Island and the main land with salt – marsh above.

7. Adam's Bridge

Between Mannar Island and Pamban Island is a shallow ridge of recent conglomerate and sand stone mantled with Island and shoals of shifting sand. This is Adam's bridge, about 30km long and 6km wide. It separates Palk bay to its North from the Gulf of Mannar to its South.

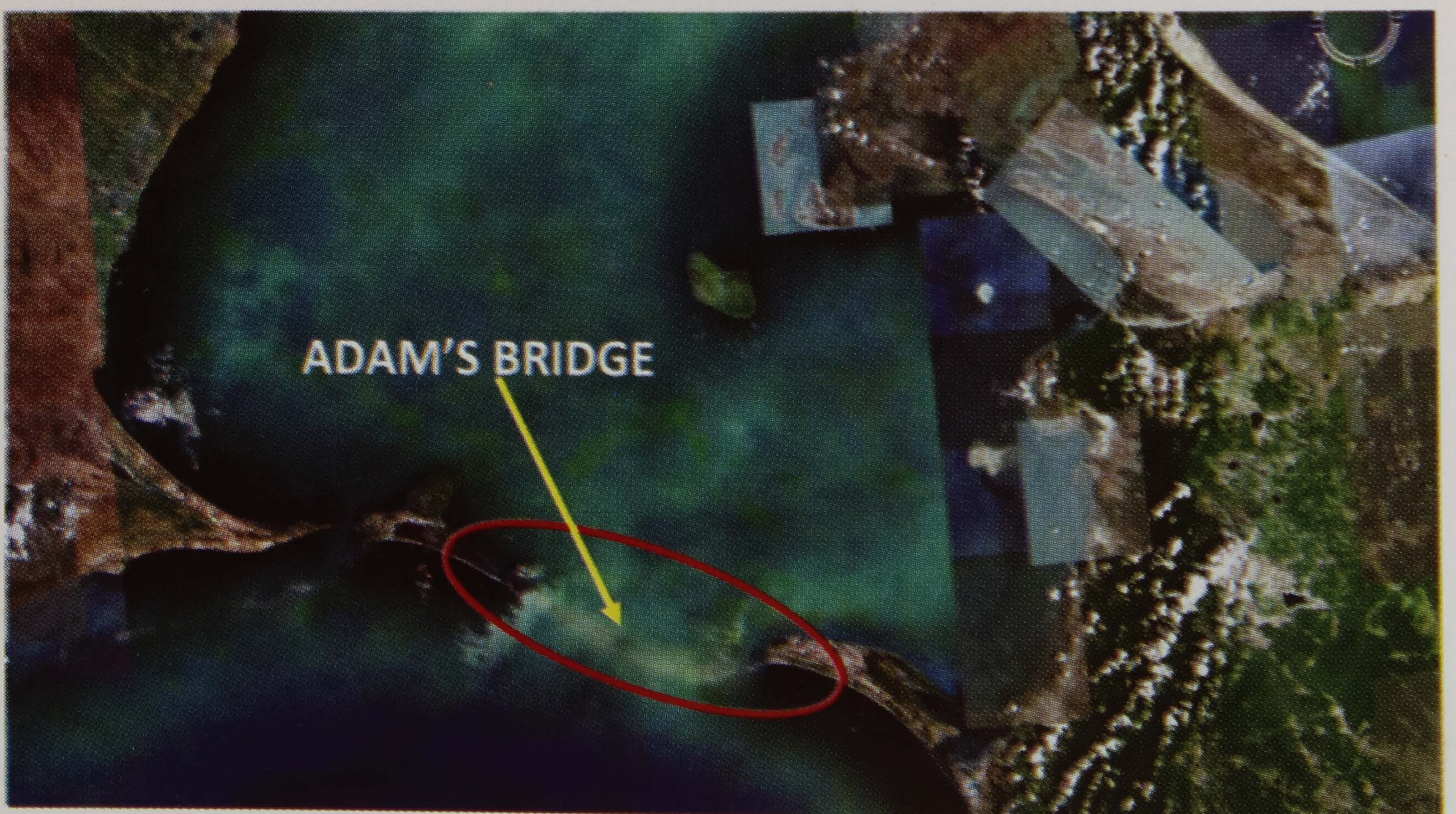


fig.12

The 'bridge' averages 0 - 2m in depth. Unlike Pamban Island, whose south facing shores are actuate and concave towards the Gulf of Mannar, Adams Bridge is convex towards the Gulf, where waters are deeper. This plan shape suggests that there is a net drift of water and sand from Palk bay into the Gulf. South of the Indo-Sri Lankan connection are traces of early shores, concave towards the Gulf and paralleling its margins. These are best seen in the line of reefs of Slavatturai and Vankalai, and their extensions across the Gulf, namely the reefs of Musalitivu, Valaitivu and others. The reefs appear to have foundations of beach rock at depths of 3.5 to 4.5 meter below M.S.L. Upon which there are overgrowths of coral. Between these reefs and shores and bridge, water depth increase. (fig.12)

The coral reefs are classified as barrier reef for this reason. That at Slavatturai has been described as the Great Barrier Reef in miniature by Clarke (1956). Coral reefs do not lie opposite Adam's Bridge itself because of abundant sand movement through the gab these shallows constitute. The portable remains of an outer, deeper reef of sandstone also of the barrier type occur at about 10 – 11m below M.S.L.

8. Mantai – Kudremalai Point

This stretch of coast consists of a belt of Holocene coastal and riverine alluvia, behind which red and yellow Pleistocene beach and dune deposits have been laid down upon limestone. These older landscapes occur largely at elevations of 15-30m and 30-58m above sea level. The northern most portion of this sector consists of the delta of the Aruvi Aru. Although the river empties at Arippu near the Southern end of the delta, the delta itself extends well North of Mantai.

9. Nayaru – Peparaputti

From the outfall of the Nayaru lagoon Northwards the coast is low and sandy, with evidence of abundant progradation. This is particularly active at Mullaitivu, where large offshore banks of sand have been laid down.

Recent beach and dune sands occupy a broad swath behind the shoreline, West of these and parallel to them are long lagoons. Beyond them are weathered latasok.

10. **Peparaputti – Point Pedro**

At Peparaputti, there commences an extensive complex of beaches, dunes and lagoons. These are arranged in belts paralleling the shoreline. The system is a tombolo which connects the limestone of the Jaffna peninsula to the mainland.

The shoreline is gently concave in plan but becomes straight to convex south of this sector. Plan shape, the alignment of multiple spits both recent and older, along this sector, sand grain size characteristics suggest that beach and spit growth and sand supply have been from the North.

2.0 Climate of the Northern Province.

Climatically, the Northern Province is unique in the entire variety of climates of the Island as there prevails long dry spells about 6 – 9 months and 3 – 4 months at rain. That is attributed to the fact that it's geographical formation as a tip of the islands which is faraway from the central highlands that facilitates or disrupts the rain making wind currents. This area is also located by the side of wind direction that brings South West monsoon. The main factor affecting the climate of the Northern Province is rainfall which accounts for making clear cut differences in vegetation types. The intensity and the distribution of rain fall is closely correlated with temperature variation and altitudinal variation.

According to published climatological information point of view, Sri Lanka lies in the monsoon zone of South Asia. It has a tropical climate characterized by bimodally distributed monthly rainfall, the two peaks being the result of the South - West (SW) and the North - East (NE) monsoons, The NE monsoon is of considerable importance in maintaining the climate in the Northern Region, because there are no physical barriers to deviate their influence away from the island. The NE monsoonal rains sets in December and prevails until February and the rest of the year experiences continued drought until the next season. The annual average rainfall received by the Northern Province (NP), (except the Mannar district) varies from 1250 to 1875 mm. Mannar district receives 1000 –1250mm. Average rainfall. The NE monsoon is active mainly in the northern, northeastern and north western lowlands. The overall contribution of the NE monsoons to the total annual rain fall of Sri Lanka is around 30%.Generally the overall range of the mean air temperature of the island is 20 – 30C while having little higher temperature around 30 – 35C in the Northern Province. In extreme conditions during severe drought seasons it goes up to 37C.

The relative humidity (RH) is closely associated with rainfall and air temperature and directly influence by wind. In contrast, in the northern and the eastern sectors of the island, the relative humidity is lower during the SW and the NE monsoons. In the extreme northwest (Mannar and Talimannar), RH remains perennially low (<70%) during the day and reaches 80% in the night. (Fig.13,14)

According to Muller Dubois, 1968, the Northern Province consists of 3 climatic zones Northwestern Lowland, Northern Lowland DZ and Arid zone. All these three zones have clear distinctive climate pattern, therefore vegetation characteristics and the diversity of fauna and flora found in the forests significantly varies from those of forest types.

Variation of climatic factors in different climatic zones of the Northern Province

Climatic Zone	Altitude (m)	Annual Rainfall (mm)	Temperature (C)	Average RH (%)	Dry period
North western lowland DZ	<100	1200 - 1400	27	70	Feb - June
Northern lowland DZ	<100	<1500	27	40 - 80	July - Aug
Arid zone	<100	<950	35 - 40	<50	April - Sept

MONTHLY RAINFALL in the Northern Province BY DISTRICT – 2010 (in mm)

District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jaffna	47.1	0.0	0.1	66.6	94.50	29.7	5.1	127.5	142.8	115.2	492.2	375.8
Kilinochchi												
Mannar	27.2	0.0	0.5	54.3	60.2	1.6	Tr	33.5	138.4	106.5	353.0	299.7
Mullaitivu												
Vavuniya	109	0.8	83.6	143.1	35	1.3	22.4	40.3	200.9	77.9	410.7	334.6

NUMBER OF RAINY DAYS in the Northern Province BY DISTRICT – 2010 (*in mm)*

District	2010											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jaffna	3	0	0	8	5	1	5	4	12	10	18	18
Kilinochchi												
Mannar	3	0	1	9	5	1	0	3	7	7	18	6
Mullaitivu												
Vavuniya	7	1	6	11	6	2	4	6	12	7	20	21

MEAN ANNUAL AVERAGE AIR TEMPRATURE – 2010(In °c)

MONTH	JAFFNA		KILINOCHCHI		MANNAR		MULLAITIVU		VAVUNIYA	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
January	21.9	29.9			24.1	29.4			21.1	30.5
February	21.7	31.3			23.9	30.9			21.4	32.2
March	23.8	33.8			24.7	33.4			22.9	35.5
April	27.3	35.1			26.5	33.7			24.9	35.3
May	27.7	33.4			27.4	32.6			25.3	34.1
June	27.7	32.5			27.6	31.6			25.4	35.1
July	27.3	33.2			26.7	31.6			24.7	35.2
August	26.6	32.2			25.8	30.5			24.5	34.3
September	26	30.8			25.8	30.6			24.3	33.9
October	25.9	30.5			25.8	30.3			23.9	32.1
November	24.1	29.9			24.8	29.6			23.3	30.8
December	23.1	28			23.9	27.7			22.4	28.1

MEAN RELATIVE HUMIDITY – 2010

Month	Jaffna		Kilinochchi		Mannar		Mullaitivu		Vavuniya	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
January	71				76	85			77	94
February	67				72	83			70	92

March	64				68	83			65	91
April	70				73	87			70	89
May	77				78	84			76	91
June	74				76	83			66	86
July	70	82			75	82			64	85
August	75	86			81	87			68	87
September	80	88			81	87			73	90
October	78	87			82	88			75	90
November	82	93			83	90			84	96
December	83	90			85	89			88	95

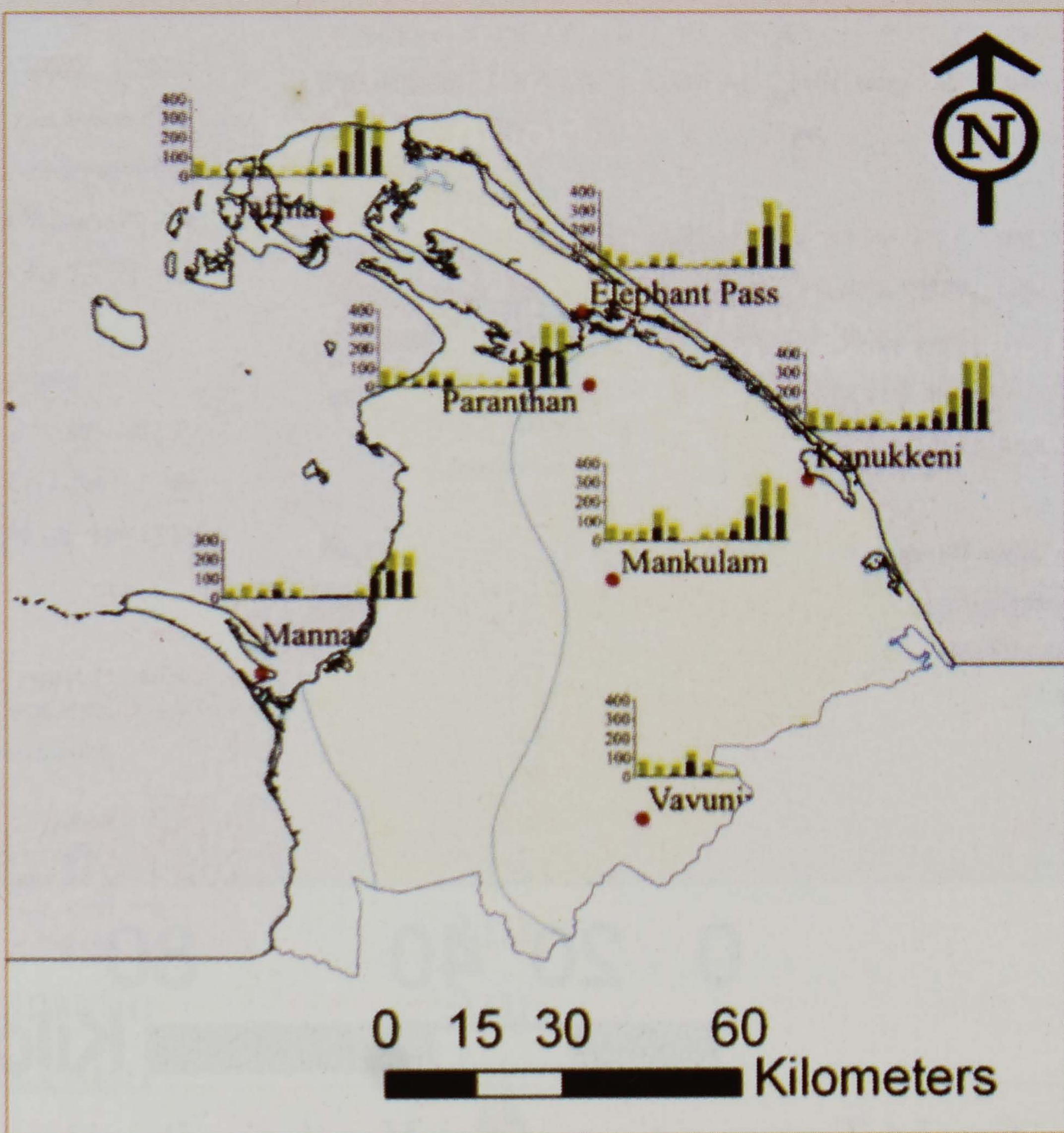


fig.13 Rainfall of the Northern Region

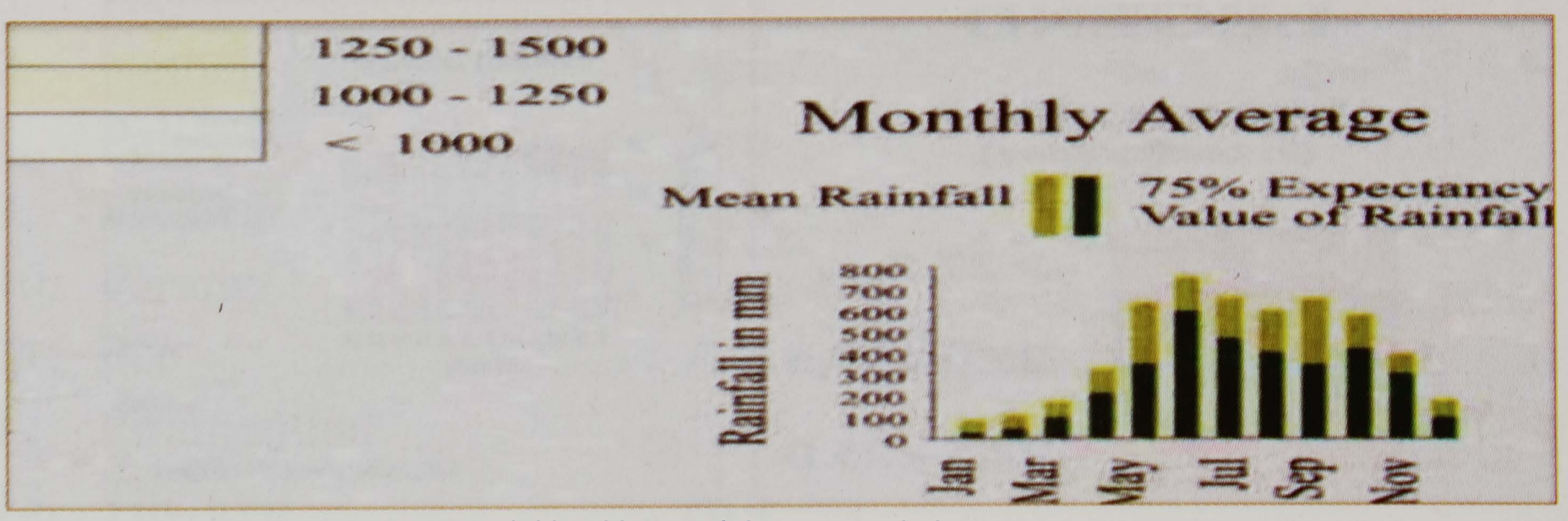
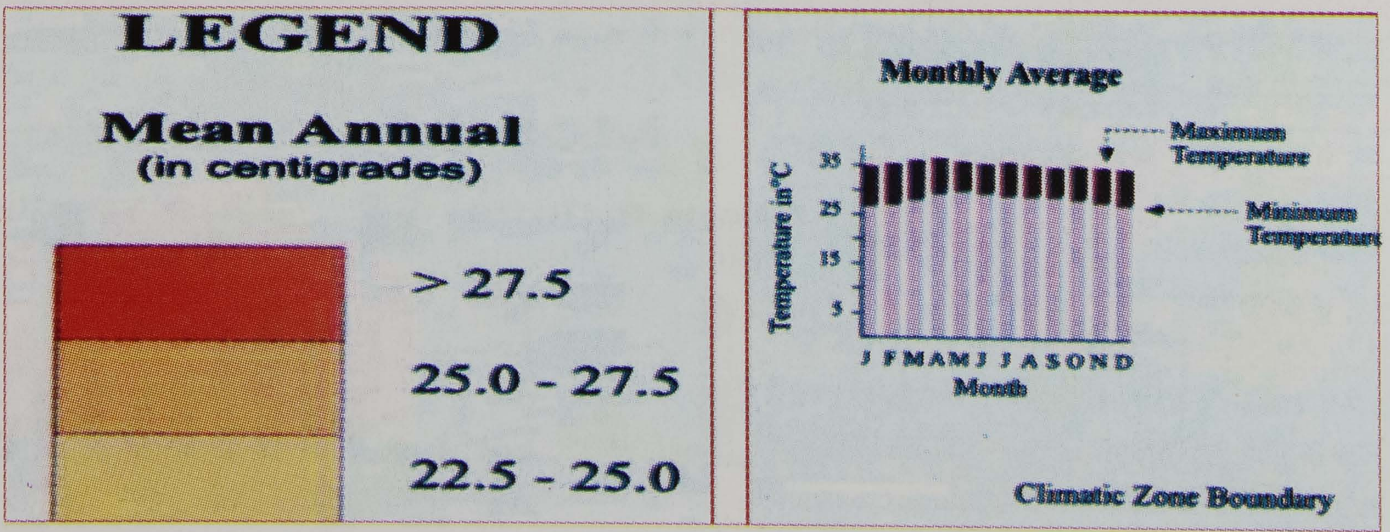


fig. 14 Temperature of the Northern Region



3.0 Water bodies of the Northern Province.

3.1 The major Rivers of the Northern Province.

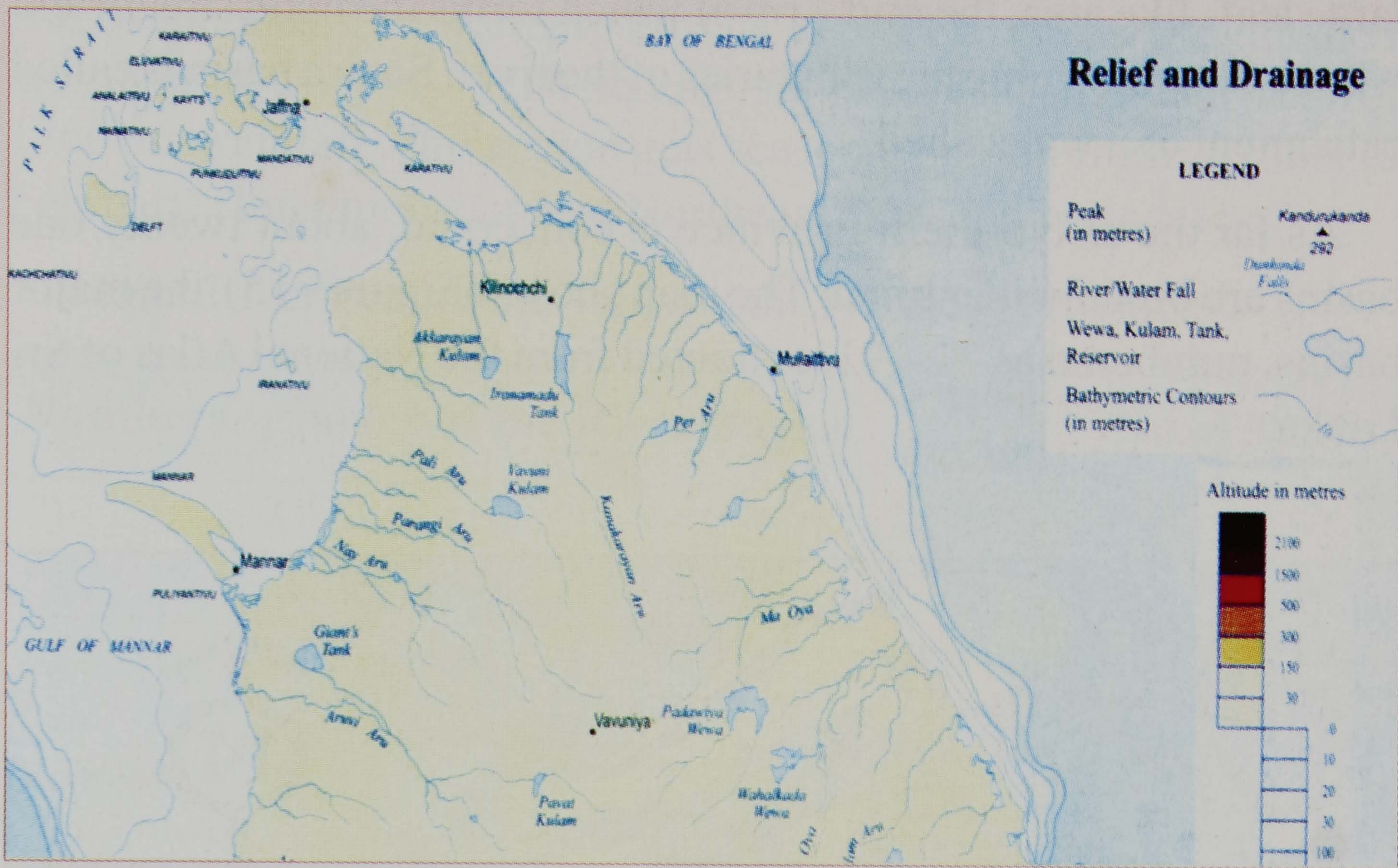


Fig. 15 The major Rivers of the Northern Province

Major rivers include:

1. Akkarayan Aru
2. Aruvi Aru
3. Kanakarayan Aru
4. Kodalikkallu Aru
5. Mandekal Aru
6. Nay Aru
7. Netheli Aru
8. Pali Aru
9. Pallavarayankaddu Aru
10. Parangi Aru
11. Per Aru
12. Piramenthal Aru
13. Theravil Aru

3.2 Surface Water of the Northern Province.

Surface water comprises the water in the streams, rivers and reservoirs. Surface water carves out rills and gullies to spread over a large leaf- like area, the mid – rib of which forms the main stream and whose veins resemble the tributaries of the river. Such a basin is called catchment or a water shed.

As far the as Northern Province is concerned, about twenty one basins are broadly identified. The map shows (Figure - 15) the major basins, numbered as 71 – 91, extracted from the National Atlas of Sri Lanka.

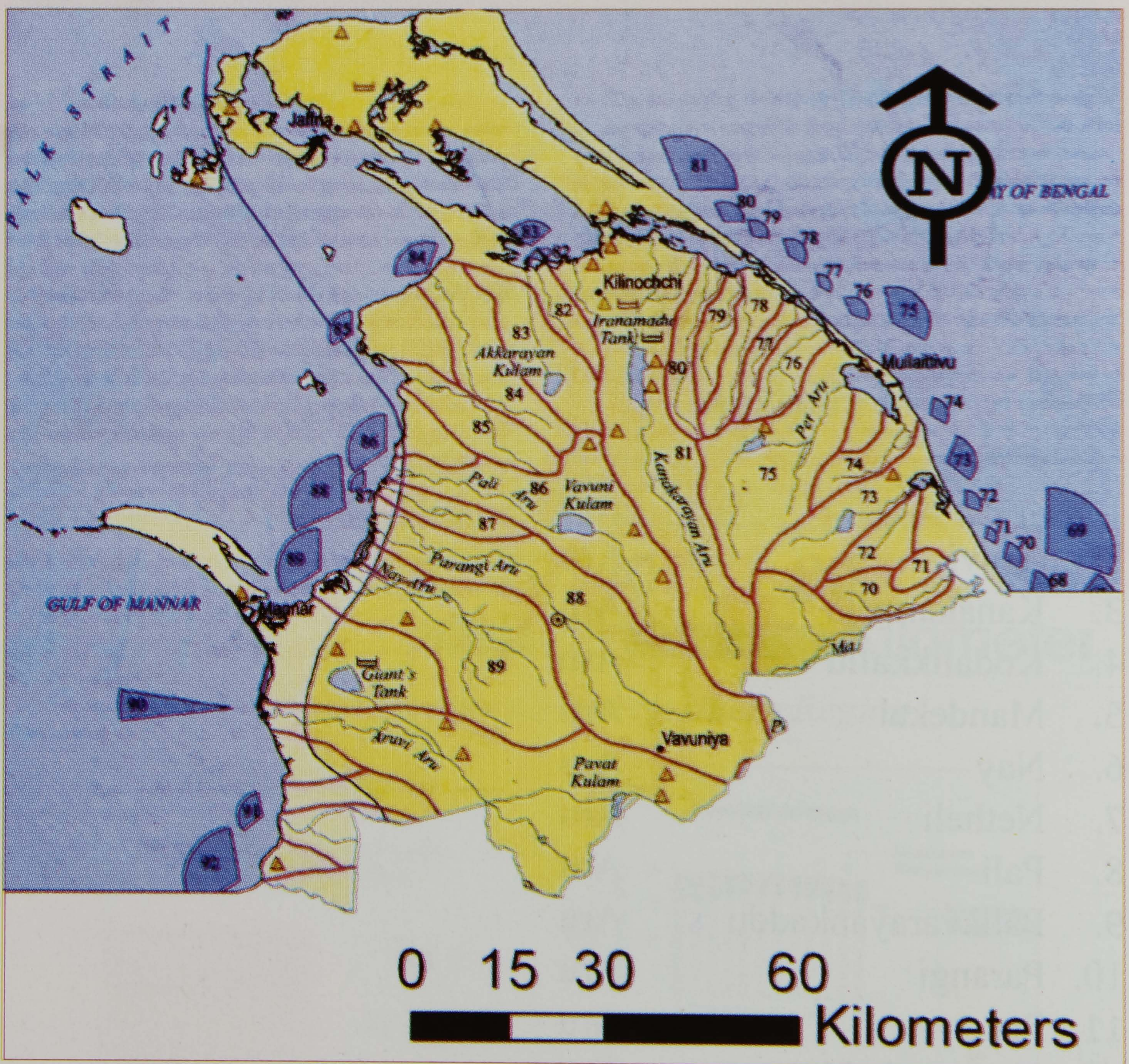


Figure:16, Major River Basins of the Northern Region.

In Sri Lanka the only source of Fresh water is rain fall. When rainfalls, a part percolates through the surface and is retained as ground water. A part flows on the surface as streams and rivers, is stored in retention reservoirs with the balance reaching the sea and a part evaporates. The Northern Province has 21 river basins, with their area ranging from 31 – 3284 Sq.kms, supplied with an annual mean of 1300 mm rainfall. This region gets seasonal rainfall from October to February. (Inter monsoon and Northeast monsoon periods)

Major River Basins and Tanks in the Northern Province

Numbers	Names of the River Basins	Area (sq.km)	No.of Tanks
71	Chavar Aru	31	24
72	Palladi Aru	62	14
73	Manal Aru	189	88
74	Kodalikallu Aru	75	59
75	Per Aru	378	156
76	Pali Aru, East	85	09
77	Marutha pillay Aru	41	08
78	Theravil Aru	91	15
79	Piramenthal Aru	83	14
80	Nethali Aru	122	22
81	Kanakarajan Aru	906	202
82	Kalwalappu Aru	57	04
83	Akkarayan Aru	194	70
84	Mandakal Aru	300	58
85	Pallavarajan Aru	161	39
86	Pali Aru,West	456	142
87	Chappi Aru	67	15
88	Parangi Aru	842	425
89	Nay Aru	561	282
90	AruviAru	3284	1726
91	Kal Aru	212	14

3.3 Ground Water of the Northern Province.

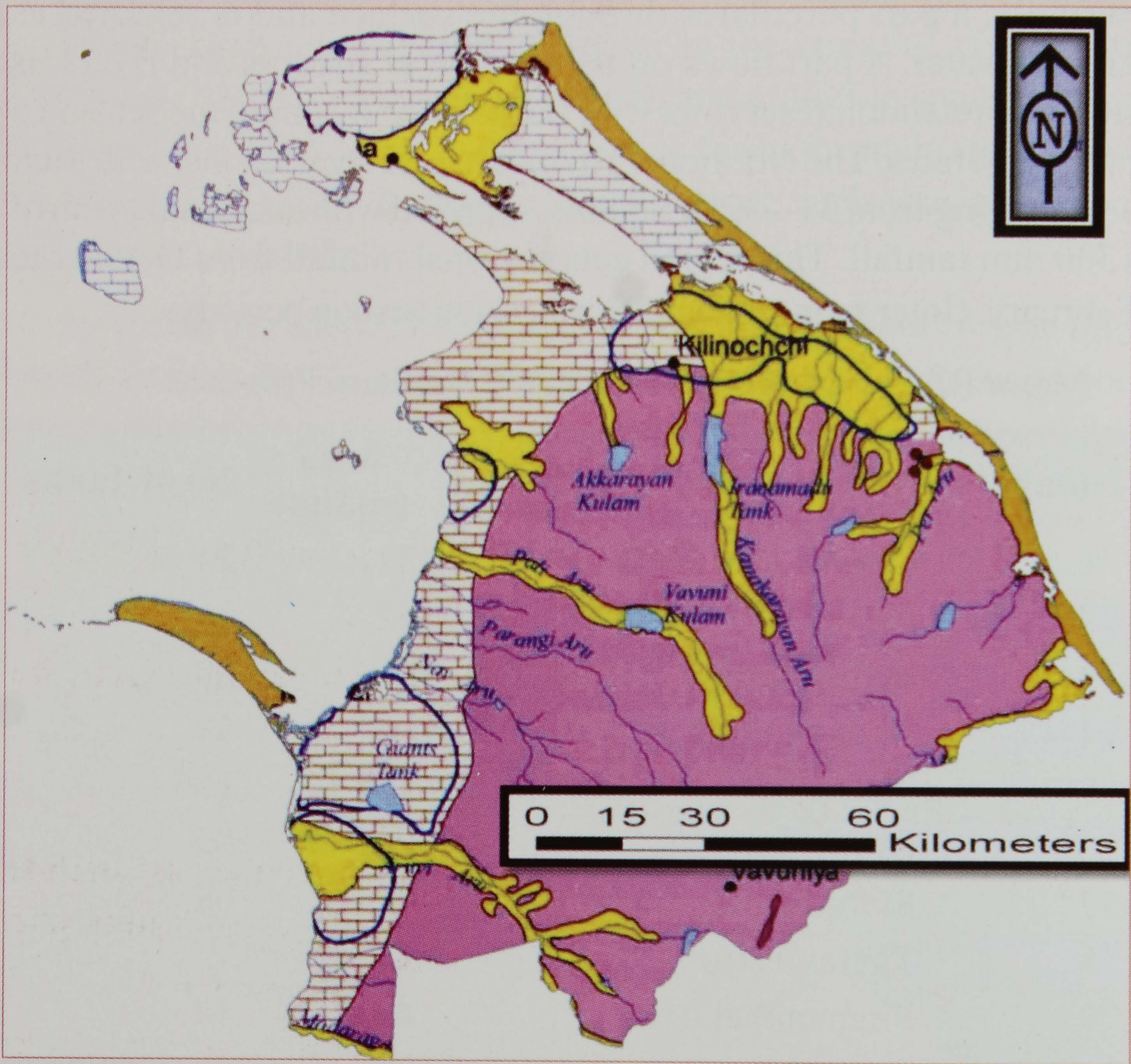
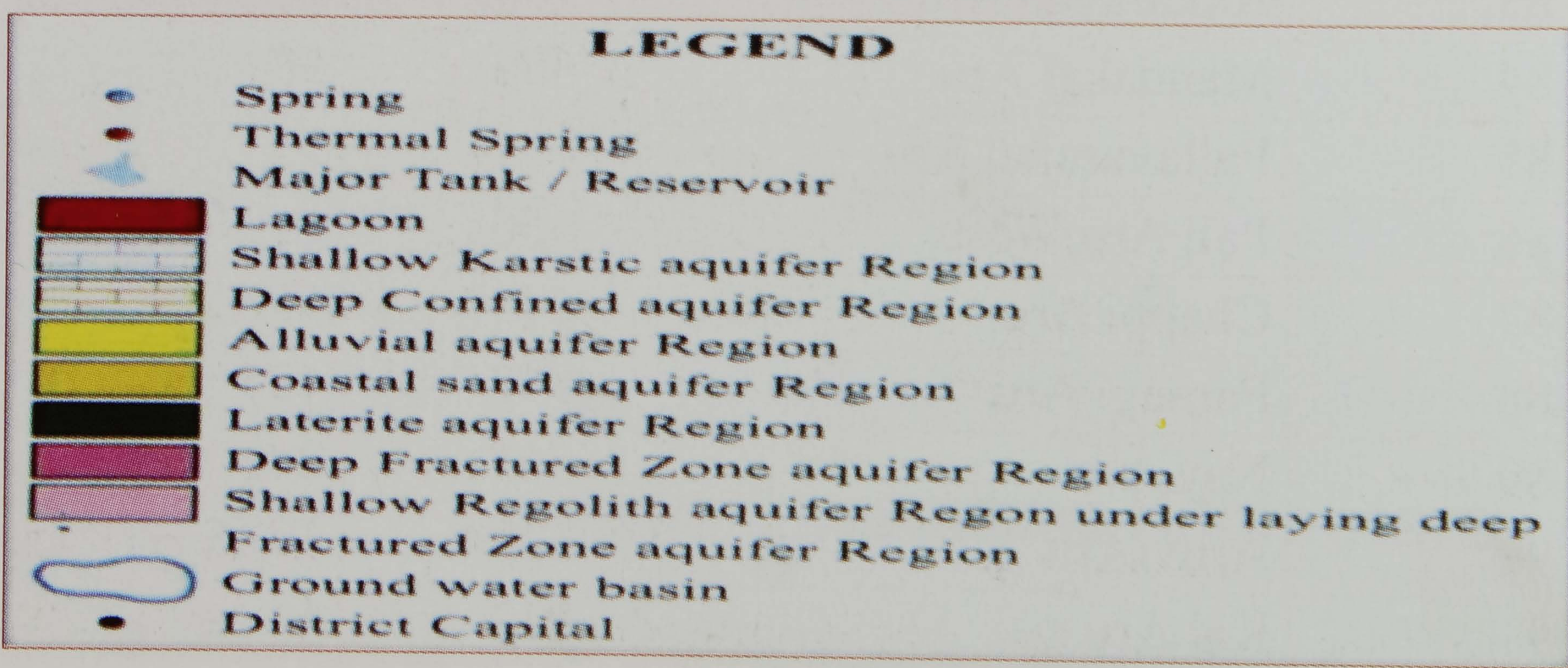


Figure:17 Ground Water of Northern Province



The water resources of any region are of two kinds, namely surface water and under ground water or ground water. Ground water in an important source of water for human consumption not only in the Northern Province of Sri Lanka but also in many other parts of Sri Lanka.

The influence of geology of an area is considered as one of the important factors for the existence of ground water. For example 50 percent or more of the rain falling on an area of loose, unconsolidated sand will percolate into the ground, where as in regions of unconsolidated crystalline rock the entire rain fall will runoff the surface,

The entire Northern Province has been broadly divided into two major geological lines such as sedimentary rock line and crystalline rock line. (fig.17)

The occurrence of ground water of these two types of rocks of the Northern Province are described as follows:

Ground water in Crystalline rocks

Nearly half of the Northern Province in underlain by crystalline rocks. This province comes under the Dry Zone with low rainfall and a long period of drought.

The un weathered crystalline rocks, by their very nature, are relatively impervious and non – porous. Water circulation does take place mainly along joints and fissures, but also along planes of foliation, schistosity and cleavage. Where joints and fissures are concentrated in zones, as in fault zones, or in particular rock types like quartzite's, then permeability is increased to important proportions. There is, therefore, no continuous body of ground water with a single water – table. The utilization of such water pockets depends on their exact location and this is often indicated by heavy fissuring and jointing. Haphazard well – sinking in areas of crystalline rocks often leads to failure.

Nature has compensated for the relatively low porosity of the crystalline rocks by the considerable depths to which these rocks have been weathered in many parts of the region. The weathered overburden on crystalline rocks generally ranges from 5 to 50feet in thickness and sometimes reaches to 100 feet below surface level, but it often occurs in patches and pockets which are separated from each other by areas where impermeable bedrock is near the surface (see fig). The decomposition products, when relatively sandy as in quartzites, gneisses, and moderately porous and permeable and are able to retain water.

The depth of the water – table ranges from 3m to 7m below the surface during the dry season (from July to September) and wells in the overburden are of two kinds. The shallow wells, generally less than 5 m deep, often dry up in the Dry Season, except when located by the sides of tanks and irrigation channels where the water level is maintained by seepage. The deep wells, generally 6m to 8m and located in the nodular ironstone layers, are perennial; these have fair yields of water in the Dry Season.

Groundwater in Sedimentary Rocks

Of the sedimentary rocks, the unconsolidated formations are more important as aquifers than the consolidated rocks and Jaffna Limestone Presents set of conditions.

Alluvium

One of the largest carriers of ground water among the sedimentary formations is alluvium, which, in the river valleys, may vary from 8m to 10m to30m in thickness and may extend laterally for several hundreds of feet on either side of the river bed.

Many of the streams and rivers of the Dry Zone have pools of water along their sandy beds and it is at these that the animals of the forest quench their thirst during the dry season of the year;

Gravel

The ferruginous gravel of the Older Quaternary formation in the north – west and the more recent gravel of other areas vary in thickness from 2m to15m , and when developed extensively, are capable of yielding large supplies of water if they are favourably situated for recharge. The gravel appears to be the principal aquifer in the area and most of the wells derive their water from it.

Sands

The unconsolidated sands of spit, bars, raised beaches, and dunes which are so common along most of the coastline are also important carriers of ground water.

The fresh water in these permeable coastal sands is generally in the form of a lens – like body resting on salty sea water, with a wide transitional zone of brackish water between the two, as at Pulmoddai. Wells situated outside the fresh – water lens, or those which penetrate the lens, will encounter the brackish -water zone and will be unsuitable for domestic consumption. The extraction of water even from wells within the fresh – water lens has to be carefully controlled, however , as excessive pumping may cause the intrusion of salt water from below into the fresh water, so contaminating it.

Miocene Limestone

Special conditions govern the occurrence of ground water in the Miocene Limestone formation which is confined to the extreme North and the North - West of the island. This Limestone is a prominent source of ground water due to its extensively cavernous(or karstic) nature and to the presence of innumerable joints, fissures, solution channels and chambers in it. Most of these openings are being constantly enlarged by solution, the slightly acid waters which circulate in them as an underground drainage system using the fissures and joints as river courses and the chambers and caverns as reservoirs of fresh water. Where the limestone lies at depth and is covered by later clay deposits, artesian conditions exist.

In the Mannar – Pooneryn area and in the Jaffna Peninsula however, the limestone beds are close to the surface (about 6m below ground level). Here, fresh – water lenses, limited in extent and recharged entirely by direct infiltration of rainfall, are scattered over the area.

In the Jaffna Peninsula itself, the level of Permanent saturation of groundwater is about 0.5m to 1m above mean sea level, and the depth of the fresh – water zone varies from a few meter to about 30m below mean sea level. Below the fresh water is a zone of brackish water which itself passes downwards into salt water. As in the coastal tracts, therefore, the fresh water in the limestone rests on a body of sea water.

3.4 Coastal Water and Oceanic Water of the Northern Province.

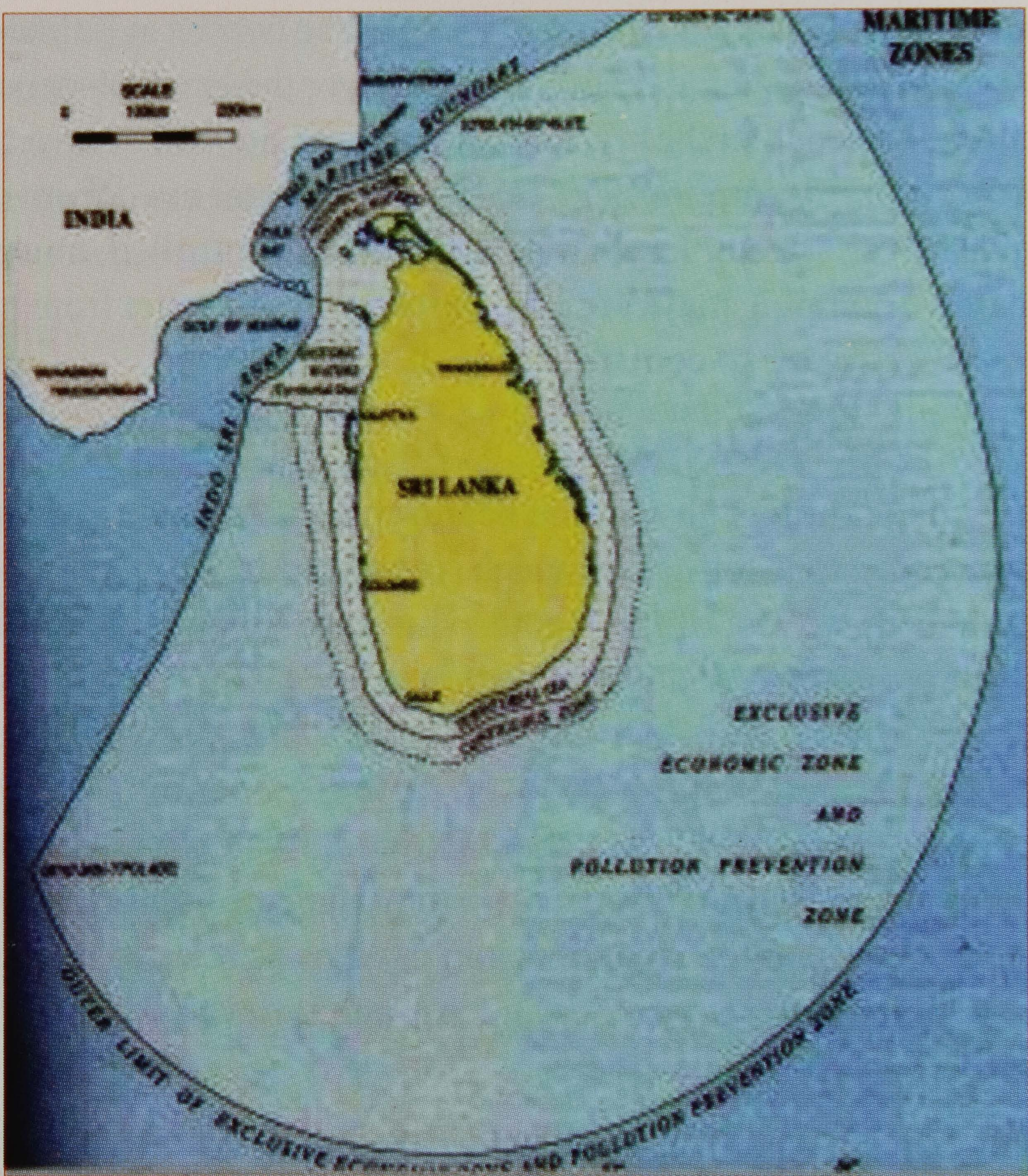


Figure: 18, Coastal Water and oceanic water of the Northern Region.

The continental shelf of Sri Lanka is narrow compared to the world average of 74 km .It is about 45km in the northern coast, and then widens north and merges with that of India. In the west coast it is about 30km and gradually narrows on the Southwest and south coast. Its width is about 08km on the southeast and coast up to Trincomalee from here onwards it widens reaching about 45km on the northeast coast and then merges with that of India.

The northern peninsula and southern tip as India are separated by the Palk Bay, its mean depth being about 60m. The mean width of the coastal waters is about 25km and the length of coastline is 1770km. The area of the continental shelf is about 44,250 sq km.

The entire body of water beyond the coastal water is considered as oceanic water by definition. Since 1979, with the unilateral declaration of 200 nautical mile (370.4km), Exclusive Economic Zone later accepted by the law of the sea convention, Sri Lanka has the exclusive rights of a further 437,000 square kilometers of sea.

It is noted that the Northern Province has been surrounded in all the directions by coastal and oceanic waters and other water bodies very important to the Northern Province for fishing activities.

4.0 Soil Types of the Northern Province.

The land of the region is relatively flat and of low elevation towards the coast. Eight major soilgroups have been identified in the region.

01. Reddish Brown Earths (RBE)

These are the prominent soils in the Dry zone. They occupy the crest, the upper slope, and the mid slope. The characteristic feature of RBE is their reddish brown color. Generally there is a layer of gravel, which is a mixture of quartz, ironstone, iron-manganese nodules, and feldspar. The texture may vary from sandy loam to sandy clay. Sometimes they may have a compact layer of gravelly soil. The RBEs are suitable for a range of crops both annual and perennial. They are best used for rain- fed agriculture or for farming with highly controlled irrigation.

Low HumicCley soils (LHS)

A high proportion of the lowlands in the dry, wet and intermediate zones is occupied by LHGs. These soils are poorly drained. Long periods of wetness have caused the iron and manganese in the soil to remain in a reduced state, giving LHGs their characteristic dark gray and grayish brown colors. Generally, the top soil is sandy loam to sandy clay loam, while the sub soil is sandy clay loam or sandy clay. Calcium carbonate concretions may occur at some depth. The soils are most suitable for intensive wetland paddy cultivation.

02. **Red – Yellow Latosols(RYL)**

The RYLs occupy a belt of land in the northwestern, northern and northeastern coastal regions. Red latosols and yellow latosols occupy higher and lower positions of the landscape respectively. In the Jaffna region, (RYL) has developed from limestone. The colors of red latosols are dark reddish brown to dark red, while the yellow latosols are yellow wish brown to yellowish red. The textures are mostly sandy loam. The RYLs are very deep soils, and their profile is uniform. They are easily workable and can support a wide variety of annual and perennial crops with controlled irrigation.

03. **Solodized Solonetz(SS)**

Characterized by the presence of sodium salts in the profile, the SS are found in the dry zone extending from west, through north to south. The SS can be suitable for wetland paddy depending on the sodium level, provided that an adequate amount of water is available for keeping salt levels low.

04. **Grumusols**

Found in small areas mainly in the north, and in very small extents in the southern dry zone, these soils are clayee. They are developed from recent or semi- recent ponded alluvial clays. These soils do not support economically significant crops.

05. **Alluvial Soils**

These are the soils that have developed on flood plains, stream and river – banks and associated valleys. They are found in wet, dry and intermediate zones. They are potentially very productive soils that can support a wide range of crops.

06. Regosols

These are soils developed on transported sandy material. They exist along the coastal regions, in wide bands in some areas. They have developed in both dry and wet zones. Some landscapes or which they occur are raised beaches, beach plains and dune sands. The color is yellow to brown; the texture is fine to moderately coarse sand. The top soil may have some organic matter. Having some weather able minerals, the regosols support a variety of deep – rooted tree crops, including coconut in the wet zone and cashew in the dry zone.

07. Soils on recent marine calcareous sediments

Composition of unit.

Great soil groups -	soils on recent Marine calcareous Sediments (90- 100 percent)
Inclusions -	solodizedsolonetz, solon chaks, regosols (0-10 percent)

Nature of the great soil groups and their distribution in the landscape - these comprise a wide variety of brownish, yellowish, whitish, grayish or blackish soils with or without mottling and gleying and ranging from coral gravel to mud's and clays in texture. They are a complex of sediments recently emerged from the sea(coral, rubber, sands, lagoon, mud sect.) And are consequently confined to coastal areas of the north.

Present land use – bare land.

08. Calcic Red- Yellow Latosols

Composition of unit. - Great soil groups – calcic red yellow latosols (90- 100 percent)

Inclusions - rock exposures, litho sols (0- 10 percent)

Nature of the grate soil groups and their distribution in the landscape – the reddish soils

Figure: 19 Soil distribution of the Northern Province

01	Reddish Brown Earths (RBE) and Low HumicGley soils
10	Red – Yellow Latosols(RYL)
11	Calcic Red- Yellow Latosols
12	Solodized Solonetz(SS)
13	Grumusols
15	Soils on recent marine calcareous sediments
16	Alluvial Soils
17	Regosols

Of variable depth, overlaying limestone. They are found in all but, the lowest depression areas. The calcic yellow latosols, which are imperfectly to poorly drained, fine textured yellowish soils occur on the slope bottoms and depression areas of this unit.

Present land use - intensive cultivation of chillies, onions, tobacco, and vegetables under lift irrigation.Small scale Palmyra and mango plantation.Urban development limestone quarrying. (fig.19)

5.0 Natural Vegetation of the Northern Province.

5.1. Forest Vegetation.

The forest resources in the Northern Province are ecologically remarkable and environmentally indispensable. Compared to other provinces there are quite a large extent of forests in Northern Province . The forest cover assessment of 1999 revealed that there are 44% dense forests in this province. This includes dry monsoon forests, reverie forests, mangroves and forest plantations. The extent of each forest type is given in the Table 4.1.

The extent of different vegetation cover in the Northern Province

District	Dry Monsoon	Riverine	Mangrove	Sparse	Total forest		Sparse dense	
					Ha	%	Ha	%
Jaffna	794	-	243	318	1037	1	318	0.3
Kilinochchi	32149	-	424	5026	32573	25.5	5026	3.9
Mannar	104888	568	1486	16797	106942	53.6	16797	8.4
Mulattivu	148746	-	405	20153	149151	57	20153	7.7
Vavunia	101482	-	-	15569	101481	51.6	11569	59.6
Total	677379	568	2557	57863	391184	44.5	57863	6.5

- Dry Monsoon Forest

The Dry Zone low land forests are assemblages of both ever green and deciduous species. They rarely exceed 30 m in height and are characterized by discontinuous tree canopies. Rosayro (1950), recognized two major types of communities:

Manilkara – Hemicyclia – Chloroxylon community
Alseodaphne – Berrya - Diospyros community

These communities consist of several species of dominant, co dominant, under story and ground layer. They grow up to 3m height

Dry Monsoon forest at Mullativu District

Riverine/flood pain forest at Oddisudan and characterized by discontinuous tree canopies. And predominantly occur in lowlands below 400 m altitude in the northern, the eastern and the north – central provinces of the island. This forest community is commonly found in Vavunia, Killinochchi and Mulativu districts.

The species variation in the dry zone, mostly depends on soil type, water availability and soil depth. For an example *Chloroxylonswieteniagrows* better on sandy soils while *Manilkarahex and re*appears to prefer clay soils. The understory vegetation includes such medium sized trees as *Diospyrosquaesita, Phyllanthusemblica, Feronialimonia*and shrubs such as *Croton laticifolia*, *Lantana camera* and *Eupatorium odoratum*. On river basins and similar moist habitats in some districts are climax communities predominated by *Alseodaphnesemecarpifolia, Berryacordifolia* and *Diospy rose begum.* These tree species rarely grow beyond 25m in height and are the most valuable indigenous timber trees in Sri Lanka.

- Arid Zone Forests

In early times workers described these forest ecosystems as thorn and scrublands. But presently it is mostly referred to as arid zone forests. These forests are characterized by three layers but the canopy layer will not exceed over 10 m. The prominent species found in arid zone forests are *Manilkarahexandra, Randiadumetorum, Dichrostachyscinerea, Salvadorapersica, Feronialimonia* and *Azadirachtaindica*. These taller trees are mostly scattered or very rarely seen in some areas. The understory is commonly comprised of few species namely *Euphorbia antiquorum, E.tirucalli, Zizyphusrugosa* and *Carissa spinarum.* The ground vegetation is characterized by typical arid zone plants having xerophytic modifications. The most prominent species found in this layer are *Aloe barbadensis*, *Asparagus racehorses* and *Cissusqu and rangularis.* Destruction of these Arid Zone forests for various socioeconomic ventures has hap hazarded the remaining patches as they have lost their typical phytosociology and physiognomy through dieback caused by reduction of rainfall due to climate change or other reasons.

- Dry Reverie Forests

They are found along the river valleys and flood plains. The type of vegetation found there is similar to Dry Monsoon forests. Most abundantly found tree species are Kumbuk (*Terminaliaarjuna,* Mee *(Madhucalongifolia)* Tel Kaduru *(Sepium insigne),* Kolon *(Adina cordifolia.) and*Kahata *(Gareyaarborea) etc.* This forest category is very limited in the Northern Province due to the limitation of rivers and streams.

- Mangrove Association

The mangroves are entirely tropical and subtropical and confined to a belt of the coast lying between the high and low tides. Their ecology is governed and characterized primarily by the salinity and height of the tidal water levels and subsidiary by the climatic and edaphic conditions. In Sri Lanka, mangroves occur in river estuaries, shallow lagoons, shores of deeper lagoons and silted bays along the coast. Some the well developed

Mangroves could be seen in the North Western Coast, mainly in Kalliadi, Illupaikadawei, and Mundampiddi and the North Eastern coast of Sri Lanka. In all other areas in the Northern Province mangroves are heavily disturbed by human activities and found in scattered nature. In some areas in the peninsula the mangrove species ie; *Avicennia marina* occur as a single species and stands covering a large extent of land, which are periodically inundated by lagoon water (Palakudah area). Following species are found in these associations.

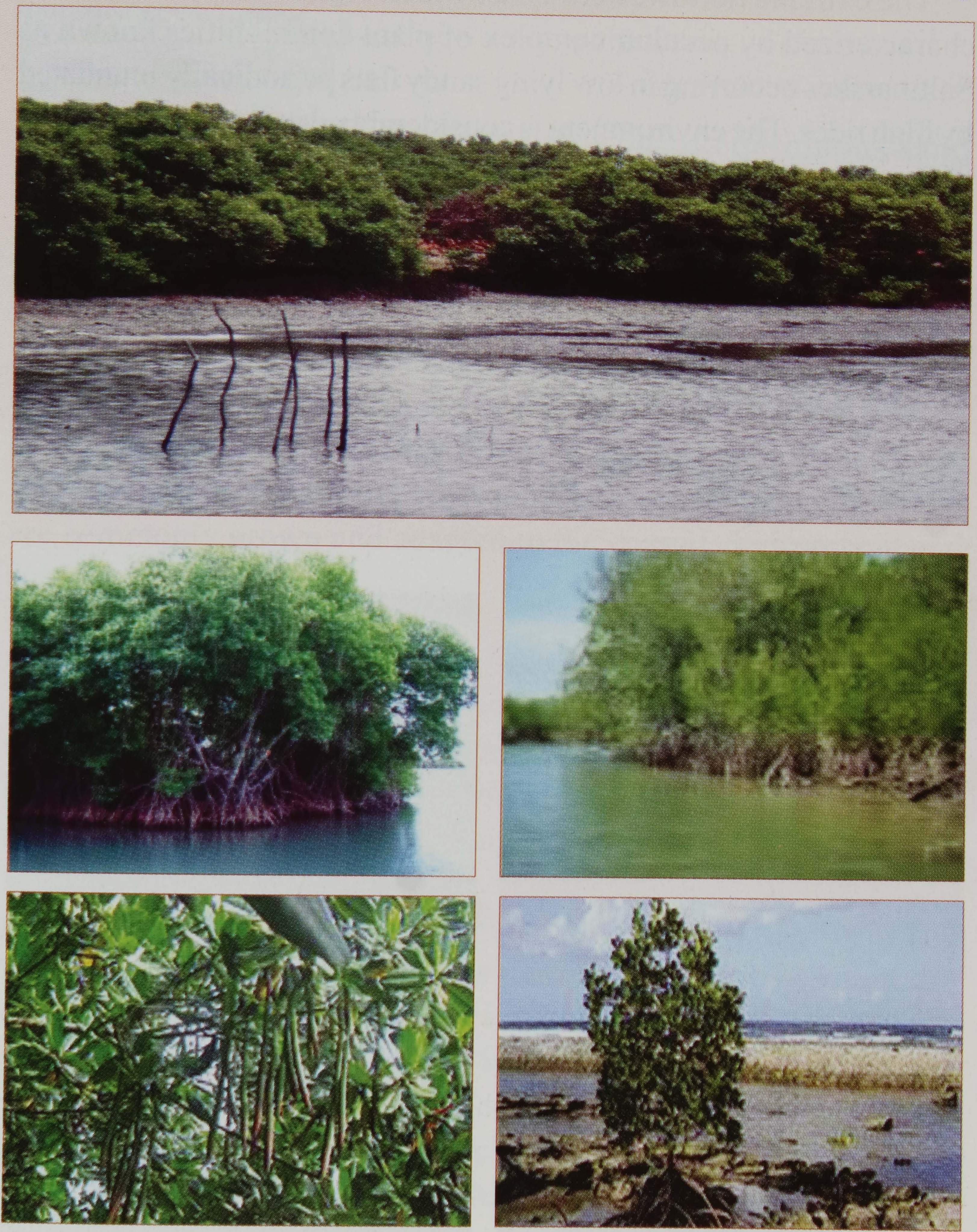
- *Rhizophoramucronata (Mahakadol)*
- *Bruguieriacylindrica*
- *Sonneratia alba*
- *Aegecerascorniculatum*
- *Ceriopstagal*
- *Avicennia marina*
- *Excoecariaagallocha*

5.2 Coastal Vegetation.

Other than forest resources the Northern Province harbors many other ecosystems. Their characteristics are briefly described below. In addition to mangroves and coastal belt the Northern Province shelters a mosaic of plant communities deferring loristically, phytosociologically and physiognomically and ecologically and playing invaluable protection role and management function. The common species found along the coast in the Northern peninsula are;

- Vetakeiya - *Pandanusodoratissmus*
- Takkada - *Scaevolasericea*
- Bintamburu - *Ipomoea ripens*

The zone that lies beyond the area that is subjected to the direct impact of waves and tides is stabilized by a carpet of densely growing



Mangroves at Alampil – Chemmalai area

creepers which help to consolidate surface soils by minimizing sea erosion and wind erosion. This carpet vegetation is mostly enriched by Ipomoea spp.

- Salt Marshes

The extreme northwestern coast which regarded as Arid Zone is characterized by peculiar complex of plant communities known as Saltmarshes occurring in low lying sandy flats periodically inundated by high tides. The environment is considerably dry receiving less than 950 mm rainfall annually with prolonged drought period during April – September. The dry atmosphere is further aggravated by dry winds and high temperature, high evaporation and very low humidity. The excessive evaporation intensifies salinity and crystallizing of salt freely on lagoons and shores. Generally salt marsh communities constitute following vegetation categories;

- Suaeda communities
- Arthrocnemum consociation




- Saltmarsh pastures
- Depressions
- Thorn scrubs

Of these thorn scrubs are the typical climax communities of the dry zone, and they may therefore be regarded as ultimate stage of salt marsh succession.

- Sand dunes

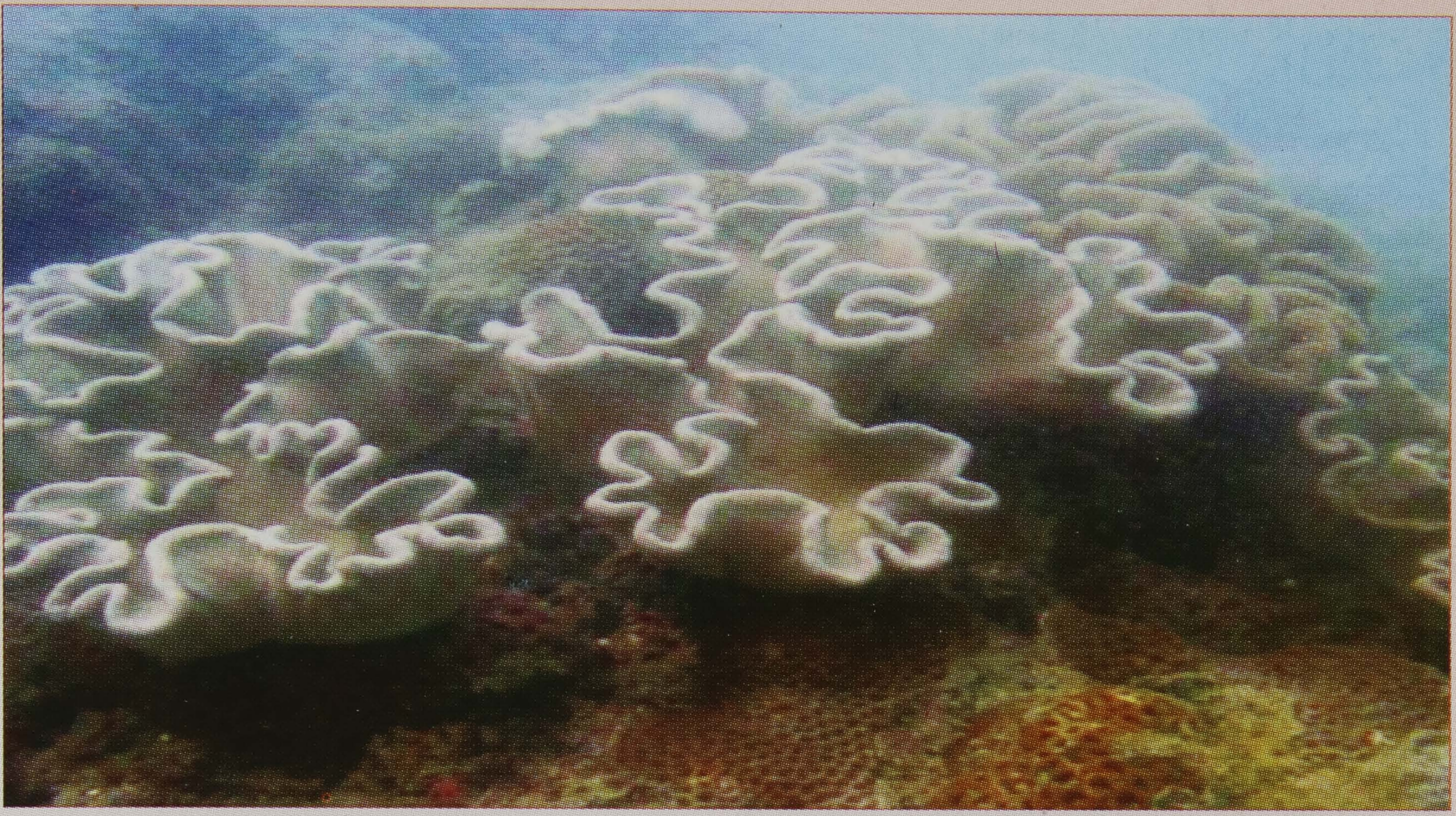
Sand dunes are developed as a result of continuous sand accumulation around certain creepers, shrubs and trees growing as clump on the coast. They are edaphically, topographically and floristically highly specific. Sand dunes are widely spread along the North Eastern and the North western coast. Very little has been studied on ecology of sand dunes. Sri Lankan sand dunes generally originate as a result of accretion of wind borne sand around clumps of vegetation that occur in the coastal belt. Hydrophilic maritime, Ipomoea pes_caprae and trees of Acasiaeburnea and Syzygiumcumini are commonly grown and adapted to the coastal environment and support this process.

- Sea grasses

Sea grass habitats are considered to be among the most productive submerged systems. This productivity supports through dependent species of epiphytes fauna, large number of fish area important in lagoon and coastal fisheries. Through their high productivity, sea grasses buildup large carbon reserves which are utilized in the tropics by herbivores such as turtles, birds and marine mammals. Many species of prawns and fish use the sea grass meadows as nurseries and even as adults are dependent on sea grasses for food via the epiphytic community. Hence sea grass ecosystems are very high in diversity and lager in number of individuals within the community, compared to the eco systems where sea grasses are not present in patches as in Vankalai in the Mannar coast Halophilaovalis and Halodulepinifolia are the major seagrasses found in lagoons such as Nayaru and Chalai lagoons.

Sand Dunes at Vadamaradchi area

Soft corals at Kankesanthurai



Plectorhinchuss chotaf at Punkuduthivu

- Seaweeds

Seaweeds were associated with Enhaulus beds in the Mannar coast. Mostly Gracilaria is found associated with sea grasses. Brown algae Sargassumspp, Turbinaria dominate all over the Northern Coast.

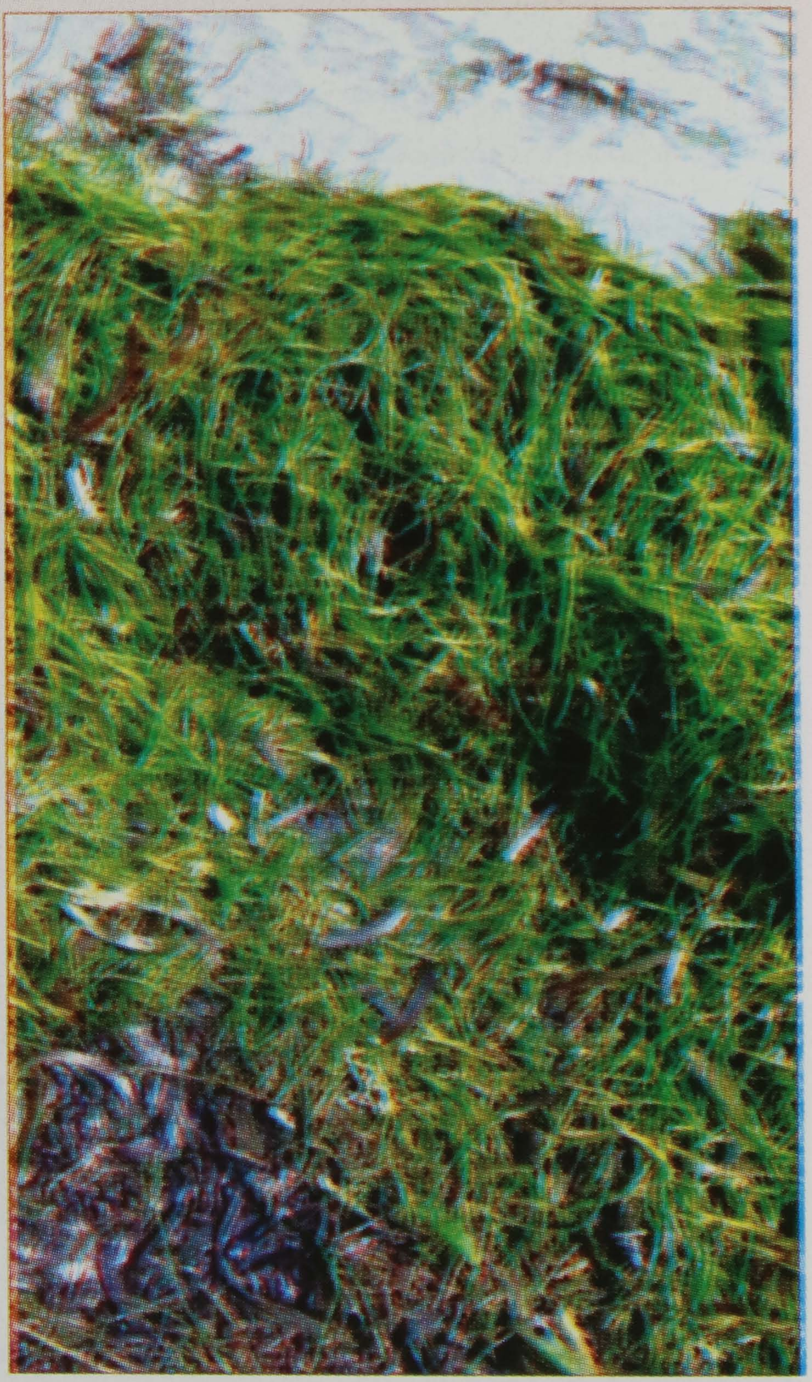
Seaweed species found in Kiracnchi bay of Nachchkuda

5.3 Palmyra Forest.

The entire northern landscape is dotted with Palms which have a wide variety of uses in daily life – as edible fruit, fibre and fodder from leaves, termite-proof wood for construction, and above all a nourishing drink. Per capita income from the Palmyra palm is anywhere up to LKR 3500.

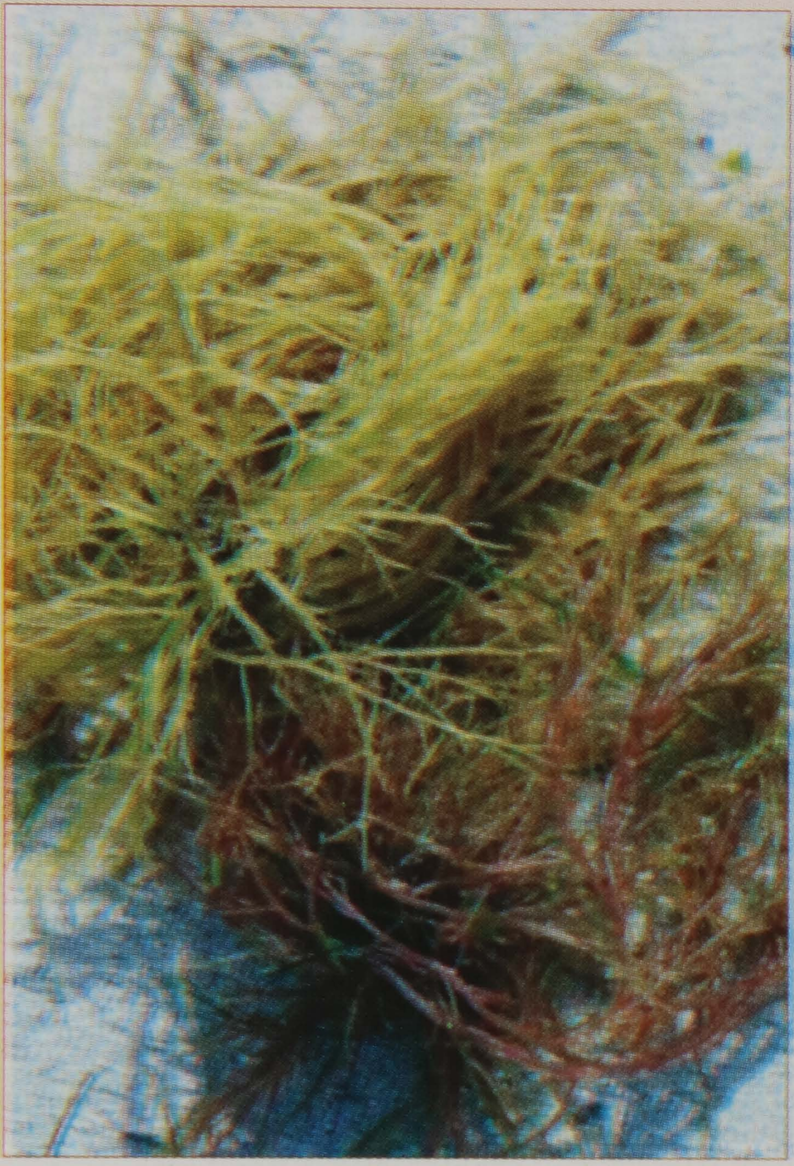
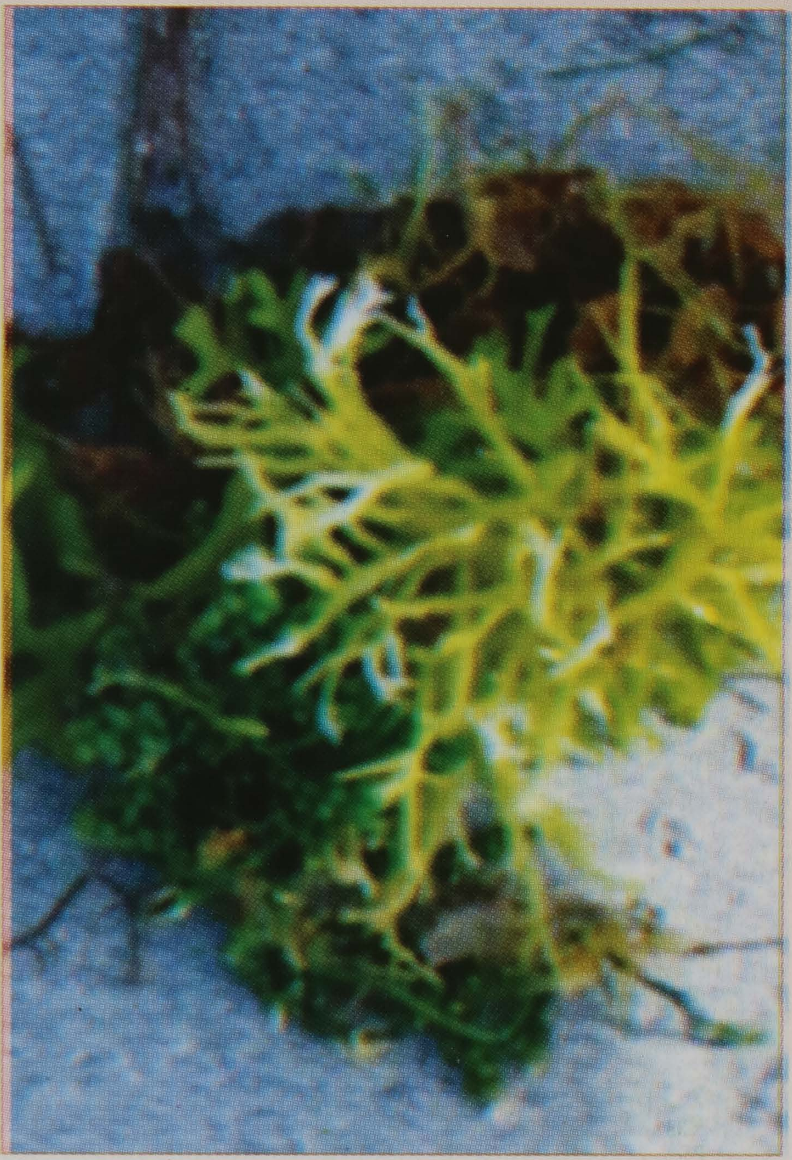
Jaffna, Kilinochchi, Mullaitivu, Mannar, Vavuniya, Trincomalee, Batticaloa, Amparai, Puttalam and Hambantota from the Palmyra belt.

Dense sea grasses



Dense sea grasses

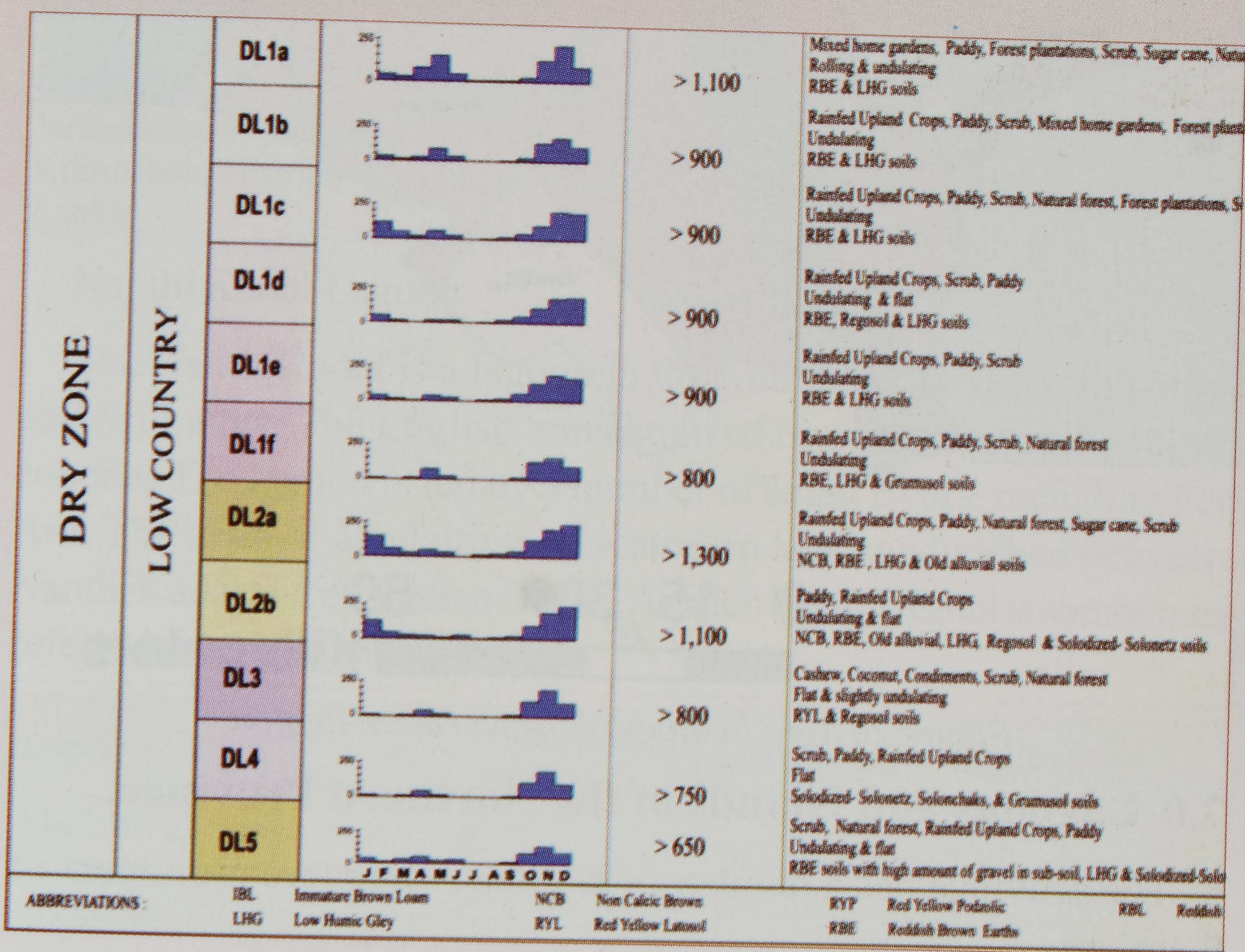
It is learnt that presently there about 2.5 million palms left in the Jaffna district, 2 million in Kilinochchi - Mullaitivu, and another 2 million in Mannar. Around 2.5 million are found in the Trincomalee, Puttalam and Hambantota districts.

6.0 Agro Ecology.

An agro – ecological region represents a particular combination of the natural characteristics of climate, soil and relief. When an agro climatic map of an area where the integrated effects of climate are uniform for crop production is superimposed on its soil and terrain, the resulting map demarcates an agro – ecological region. Thus, each agro – ecological region represents somewhat uniform conditions of agro climate, soil, and terrain, which would best support a particular farming system where a certain range of crops and farming practices find optimal expression.

The region falls under low country dry - zone with 04 agro – ecological sub divisional zones as DL1, DL2, DL3 and DL4 are indicated in the map. (Fig.20)



The table shows the sequential histograms of a model 75% expectancy value of monthly rainfall for each of the agro – ecological sub – regions, along with a modal 75% expectancy value of annual rainfall, major land – usage(s), terrain and predominant grate soils group. Both modal monthly and annual expectancy values at a 75% probability level have been calculated from the historical rainfall data of 646 rain – gauge stations scattered throughout the island.

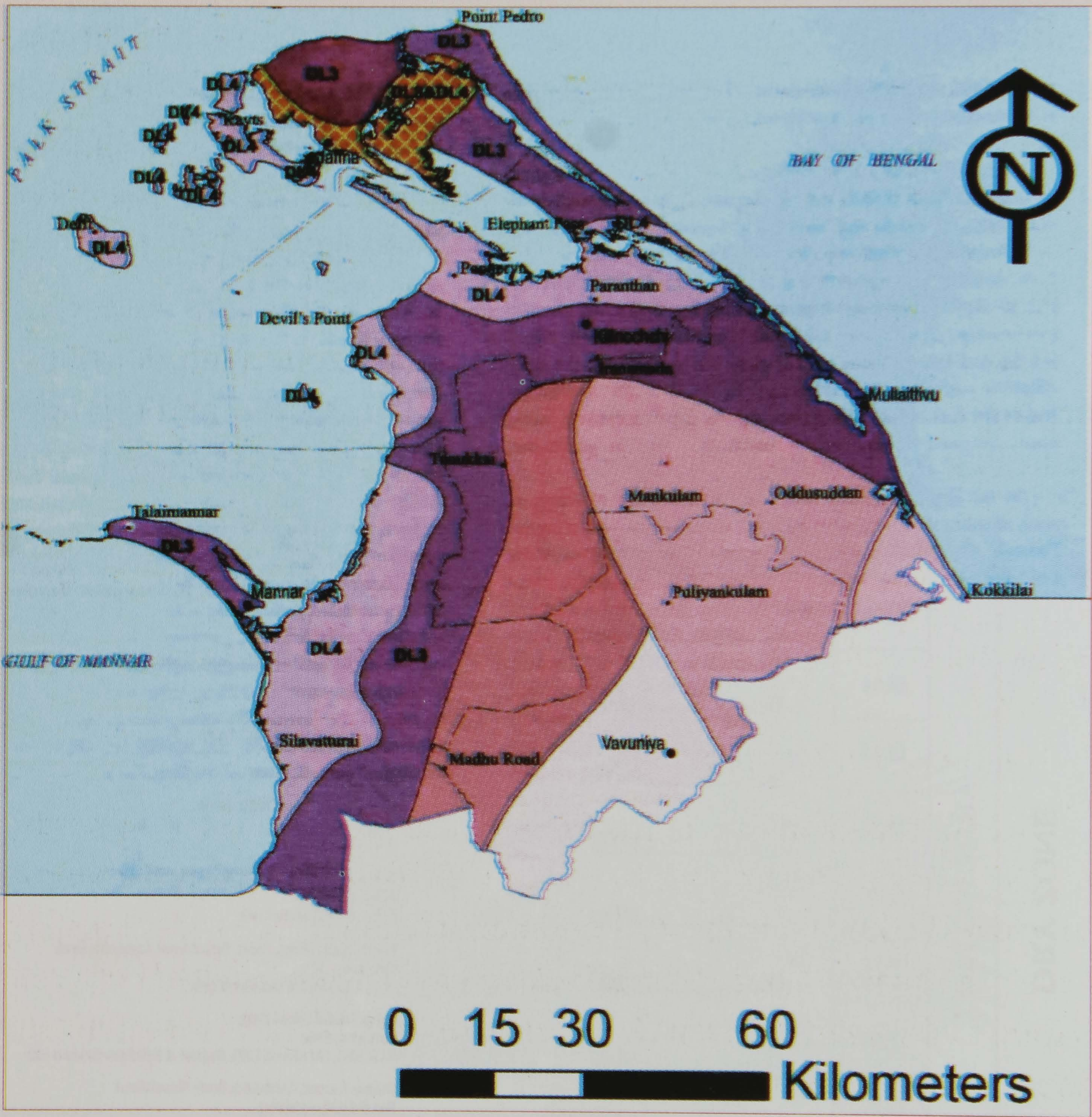


Figure.20 Agro Ecology of the Northern Region

7.0 Lagoons and Islands of the Northern Province.

The province has a number of lagoons. The more prominent of them are

1. Jaffna Lagoon
2. Nanthi Lagoon
3. Chundikkulam Lagoon

4. Vadamarachchi Lagoon
5. Uppu Aru Lagoon
6. Kokkilai Lagoon
7. Nai Aru Lagoon
8. Chalai Lagoon

Jaffna lagoon

The Jaffna lagoon is a large lagoon off the Jaffna District and the Kilinochchi District, in northern Sri Lanka. The lagoon is surrounded by the densely populated Jaffna peninsula containing palmyra palms, coconut plantations, and rice paddies. There are numerous fishingvillages and some salt pans. The lagoon has extensive mudflats, sea grass beds and some mangroves. The lagoon attracts a wide variety of water birds including American Flamingoes, ducks, gulls, terns and other shorebirds.

Location	Primary outflows	Surface area	Surface elevation
JaffnaDistrict, Sri Lanka Kilinochchi District, Sri Lanka	Indian Ocean	400 square kilometers (150 sq mi)	Sea level

Nanthi Kadal Lagoon

The NanthiKadal is a lagoon in the Mullaitivu District, in north-east Sri Lanka. The English translation of Nanthi Kadal is the sea of conches The lagoon is fed by a number of small rivers, including Per Aru. The town of Mullaitivu is located on land sandwiched between Nanthi Kadal and the Indian Ocean. As such Nanthi Kadal is sometimes referred to as Mullaitivu lagoon.

Location	Primary inflows	Primary outflows	Max. length	Max. width
Mullaitivu District, Sri Lanka	Indian Ocean	Indian Ocean	14 kilometers (8.7 mi)	5 kilometers (3.1 mi)

Chundikkulam Lagoon

The Chundikkulam Lagoon is a lagoon in the Jaffna District and the Kilinochchi District, north-east Sri Lanka. The town of Chundikkulam is located on a narrow piece of land between the lagoon and the Indian Ocean. The lagoon is sometimes referred to as Elephant Pass Lagoon. The lagoon is fed by a number of small rivers from the south, including Kanakarayan Aru, Netheli Aru and Theravil Aru. It used to be linked to the Jaffna Lagoon but since the construction of the causeway at Elephant Pass the lagoon has in effect been a lake. The lagoon's water is brackish. The lagoon is surrounded by palmyra palm plantations and scrubland. The land is used for prawn fishing and some salt production. The lagoon has small areas of mangrove swamp and sea grass beds. The lagoon attracts a wide variety of water birds including storks, ibis, ducks, coot, gullsand tern. Most of the lagoon was designated a bird sanctuary in 1938.

Location	Surface area	Surface elevation
Jaffna District, Sri Lanka Kilinochchi District, Sri Lanka	135 square kilometers (52 sq mi)	Sea level

Vadamarachchi lagoon

The Vadamarachchi lagoon is a lagoon in the Jaffna District, in northern Sri Lanka. The lagoon is sometimes referred to as the Thondamannar lagoon. The lagoon separates the Vadamarachchi region from the Valikamam and Thenmarachchi regions. The lagoon is connected to the Indian Ocean by a narrow channel to the north, near the town of Thondamannar. The lagoon's water is brackish to saline. There is a sluice gate at Thondamannar to prevent sea water entering the lagoon. The lagoon is surrounded by a densely populated region containing Palmyra palms, Coconut palms, Grassland, Rice paddies, arid scrubland and open forest. The lagoon has extensive mudflats, sea grass beds and mangrove swamps, particularly Avicennia. The lagoon attracts a wide variety of water birds includingAmerican Flamingoes, Ducks, Gulls, Terns and other shorebirds.

Location	Primary outflows	Surface area	Max. depth	Surface elevation
Jaffna District,	Indian Ocean	77.87 square kilometers (30.07 sq mi)	2 meters (6.6 ft)	Sea level

Uppu Aru lagoon

The Uppu Aru lagoon is a lagoon in the Jaffna District, in northern Sri Lanka. The lagoon separates the Valikamam region from the Thenmarachchi region. The lagoon is linked to the Jaffna Lagoon by a short channel to the south. The lagoon's water is brackish. The lagoon is surrounded by a densely populated region containing Palmyra palms, Coconut plantations, grassland, rice paddies and extensive vegetable gardens. The lagoon has extensive mudflats and salt marshes. It is surrounded by mangroves, particularly Avicennia. The lagoon attracts a wide variety of birds including American Flamingoes, ducks, garganey, black-tailed godwit and other shorebirds.

Location	Primary outflows	Surface area	Max. depth	Surface elevation
Jaffna District	Jaffna Lagoon	30 square kilometers (12 sq mi)	3 meters (9.8 ft)	Sea level

The Kokkilai lagoon

Kokkilai lagoon is an estuarine lagoon in The Mullaitivu District and the Trincomalee District, in north-east Sri Lanka. The town of Kokkilai is located on a sand bar between the lagoon and the Indian Ocean. The lagoon is fed by a number of small rivers, including Churiyan Aru. It is linked to the sea by a narrow channel that is very often blocked by the sand bar. The lagoon's water is brackish. The lagoon is surrounded by a densely populated region containing cultivated land, scrubland and open forest. The land is used for prawn fishing, paddy cultivation and some shifting cultivation. The lagoon has extensive sea grass beds and small areas of mangrove swamp and mudflats. The shallow waters of the lagoon attracts a wide variety of water birds including pelican, cormorant, herons, egrets, wild duck, stork, waders and pink flamingoes. The lagoon was designated a wildlife sanctuary in 1951.

Location	Primary inflows	Primary outflows	Surface area	Max. depth	Surface elevation
Mullaitivu District, Trincomalee District	Churiyan Aru	Indian Ocean	29.95 square kilometers (11.56 sq mi)	4 meters (13 ft)	Sea level

Nai Aru Lagoon

The Nai Aru Lagoon is an estuarine lagoon in the Mullaitivu District, in north-east Sri Lanka. The lagoon is fed by a number of small rivers, including Nay Aru (Mullaitivu). It is linked to the sea by a narrow channel to the south that is very often blocked by sand. The lagoon's water is brackish. The lagoon is surrounded by dense forest, scrubland, rice paddies and coconut palm. The land is used for prawn fishing and paddy cultivation. The lagoon has extensive sea grass beds and mangrove swamps. The lagoon attracts a wide variety of water birds including ducks, gulls, terns and other shorebirds.

Location	Primary outflows	Surface area	Max. depth	Surface elevation
Mullaitivu District	Indian Ocean	17.6 square kilometers (6.8 sq mi)	4 meters (13 ft)	Sea level

Chalai Lagoon

The Chalai Lagoon is a lagoon in the Mullaitivu District, in north-east Sri Lanka. The town of Chalai is located on a sand bar between the lagoon and the Indian Ocean. The lagoon is fed by a number of small rivers. It is linked to the sea by a narrow channel near Chalai. The lagoon's water is brackish. The lagoon is surrounded by dense forest, scrubland and some rice paddies. The land is used for fishing and salt production. The lagoon has extensive sea grass beds and mangrove swamps. The lagoon attracts a wide variety of water birds including ducks, gulls, terns and other shorebirds.

Location	Primary outflows	Surface area	Surface elevation
Mullaitivu District	Indian Ocean	14.6 square kilometers (5.6 sq mi)	Sea level

Most of the islands around Sri Lanka are to be found to the west of the Northern Province. The large islands are:

1. Neduntivu (Delft),
2. Velanaitivu (Kayts),
3. Karaitivu,
4. Pungudutivu
5. Mandativu
6. Nainativu

Neduntheevu

Neduntheevu or Neduntivu (also known by its Dutch name Delft) is an island in the Palk Strait, in northern Sri Lanka. This island is named as Delft in the Admiralty Chart unlike the other islands in the area which are named with their Tamil names. The island's area is 50 sq km and it is roughly oval-shaped. Its length is 8 km and its maximum width about 6 km.

Neduntivu is a flat island surrounded by shallow waters and beaches of coral chunks and sand. There are feral ponies on the island that were abandoned after the Dutch period , which is home to a small population of Tamil people, mostly living in quiet compounds close to the northern coast.

The vegetation is of a semi-arid tropical type, with Palmyra palms, dry shrubs and grasses that grow on the pale Grey porous coralline soil. Papayas and bananas grow close to the local people's homes. In the western coast of the island there are remains of a 1000 year old ancient temple built by the Chola Dynasty. The water is slightly brackish. It is taken from shallow wells using buckets made from Palmyra palm leaves.

The ruins of a Dutch colonial fort can also be seen Delft. A naval battle was fought off the coast of the island in 2008 during the Sri-Lankan Civil War.

The island was named after the Dutch city of Delft by Rijckloff van Goens. He named the eight most important islands after Dutch cities, but the seven others are now named with domestic names.

Kayts

Kayts, is one of the important villages in Velanai Island which is a small island off the coast of the Jaffna Peninsula in the North of Sri Lanka. There are number of other villages within the Velanai Island such as Allaipiddy, Mankumpan, Velanai, Saravanai, Puliyankoodal, Suruvil, Naranthanai and Karampan. The majority of the people are Hindus along with a minority of Muslims and Christians. There are a number of Hindu Temples along with a Church and a Mosque. The island is also served by a dozen schools. Since 1983 Kayts Island has also been the scene of violence as part of the Sri Lankan civil war including the Allaipiddy massacre

Karaitivu

Karaitivu or Kaaraitheevu , is an island linked to the Jaffna Peninsula, in Sri Lanka by a Causeway. Karainagar is the biggest town on this island.

Pungudutivu

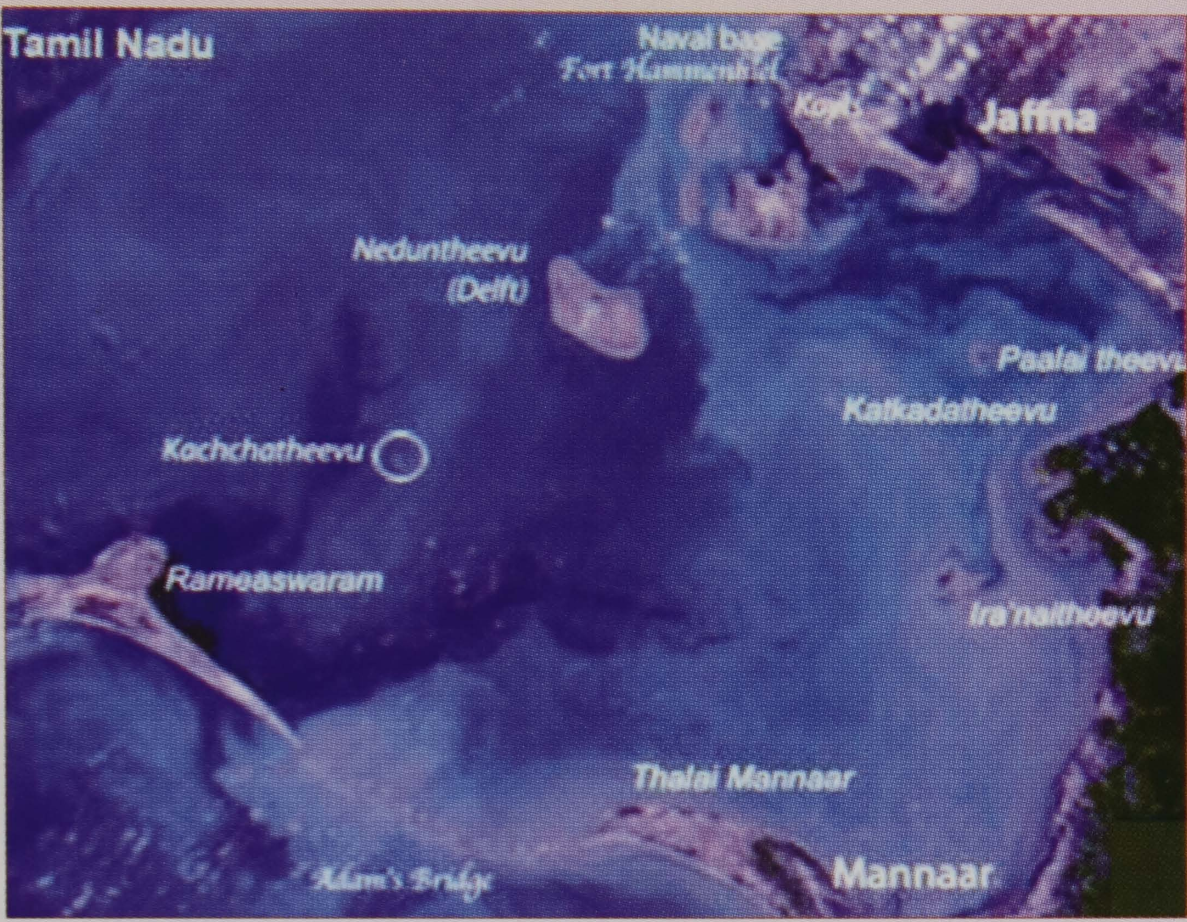
Pungudutivu is a small island composed of a number villages that are just west of the Jaffna Peninsula in the Sri Lankan Tamil dominated Northern Province. It is divided into 12 wards internally, each corresponding to a major settlement. Most of the residents of the Island are Tamils with the majority being Hindus and a minority Christians. It has come to prominence due to a number of cases of rapes and murders such as Sarathambal and Ilayathambi Tharsini during the Sri Lankan civil war. The civil war has also led to a large number of people migrating out of the Island.

Mandativu

Mandativu or Mandaitheevu is small island off the coast of the Sri Lankan Tamil dominated Jaffna Peninsula in the north of Sri Lanka. It is connected to the mainland via a causeway

Nainathivu

Nainathivu or Nainatheevu , is a small but notable island off the coast of Jaffna Peninsula in the Sri Lankan Tamil dominated Northern Province, of Sri Lanka. The name of the island alludes to its aboriginal



Islands of Northern Province.

inhabitants, the Nayanair or Nāka people. It is home to the ancient Hindu shrine of Sri Nagapooshani Amman, one of the 64 Shakti Peethas, and the Buddhist shrine *Naga Vihare*. Historians note that the island is mentioned in the ancient Tamil Sangam literature of nearby Tamil Nadu (such as *Manimekalai*) and ancient Buddhist legends of Sri Lanka (such as *Mahavamsa*). Ptolemy, a Greek cartographer, describes the Tamil territory including islands around the Jaffna peninsula as *Nagadibois* in the first century CE.

The north-west coast is part of the deep Cauvery (Kaveri) River Basin of south-east India, which has been collecting sediments from the highlands of India and Sri Lanka since the breakup of Gondwanaland.

Brief Description of Island of Northern Province

Island	District	Divisional Secretariat	Coordinates	Area (km^2)	Population (approx)	Notes
Analativu	Jaffna	Islands North (Kayts)	9°40′01″N79°46′32″E	4.82	2,200	Dutch: *Rotterdam*, Annelletivo Sinhala: annaladoova.
Chirutivu (Sirutivu)	Jaffna	Islands South (Velanai)	9°38′36″N80°00′37″E	0.28		Between Mandativu and Jaffna Peninsula.Sinhala: Hiridoova
Eluvaitivu	Jaffna	Islands North (Kayts)	9°42′03″N79°48′38″E	1.40	800	Sinhala: Eluvadoova
Erumaitivu	Kilinochchi	Poonakary	9°20′15″N80°03′20″E	1:04		Sinhala: Mahisadoova

Iranaitivu North	Kilinochchi	Poonakary	9°17′31″N79°58′54″E	4.22		Dutch: *Enkhuizen*. Sinhala: Erandoova.
Iranaitivu South	Kilinochchi	Poonakary	9°16′50″N80°00′04″E	1.71		Dutch *Hoorn*.Sinhala: Uoonadoova.
Kachchatheevu	Jaffna	Neduntivu (Delft)	9°23′16″N79°31′37″E	0.68		Pali: Kachchatheetha. Sinhala: Kachchadoova.
Kakaraitivu	Jaffna?	Neduntivu (Delft)?	9°26′23″N79°53′14″E	0.14	Uninhabited	Dutch: *Calienye*.Sinhala: Sakkaradoova.
Kakkativu	Kilinochchi	Poonakary	9°19′01″N80°04′51″E	1.10		Sinhala: Kaakadoova
Kalliaditivu	Mannar		8°56′54″N79°54′42″E	1.71		Sinhala: Galadidoova
Kanantivu	Jaffna	Islands South (Velanai)	9°37′33″N79°51′26″E	1.22		Between Kayts and Pungudutivu.Sinhala: Kaennadoova.
Karaitivu	Jaffna	Islands South (Velanai)	9°36′27″N79°49′48″E	0.97		Adjacent (north) of Pungudutivu.
Karaitivu	Jaffna	Karaitivu (Karainagar)	9°44′03″N79°52′33″E	22.95	8,600	Dutch: *Amsterdam*.
Kayts / Velanai	Jaffna	Islands North (Kayts) atuvan & Islands South (Velanai)	9°39′09″N79°54′11″E	64.01	16,300	Named *Leiden* by Dutch.Sinhala: Uruthota (Kayts); Bellana (Velanai)
Kurikadduvan	Jaffna	Islands South (Velanai)	9°35′43″N79°47′40″E	0.38		Adjacent (north west) of Naduturitti. Sinhala: Kiralakatuvana
Mandativu	Jaffna	Islands South (Velanai)	9°36′48″N79°59′44″E	7.56	900	Sinhala: Mandadoova
Mannar	Mannar	Mannar Town	9°03′10″N79°49′42″E	126.46		Sinhala: Mannaramdoopatha
Naduturitti	Jaffna	Islands South (Velanai)	9°35′05″N79°47′54″E	0.88		Adjacent (south west) of Pungudutivu. Sinhala: Madduriththa
Nainativu	Jaffna	Islands South (Velanai)	9°36′15″N79°46′04″E	4.22	2,700	Dutch: *Haarlem* Sinhala: *Naga Deepa*.
Neduntivu	Jaffna	Neduntivu (Delft)	9°30′48″N79°41′22″E	47.17	4,200	Dutch: *Delft*. Sinhala: Maedundoova.
Palaitivu	Jaffna	Islands South (Velanai)	9°37′22″N79°49′10″E	0.16		Adjacent (north) ofPungudutivu.
Palaitivu	Kilinochchi	Poonakary	9°28′39″N80°00′45″E	1.81		Named *Galue* by Dutch. Sinhala: Paludoova.
Paratitivu	Jaffna	Islands North (Kayts)	9°41′06″N79°47′32″E	0.38	Uninhabited	Between Analativu and Eluvaitivu. Sinhal: Sinhala: Paludoova.
Puliyantivu	Jaffna	Islands North (Kayts)	9°38′52″N79°46′28″E	0.44		Adjacent (south east) of Analativu. Sinhala: Kotidoova.
Puliyantivu	Mannar		8°57′19″N79°54′01″E	0.90		Sinhala: Kotidoova.
Pungudu tivu	Jaffna	Islands South (Velanai)	9°35′08″N79°50′05″E	22.56	3,600	Dutch: *Middleburg*. Pali/ Sinhala: Punguthdeepa
Thimilathiu west	Batticaloa		7°42′17.40″N81°40′37.40″E			Location of SLAF Batticaloa. Sinhala: Kevuldoova
Thorattapputti	Jaffna	Valikamam West (Chankanai)	9°44′55″N79°54′23″E	0.14		Between Karaitivu and Jaffna Peninsula.Sinhala: Doratumukka.

8.0 An Overview of all Districts of the Northern Province.

Northern province of Sri Lanka

The Northern Province covers about 14% of the total land mass of Sri Lanka. Its total extent, around 8,884 sq km including Jaffna Peninsula and its isles, consists of five districts namely, Jaffna, Kilinochchi, Mullaitivu, Vavunia and Mannar, Provincial boundaries are formed by the Gulf of Mannar and Palk Bay to the west, Palk Strait to the north, the Bay of Bengal to the east and the Eastern, the North Central and the North Western provinces to the south. Around 40% of Sri Lanka's coastal area is within the province. The distance from Thalaimannar to Southern India is just 22 miles (35 km). Most of the islands around Sri Lanka are to be found to the west of the Northern Province. The larger of the are: Kayts, Neduntivu, Karaitivu, Pungudutivu and Mandativu.

Jaffna District of Northern province

The Province's population was estimated to be 1.3 million in 2007, which is around 7% of the total population. The majority of the population are Sri Lankan Tamils, with a minority Sri Lankan Moor and Sinhalese population. Sri

Lankan Tamil is the major language spoken in the province by the vast majority of the population. English is widely spoken and understood in the cities.

Jaffna District

The Jaffna district is located furthest in the Northern Province of Sri Lanka, covering an area of 1,025 sq. km. It consists of the peninsula and the seven inhabited Islands. The North, East and West boundaries of the district are the Indian Ocean. On the South is the Jaffna Lagoon and Kilinochchi District. Jaffna District is divided into four Sub Divisions as given below.

- Valigamam or Valikamam
- Thenmarachi or Thenmaradchi
- Vadamarachi or Vadamaradchi
- Jaffna Island.

The Jaffna District, which is administered by a District Secretariat headed by a District Secretary, is divided into 15 Divisional Secretary's (DS) Divisions, each headed by a Divisional Secretary, and the DS divisions are further sub-divided into 435 "GramaNiladhari" (GN) Divisions. It has 17 local authorities of which one is a Municipality, three are Urban Councils and the remaining 13 are "PradeshyaSabhas."

The district occupies the land that constituted the pre-colonial Jaffna kingdom. Important Hindu temples such as Nainativu Nagapoosani Amman Temple, Naguleswaram, NallurKanthaswamy temple, Maviddapuram Kanthaswamy temple, Selvachannithy, Vallipuram and Buddhist Nagadweepa Vihara are located in the Jaffna District. At the time that Sri Lanka gained independence, Jaffna was one of the three districts located in the Northern Province. Parts of the Jaffna District were redistricted with the creation of the Kilinochchi and Mullaitivu districts.

The Jaffna District is one of the most densely populated Districts in the country, with the highest population density reported from the city limits of Jaffna. Other areas are sparsely populated, except for local townships such as Point Pedro and Kankesanthurai, where population density is low to intermediate. Jaffna District's population was 650,720 in 2009. The population of the district is almost exclusively Sri Lankan Tamil.

The area covered by Jaffna District falls under the dry zone of Sri Lanka where tropical dry climate is prevalent. The mean annual rainfall is approximately 1255 mm and falls mainly during the inter–monsoonal (October to November) seasons and North East (NE) monsoon (December to February). The mean annual temperature is about 30-34°C. The highest average monthly temperature is recorded in the months of June, July & August (30°C) while the lowest is encountered in the months of January and December (25°C).

Physiographically, the area covered by the Jaffna District belongs to the lowest pen plain of Sri Lanka. Topography of the entire District is less pronounced, having a flat coastal plain with 1-3 km width in the eastern coastal stretch and towards the west coastal plain is restricted. Relief within the area is very low and featureless, with an elevation generally less than 10 m above mean sea level (a.m.s.l.) except along the southeastern boarder where there is a gradual rise in elevation. There are several small islands in the Western coastal area of the Jaffna District, such as Delft, Kayts, Kachchathivu, Iranativu, which together form the Jaffna Archipelago.

Jaffna District of Northern province

The land in the Jaffna district could be characterized as flat with less than five degree inclination. Except "ValukiAru" in Arali and Todaiman in Idaikkadu, surface drainage is minimal under ordinary or light rainfall conditions. However, as most precipitations fall during a short period – sometimes 50% within 24 hrs, surface run off is usually very marked and is concentrated in shallow in ephemeral channels, the smaller canals and may lead to flooding and overland sheet flow. There are over 631 ponds and 2,433 ditches scattered all over the district with connected channels to conserve rainwater. Excess water easily gets drained into the sea and the lagoon.

Kilinochchi District

The Kilinochchi District is located in the central part of the Northern Province of Sri Lanka. The city of Kilinochchi was established in 1936 as part of a colonization project that sought to ease overpopulation and unemployment in Jaffna.

The total land area of the Kilinochchi District is approximately 1,279 sq km the District is bordered by Mannar District to the South West, Mullaitivu District to the South & South East, Jaffna Lagoon to the North West & North, Jaffna district to the North East and the Indian Ocean to the West and East. The District comprises four DS divisions namely, Pachchilaipillai, Kandawalai, Karachchi and Punakari, and 95 GN divisions. The Kilinochchi district has three local authorities all of which are "PradeshyaSabhas." The District is one of the poorly developed and less populated among the others in the country. Most of the people living in Kilinochchi are Sri Lankan Tamils.

The Kilinochchi area covered by the Kilinochchi District falls within the Dry Zone of Sri Lanka where tropical dry climate is prevalent. The District receives a somewhat low rainfall throughout the year. Annual rainfall in the Eastern half of the District varies from 1250 – 1500 mm while that of Western half of the District is comparatively low ranging from 1000 – 1250 mm. The area experiences heavy rains during the months of October to January, during NE monsoonal season. The highest average monthly temperature is recorded in the months of June, July & August (36°C) while the lowest is encountered in the months of January and December (25°C). Kilinochchi; mean annual temperature is about 30- 34°C.

Physiographic ally, the area covered by Kilinochchi District belongs to the lowest pen plain of Sri Lanka. Topography of the entire District is very low and featureless, with elevations generally less than 10m a.m.s.l., except along the southeastern border where there is a gradual rise in elevation. Major river systems are completely absent within the Kilinochchi District. However, a number of small to medium scale streams, all are seasonal streams that are active mainly during NE monsoonal rainy periods, is drained through the District. KanakarayanAru (the largest stream occupying an area of 896 sq. km), along with several other minor streams such as ToravilAru, PiramanthalAru, KodikathaiAru, PuluthiAru and AkkarayankuamAru drain in a northern and North - North East direction, before connecting their outlets to Jaffna Lagoon. In addition, MandekalAru and PallavarayankadduAru are the two stream systems connected to the sea south of Punakari.

Mullaitivu District of Northern province

Kilinochchi is one of the major agrarian destinations in the island from the pre-historic times. Iranamadu (Ranamaduva) Tank, KanakampikaiKulam (Pond), and KilinochchiKulam are the major irrigation sources for paddy and various other cultivations.

Mullaitivu District

The Mullaitivu The District is bordered by Vavuniya District to the South, Mannar District to the West, Kilinochchi District to the North and Indian Ocean to the East. The District comprises five Divisional Secretariat Divisions, namely, Pandiyankulam, Thunukkai, Oddusudan, Puthukkudyirippu and Mullaitivu, and 127 GN Divisions. The District has four local authorities all of which are "Pradeshya Sabhas".

The population of Mullaitivu District was 220,311 in 2007, comprising, almost exclusively, Sri Lankan Tamils. It is one of the poorly developed and less populated Districts in the country.

The area covered by the Mullaitivu District falls within the Dry Zone of Sri Lanka where tropical dry climate is prevalent. The District receives somewhat low annual rainfall ranging from 1250 – 1500 mm. The area experiences heavy rains from October to December, during the NE monsoonal season. In comparison, the amount of rainfall receive during the rest of the months is considerably low. The highest average monthly temperature is recorded in the months of June, July & August (36°C) while the lowest is encountered in the months of January and December (25°C). The mean annual temperature is about 32°C.

Physiographic ally the area covered by the Mullaitivu District belongs to the lowest pen plain of Sri Lanka. Topography of the entire District is less pronounced, having flat coastal plain with 1 – 2 km width in eastern coastal stretch and towards west, gradually changing to gentle undulating terrains, having elevations rising from sea level to 30 m a.m.s.l. The topography becomes more pronounced in the South Eastern part of the District. An isolated hillock to the South of Kokavil has the highest elevation of 57m.

Mannar District of Northern province

Major river systems are absent within the Mullaitivu District. However, a number of small to medium scale streams drain through the District, all of which are seasonal streams that are active mainly during NE monsoonal rainy periods. Most of these streams drain in a North-East direction and connect to the sea in the North-East coastal zone between Kokilai and Mullaitivu. Of these streams Ma Oya and Per Aru are significant. In addition, some other streams (Pali Aru, Parangi Aru, etc,) are draining in North-North West direction and meet Mannar District before reaching the sea. The Kanakarayan Aru flowing in the northern direction, feed into the Iranamadu Tank located in the Kilinochchi District.

Mannar District

The Mannar district is located in the north west of Sri Lanka in the Northern Province, covering a land area of 2,002 sq. km. The District is bordered by the Kilinochchi District to the North, Mullaitivu District to the North East & East, Vavuniya District to the South East, Anuradhapura and Puttalam Districts to the South and Indian Ocean to the West. The District comprises five Divisional Secretariat Divisions, namely, Mannar, Manthai West, Madhu, Nanaddan and Musali, which further sub-divide into 153 GN Divisions. Mannar district is one of the poorly developed and less populated District in the country. The district has 5 local authorities of which one is an Urban Council and the remaining four are "Pradeshya Sabhas"

The population of the Mannar District was 103,688 in 2007, comprising mostly of Sri Lankan Tamils. It is a predominantly Catholic Christian area, with an equal proportion of Muslim population and a few Sinhalase before 1990. Mannar is part of the "Catholic Belt" extending from Negombo to Jaffna. The ancient "Madu Church" is one of the ancient churches in Asia and located near Murunkan in the District of Mannar An ancient Kali Temple was demolished by the Portuguese to construct the Catholic Church on the same location. Mannar District is unique in its vegetation and wildlife contrasting with the rest of Sri Lanka. The district is notably one of the few places in Sri Lanka where Boabab trees (*Adansoniadigitata*) thrive. The Boabab tree, native to Africa, was bought by Arab sailors to feed camels.

The Western part of the District, including the Mannar Island forms a part of Sri Lanka's Arid Zone while the rest of the areas of the District fall within the Dry Zone of Sri Lanka, where a tropical dry climate is prevalent. The area covered by the District receives somewhat low rainfall throughout the year. Annual rainfall in the western part of the District, including the Mannar Island, is less than 1000 mm while that in the rest of the District is between 1000 –1250 mm. The area experiences heavy rains from October to December, during NE monsoonal season. In comparison, the amount of rainfall receive during the rest of the months is extremely low. The highest average monthly temperature is recorded in the months of June, July & August (36°C) while the lowest is encountered in the months of January and December (25°C). The mean annual temperature is about 30-34°C.

Physiographically the area covered by the Mannar District belongs to the lowest peneplain of Sri Lanka. Variations in topography are less pronounced within the District. The Coastal plain exists as 10 – 15 km wide and North-South trending belt in the entire western part of the District. Towards further East, the topography gradually increases and forms a gently undulating terrain with elevations rising up to 65m a.m.s.l.

Perennial river systems are absent within the Mannar District. However, a number of main streams drain through the District in their matured stages and discharges to sea within the North Western coastal zone of the District, between northern boundary zone of Wilpattu. National Park and Vellankulam. These streams get dried up during the period of July to September. The "Aruvi Aru" (MalwatuOya)

Vavuniya District of Northern province is prominent as it is the second longest river in the country. The other significant streams within the District are, Kal Aru, Parangi Aru, Pali Aru and Modaragam Aru. In addition, Nai Aru and Uppu Aru are also noteworthy streams within the district.

The existence of a number of irrigation tanks within micro-catchments allow efficient local water use. The Giant's Tank in the South-East part of the District is the largest irrigation tank in the area fed by a tributary of "Aruvi Aru"

Vavuniya District

The Vavuniya District is located in the southern part of the Northern Province of Sri Lanka covering a land area of 1,966 sq. km. The District is bordered by the Mullaitivu District to the North, North West and North East, Mannar District to the West and Anuradhapura District to the South West, South, South East and East. The Mullaitivu district was carved out of the northern part of Vavuniya district in September 1978.

The district is divided into four DS Divisions, namely-Nedunkerni (formerly Vavuniya North), Vavuniya South (Tamil), Vavuniya South (Sinhala) and Cheddikulam, and further sub-divided into 102 GN Divisions. The Vavuniya district has five local authorities, out of which one is an Urban Council and the remaining 4 are Pradeshya Sabhas. The main township in the District is Vavuniya while Cheddikulam, Puliyankulam, Kanakarayankulam, Omanthai and Nedunkerni are the medium scale townships located within the District. The total population in the district is approximately 182,957, and the majority are Sri Lankan Tamils.

The Vavuniya District falls within the Dry Zone of Sri Lanka where a tropical dry climate is prevalent. The area covered by the District receives somewhat low rainfall throughout the year. The annual rainfall in the District varies from 1000 – 1500 mm, and experiences heavy rains from October to December during the NE monsoonal season. In comparison, the amount of rainfall received during the rest of the months is considerably low. The highest average monthly temperature is recorded in the months of June, July & August (36°C) while the lowest is encountered in the months of January and December (25°C). The mean annual temperature is about 34°C.

Physiographically the area covered by the Vavuniya District belongs to lowest pen plain of Sri Lanka. The relief of the District varies from 100 – 200 m a.m.s.l. Generally, the area comprises flat terrain with small scattered hillocks. The topography becomes more pronounced in South Eastern sector while a flat terrain is identified in the rest of the areas within the District. Madukanda, Thammannakanda and Velikanda are the prominent strike ridge structures identified within the South Eastern sector, representing higher elevations in the District.

Major river systems are absent within the Vavuniya District. However, a number of small to medium scale streams drain through the District and all of them are seasonal streams, which are active only during NE monsoonal rainy periods. Kanakarayan Aru, Chamali Aru, Kiul Aru, Chamalankulam Aru, Per Aru, Kal Aru and parts of Malwathu Oya are the main river systems draining within the District. These river systems show a remarkable variability in discharge during dry and wet season.

SECTION 2-1

LAND RESOURCES AND DEVELOPMENT

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1.0 Land Use and Land Cover in the Northern Province.

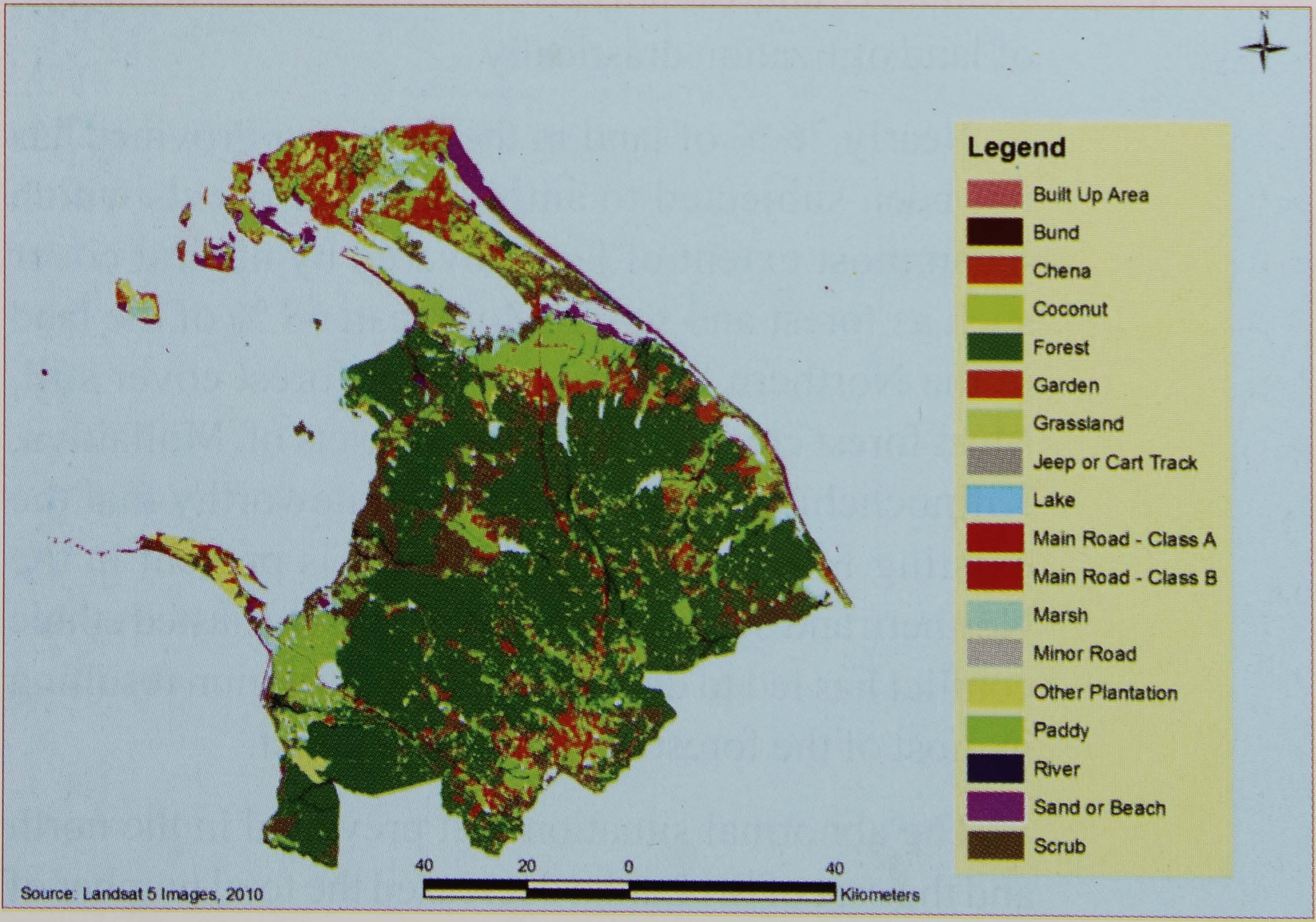
Land use pattern in the Northern Province has been subject to economic and political processes that has taken place historically. During 1950s, most land in the Northern Province except Jaffna was intact of human activities. In the subsequent decades, several settlement schemes under major irrigation tanks in Wanni were executed that increased the population in Kilinochchi, Mullaitivu and Vavuniya districts and led to the change of land utilization drastically.

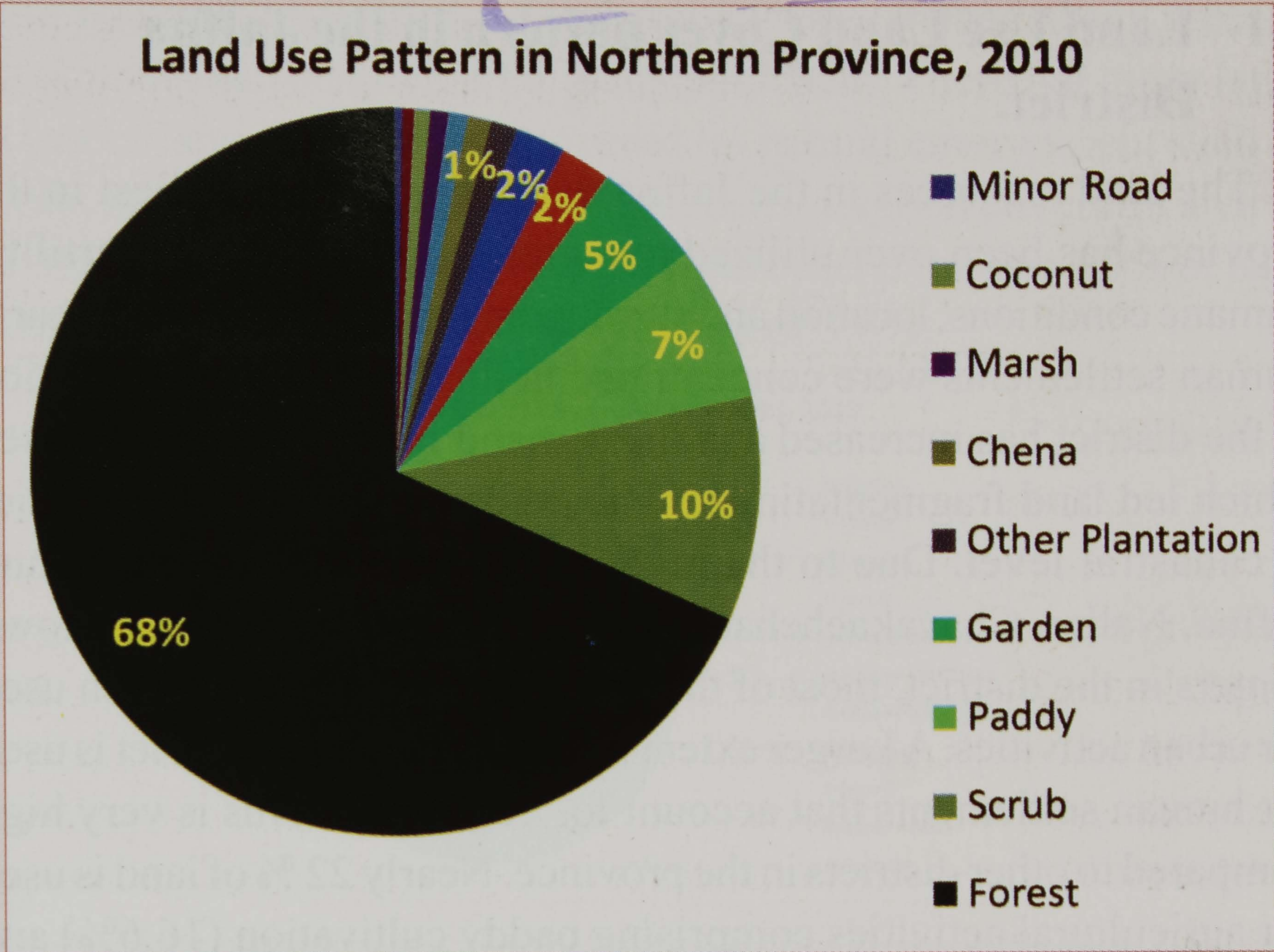
Nearly 76 % of land in the Northern Province has not been subjected to anthropogenic effects which mean most extent of land covered by natural cover such as forest and scrub. More than 68 % of the land in the Northern Province is under forest cover still. Most forest cover exists in the districts of Mullaitivu, Kilinochchi and Vavuniya. It is noteworthy that the existing forest cover in Sri Lanka is present in the Northern and the Eastern Provinces. Long lasted ethnic conflict has led to depopulation in the region resulting in most of the forest cover to be be intact.

The abnormal situation that prevailed in the north and the east of Sri Lanka decreased the total number of population. This situation did not claim forest land for human needs in the region during the last few decades. Because of the depopulation, most of the forest cover has survived today.

Scrub occupies nearly 10% of total land in the Province. Scrub exists in the lands that have lack of water resources and fertility. Human intervention has not changed the very nature of these lands. Most scrub land cover exists in the district of Mannar and Kilinochchi districts.

Paddy cultivated lands account for 6.8 % where irrigated and rain fed mode of cultivations are prevalent. These paddy lands exist in the areas under major irrigation tanks such as Iranaimadu, Giant Tank, Vavunikulam, Muthayankaddu Kulam, Vanerikulam and Akkarajan kulam and 6 other medium irrigation tanks. The Northern Province is well endowed with cultivable land which has long been a key factor in the region's socio-economic development. Arable land includes net sown area, current fallow, other fallow and land under trees. Marshy lands cover the extent of 0.8 % and same extent of land is occupied by sand and beaches. Circulation spaces such as main roads, minor roads, local roads and tracks occupy less than 3 % of the land area.





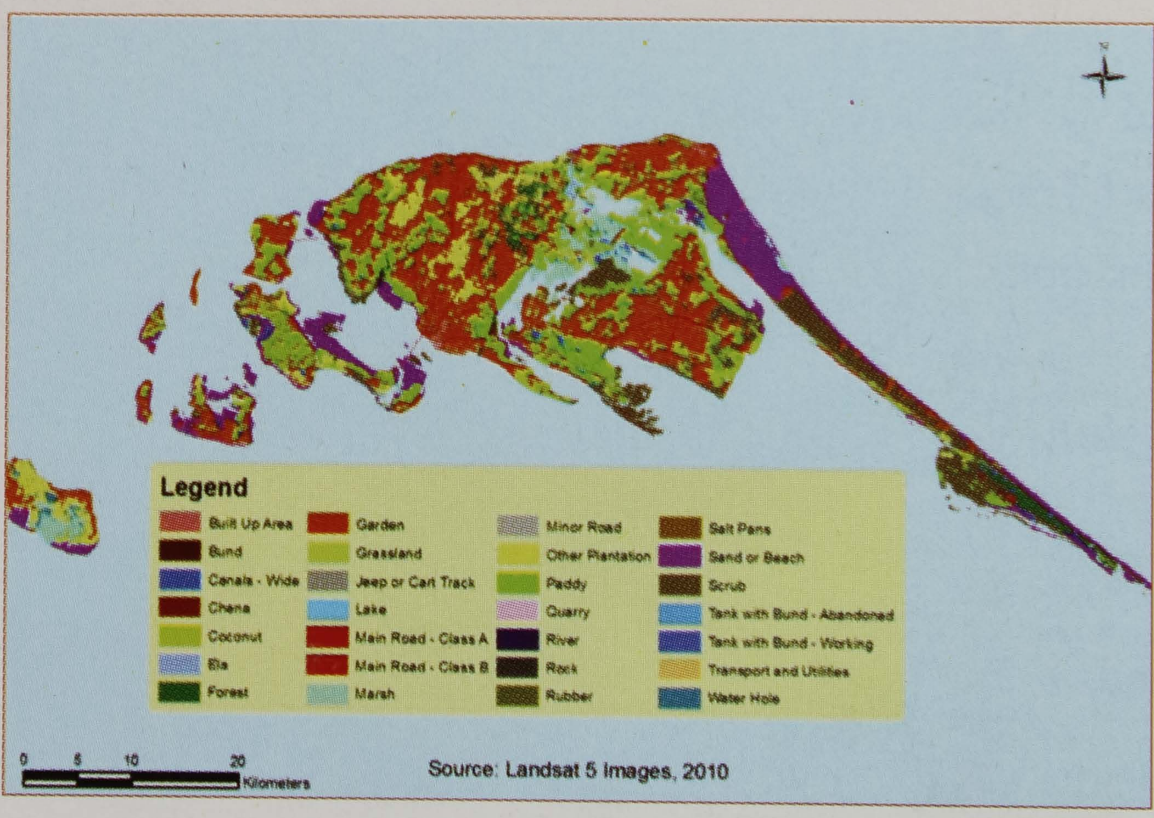
Land Use Land Cover Pattern – Northern Province 2010

Land Use Pattern – Northern Province, 2010

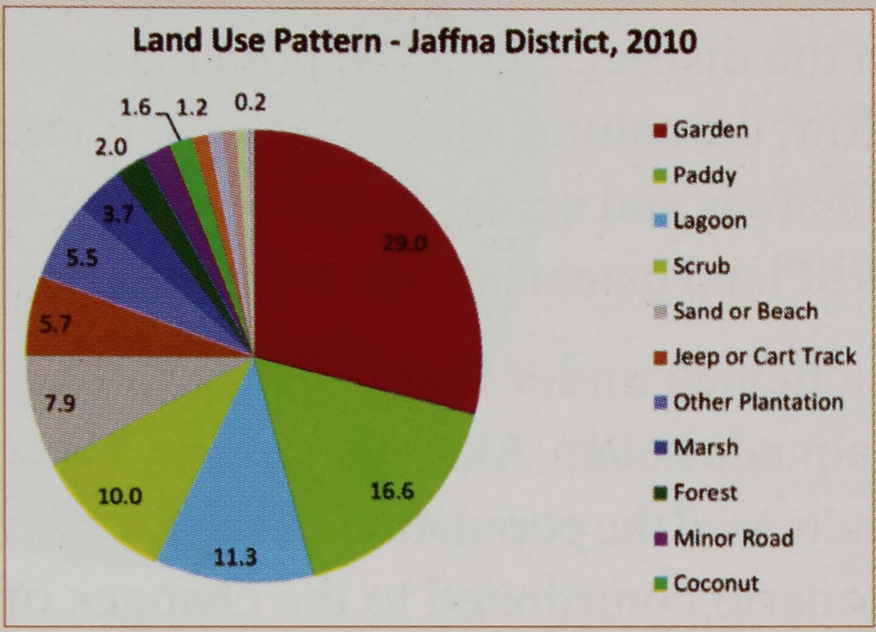
Land use	Percent
Forest	67.65
Scrub	9.93
Paddy	6.82
Homestead	4.79
Jeep or Cart Track	2.22
Other Plantation	1.13
Chena	1.05
Sand or Beach	0.83
Marsh	0.81
Coconut	0.70
Minor Road	0.35
Total	100
Source: Survey Department, 2010	

1.1 Land Use Land Cover pattern in the Jaffna District.

The land resources in the Jaffna district which is smallest in the province has been over utilized to a great extent due to its fertility, climatic conditions, location and surrounding environment. Since early human settlements were concentrated in this district, the population in the district has increased and the demand for land has been raised which led land fragmentation and heterogeneous land use activities at cadastral level. Due to the higher level of urbanization around Jaffna, Nallur, Chavakachchaeri, Point Pedro and Chunnakam town centers in the district, most of the land in those areas have been used for urban activities. A Larger extent of land in the Jaffna district is used for human settlements that account for 28 percent. This is very high compared to other districts in the province. Nearly 22 % of land is used for agricultural activities comprising paddy cultivation (16.6%) and other agricultural crops (5.4 %). In the Jaffna district, unsustainable agricultural activities and natural resource exploitation have degraded the land resources to a larger extent. The over extraction of ground water for agricultural purpose has led to sea water intrusion resulting in salinization of coastal lands and shoreline areas of lagoons. Extensive uses of agro chemicals such as chemical fertilizers and pesticides



Land Use Land Cover Pattern – Jaffna District have polluted the fertile land and ground water in the red soil areas in Valikamam and central part of Vadamarachchi. There is a fairly large extent of land in the district covered by natural environment such as scrub, marshes, sand beaches and lagoons. Lagoon covers an area of 11.3%, scrub land covers 9.9%, sand and beaches covers 7.9% of land extent and marshy land covers an extent of 3.6%.

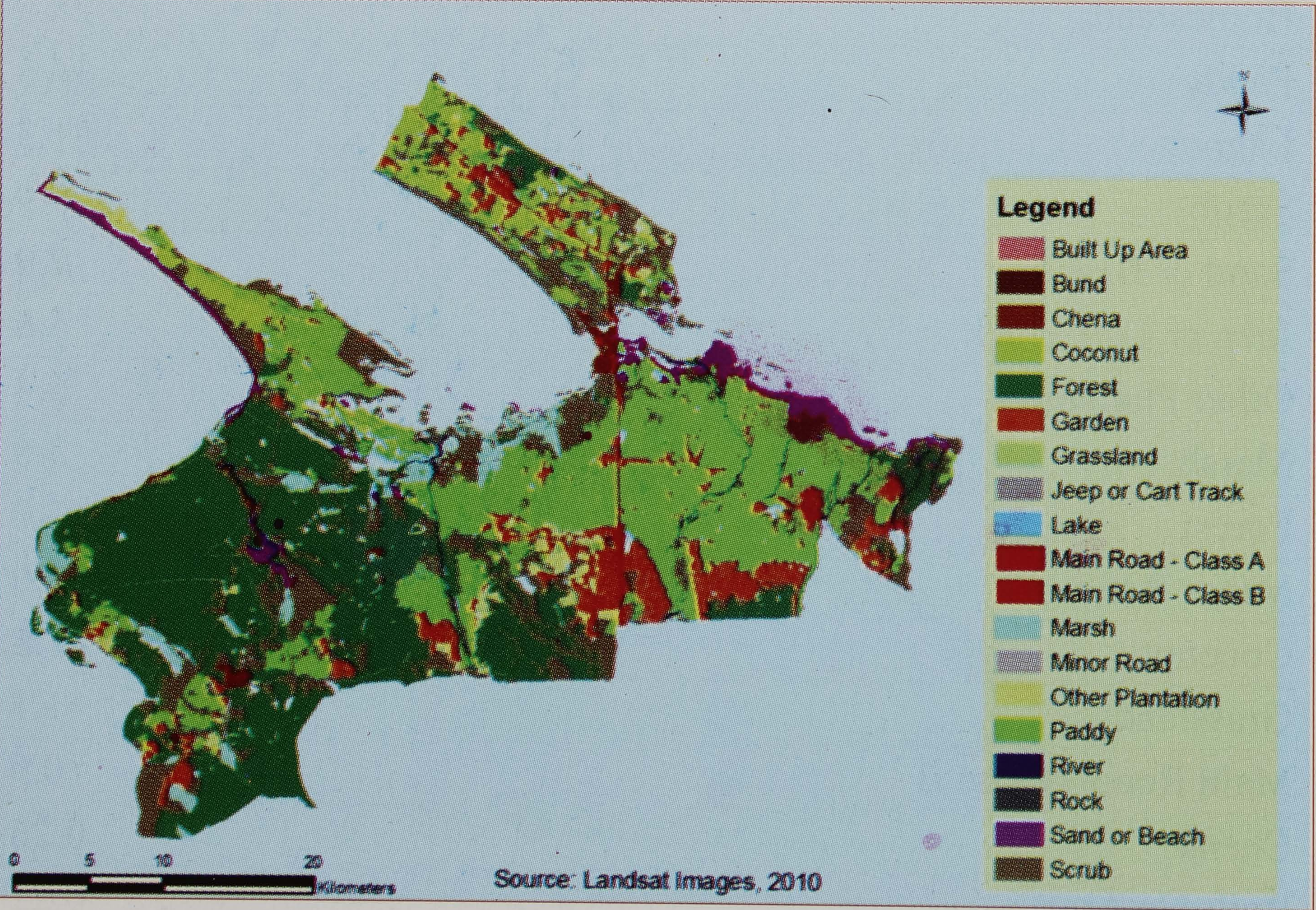


Land Use Pattern – Jaffna District	
Land Uses	**Percent**
Homestead	28.9
Paddy	16.6
Lagoon	11.3
Scrub	9.9
Sand or Beach	7.9
Jeep or Cart Track	5.6
Other Plantation	5.4
Marsh	3.6
Forest	2.0
Minor Road	2.0
Coconut	1.6
Grassland	1.1
Main Road - Class B	0.9
Chena	0.26
Built Up Area	0.22
Source: Survey Department of Sri Lanka, 2010	

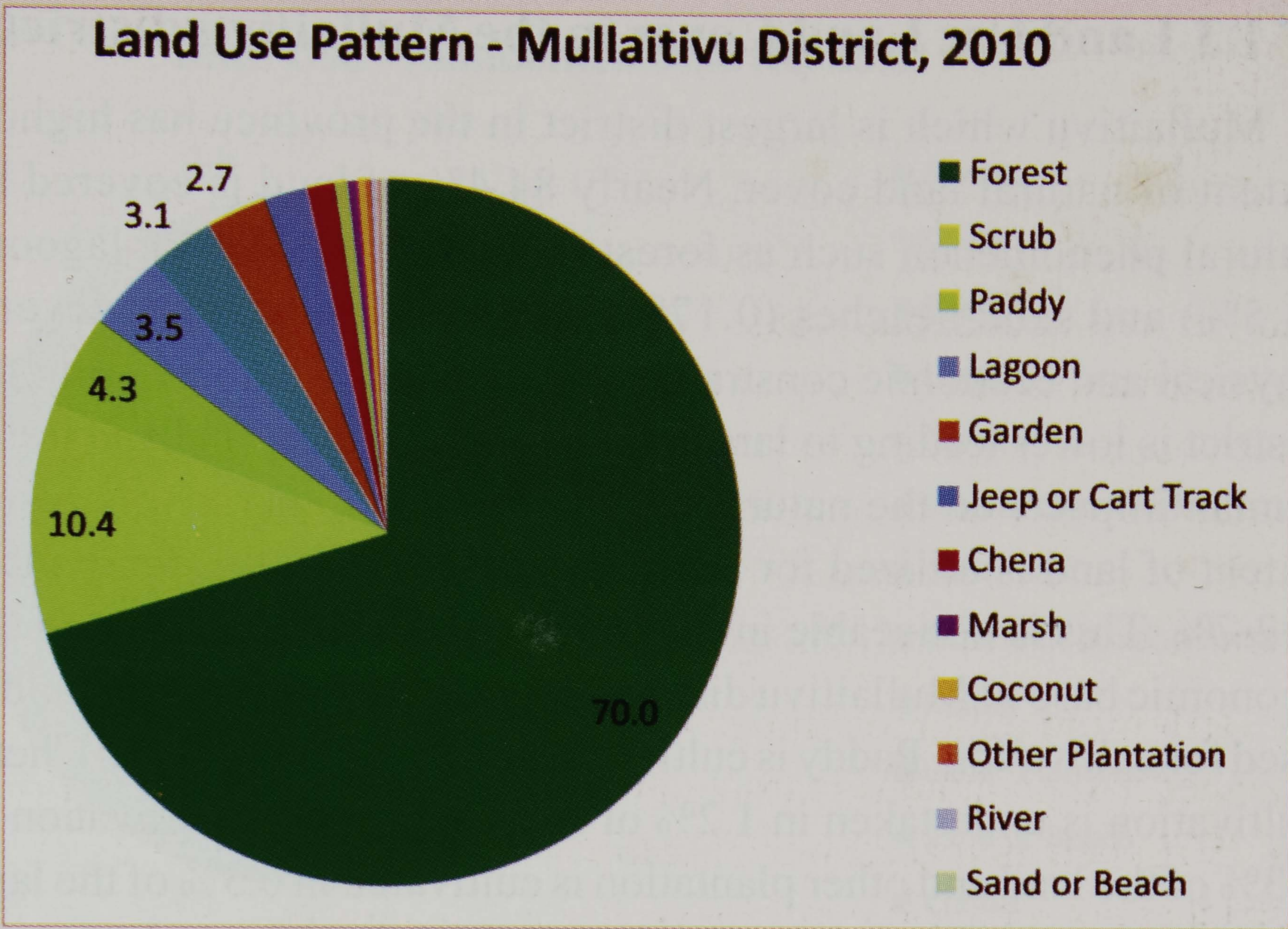
1.2 Land Use Land Cover in the Kilinochchi District.

Kilinochchi is the third largest district in the province in terms of land extent and population and has substantial extent of land with natural cover. A Small extent of land has been utilized for human habitation that is about 3.6%. 77% of total land extent has not been subjected to human influences that consist of forest, scrub, marsh and sand beaches in the district. Since the population in the district has been relatively low, the natural land cover exist is intact. Forest exists in 59.3% of land areas and scrub covers 10.4% of the land. Lagoon extends to 5.7% of land extent and marshy lands cover 1.4%.

Settlement schemes under major irrigation tanks which were executed in Iranaimadu kulam, Akarayan kulam, Vanerikulam in 1960s and 1970s had increased the population distribution in the Kilinochchi district. This scenario contributed to the changes of land use in the district in following decades.



Land Use Land Cover Pattern – Kilinochchi District 2010

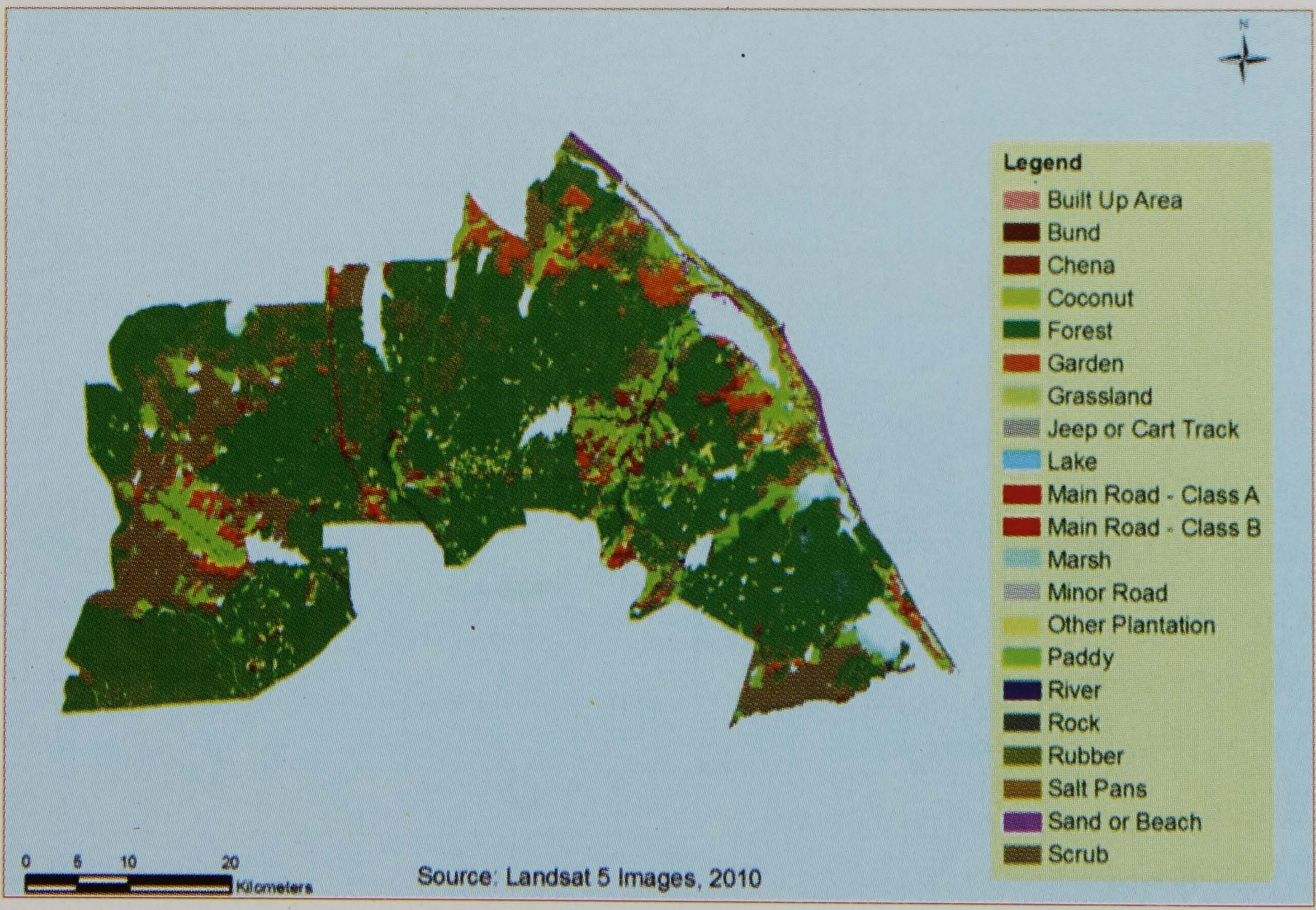


Land Use in Kilinochchi District 2010	
Land Use	**Percent**
Forest	59.3
Scrub	10.4
Paddy	10.0
Lagoon	5.7
Homestead	3.6
Jeep or Cart Track	2.2
Coconut	2.0
Marsh	1.4
Other Plantation	1.0
Sand or Beach	0.7
Chena	0.4
Minor Road	0.23
Main Road - Class A	0.19
River	0.18
Main Road - Class B	0.12

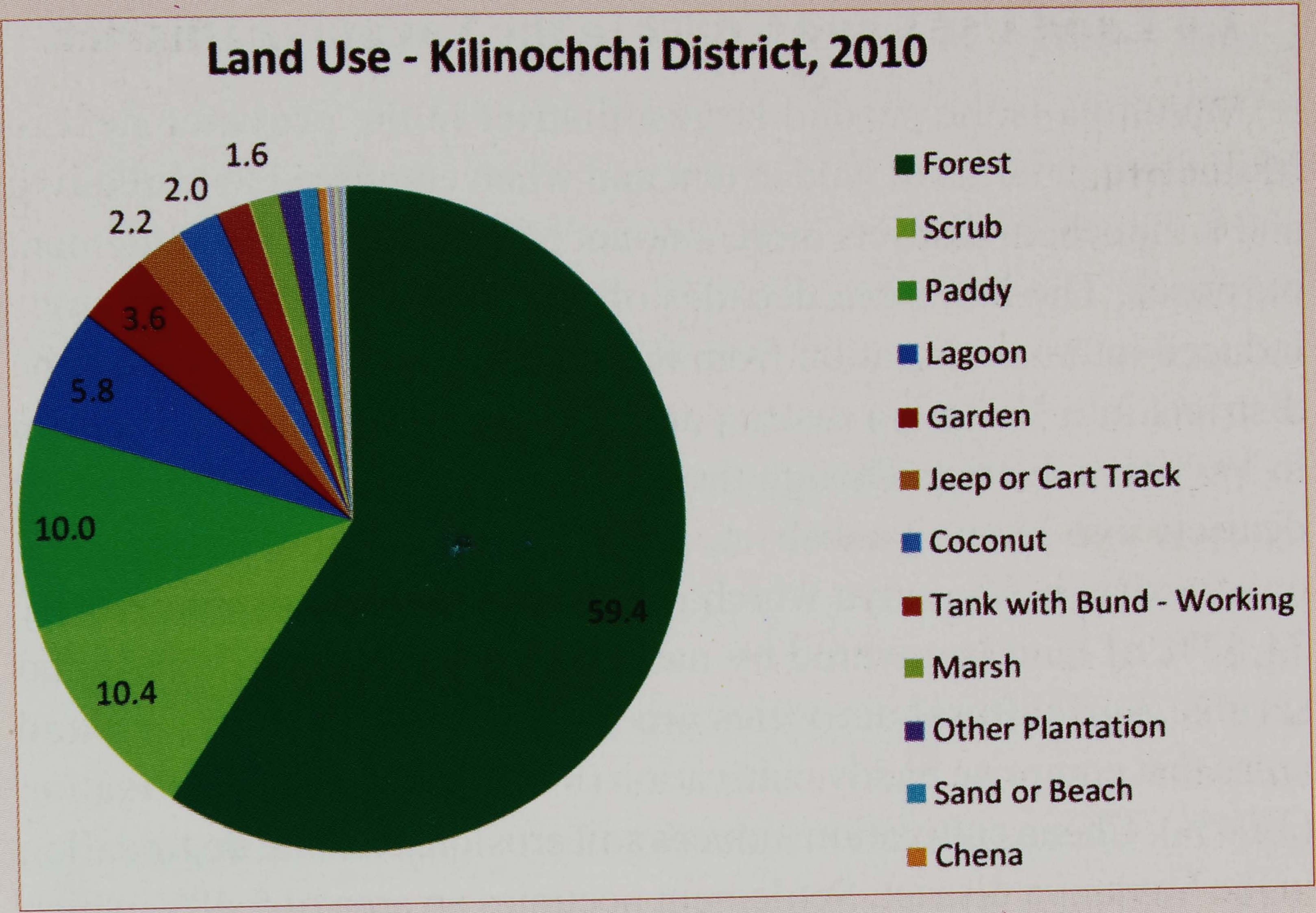
Source: Landsat 5 Images, 2010

1.3 Land Use Land Cover in the Mullaitivu district.

Mullaitivu which is largest district in the province has highest extent of natural land cover. Nearly 84.4% of land is covered by natural phenomenon such as forest (70%), scrubs (10%), lagoons (3.5%) and sand beaches (0.17%). Since the district has several physical and economic constraints, the number of population in the district is lower leading to larger extent of per capita land and lesser human impacts on the natural environment. Comparatively lesser extent of land is utilized for settlement activities in the district that is 2.7%. This is noticeable in the province particularly. Though the economic base of Mullaitivu district is agriculture, only 6% of land is used for cultivation. Paddy is cultivated in 4.2% of the land and Chena cultivation is undertaken in 1.2% of the land, coconut cultivation in 0.3% of the land and other plantation is cultivated in 0.3% of the land areas. Settlement development has been spread along the major arterial routes such as Mankulam Mullaitivu road, Paranthan Mullaitivu road. Lack of economic potential and physical constraints contributed for low density in settlement development.



Land Use Land Cover Pattern – Mullaitivu District 2010



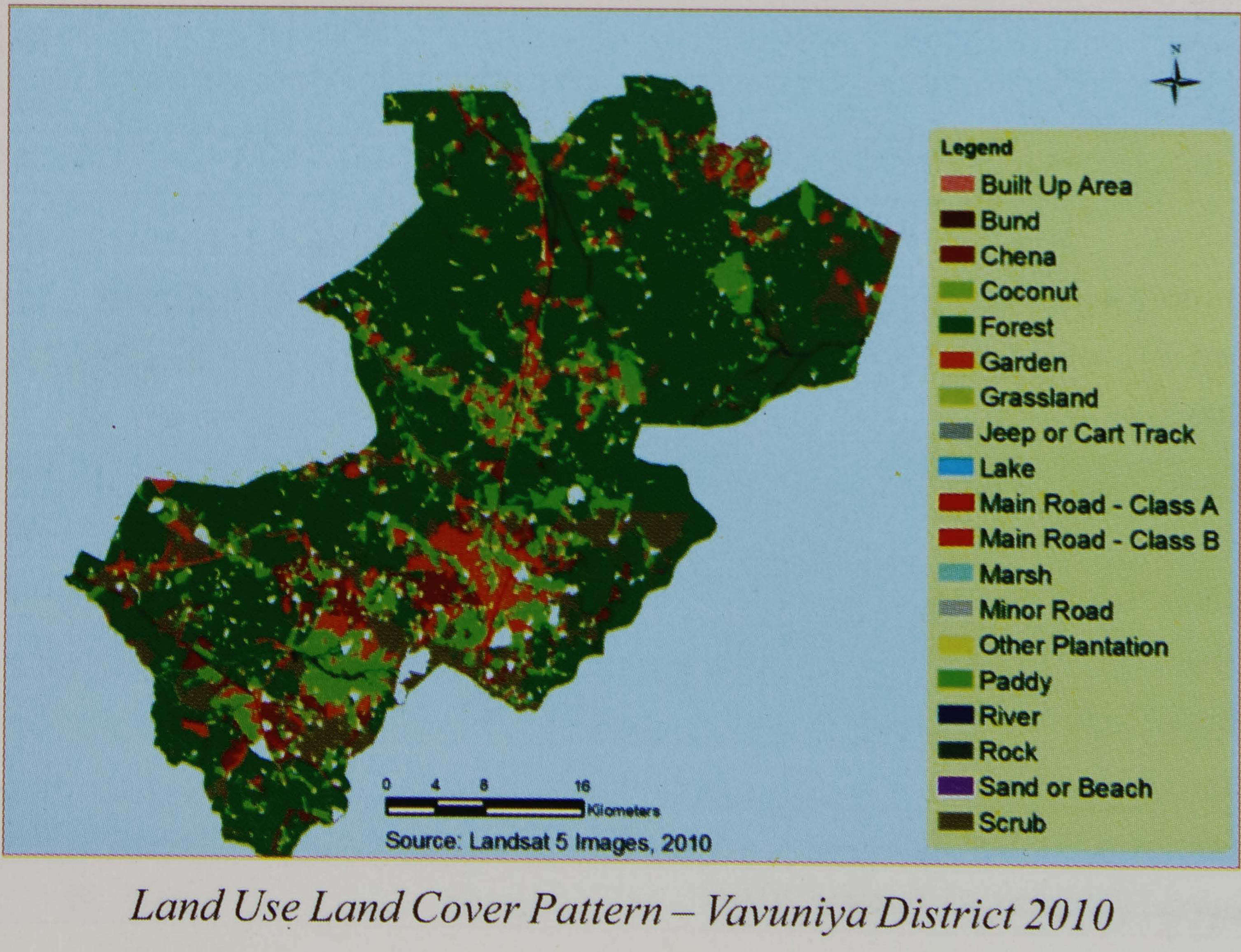
Land Use – Mullaitivu District, 2010

Land Use	Percent
Forest	70.0
Scrub	10.3
Paddy	4.2
Lagoon	3.5
Homestead	2.7
Jeep or Cart Track	1.9
Chena	1.2
Marsh	0.47
Coconut	0.30
Other Plantation	0.30
River	0.23
Minor Road	0.20
Sand or Beach	0.17
Main Road - Class A	0.16

Source: Landsat - 5 Images 2010

1.4 Land Use Land Cover in the Vavuniya District.

Vavuniya is the second largest district in the province next to Mullaitivu in terms of land extent and when compared to Mullaitivu and Kilinochchi districts more amount of land is used for settlement purposes. The last three decades of war in the Northern province induced internal migration from Kilinochchi, Mullaitivu and Jaffna districts into Vavuniya district and influenced the land use pattern in Vavuniya district. Though there were large migration from other districts into Vavuniya district, considerable extent of natural land cover exists in Vavuniya which is 62% of total land extent. Nearly 74.57% of land is covered by natural scenario such as forest and scrubs. Agricultural activities are undertaken in 11.52% of land areas that comprise paddy cultivation (8.48%) and Chena cultivation (3.04%). Chena cultivation induces soil erosion and land degradation in the Vavuniya district. Settlement occupies an area of 5.48% which indicates more lands disposed for urban activities next to Jaffna district. Circulation space consist 3.51% of land and this is below the required standard for transportation needs. Post war scenario has created

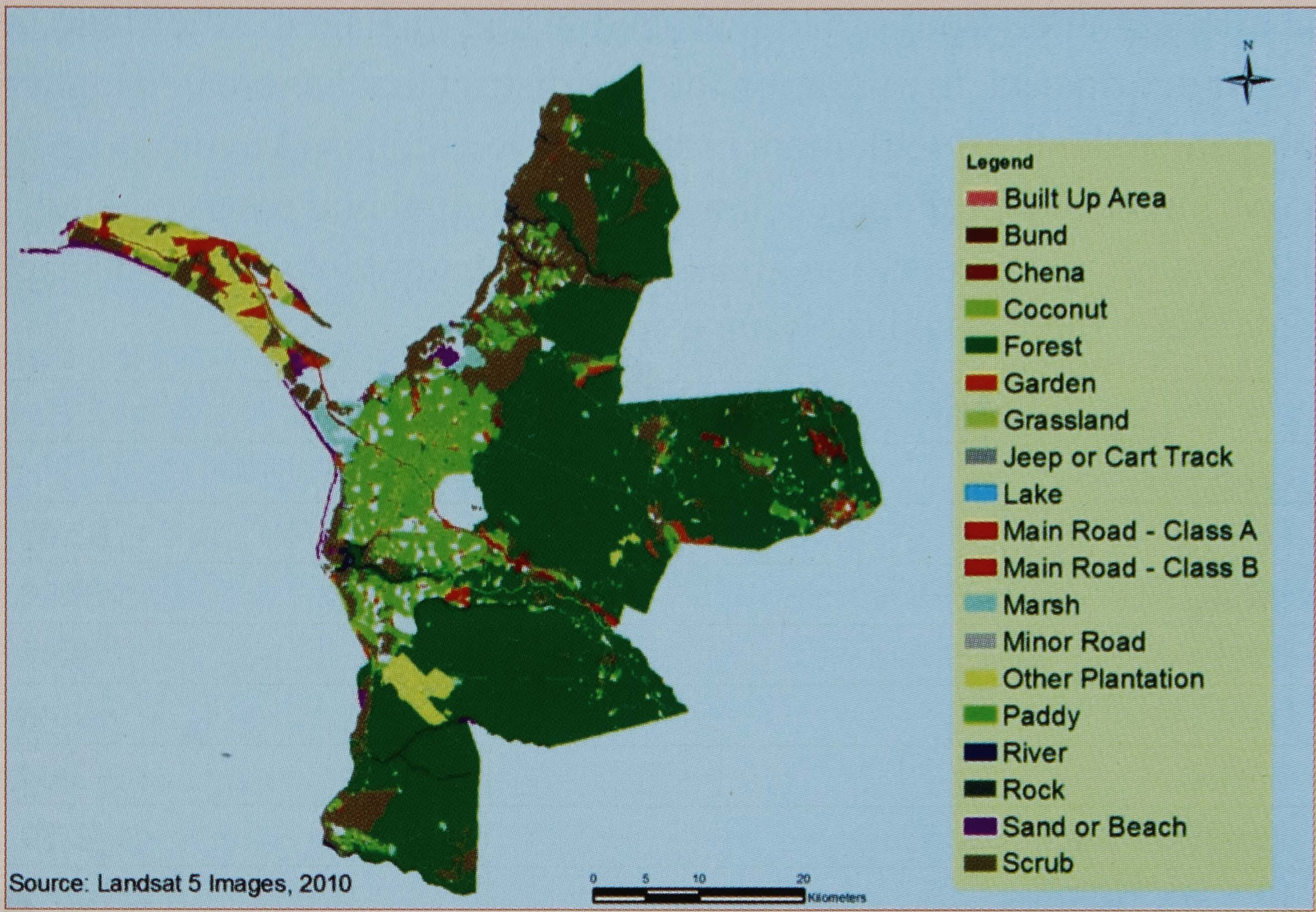


Land Use Land Cover Pattern – Vavuniya District 2010 challenges and issues of land utilization and management of land in Vavuniya district. In migration into the district that has created higher demand to land for settlement in strategic locations in Vavuniya town contributed for land encroachments in marginal and reserved lands. Almost all water retention areas of major water tanks in the district have been encroached for human settlements.

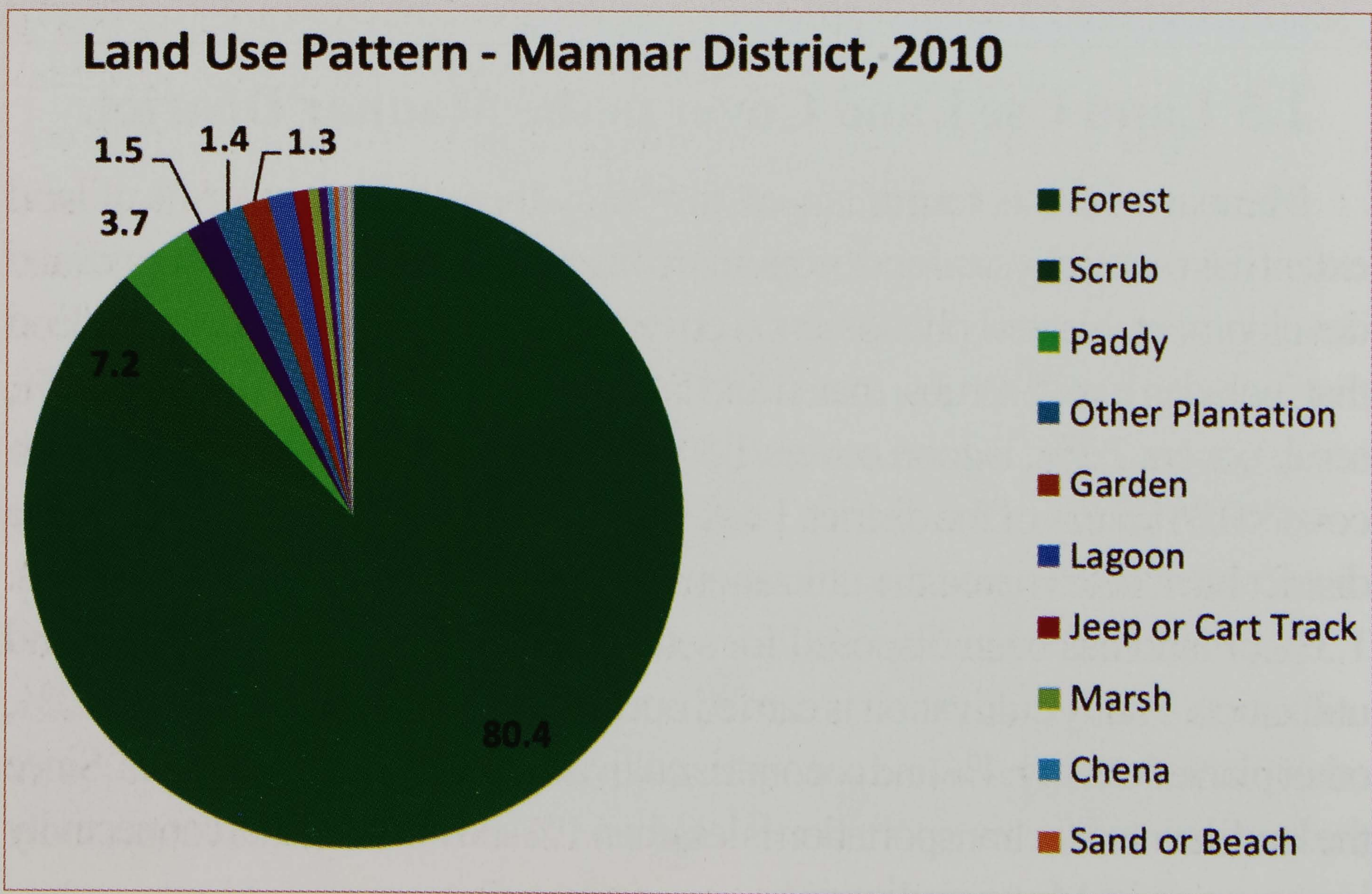
Land Use Pattern in Vavuniya District, 2010	
Land Use	Percent
Forest	62.47
Scrub	12.10
Paddy	8.48
Homestead	5.48
Chena	3.04
Tank with Bund - Working	2.89
Jeep or Cart Track	2.81
Tank with Bund - Abandoned	1.20
Minor Road	0.39
Main Road - Class A	0.31
River	0.22
Source: Landsat - 5 Images, 2010	

1.5 Land Use Land Cover in the Mannar District.

Mannar which is fourth largest district in the province in terms of land extent has many physical and economic constraints for land utilization and land development. Natural phenomenon covers nearly 89.7% of the district's land that includes forest, scrubs, marsh and lagoons. Forest cover occupies of 80%, scrub covers 7.2%, lagoon covers 1.3%, marsh covers 0.5% and sand beach covers 0.3% areas of the district. Lack of water resources and fertile soil in the district have determined the utilization resulting marginal economic benefits. 1.3% of land has been disposed for settlements indicate lower level of land utilization. Paddy cultivation is carried out in 3.7%, Chena cultivation in 0.3%, other plantations in 1.4% and coconut is cultivated in 0.2% of the land area. Since the land devoted for transportation is less than 1% shows the spatial connectivity is very poor in Mannar district.



Land Use Land Cover Pattern – Mannar District 2010



Land Use Pattern – Mannar District, 2010	
Land Use	**Percent**
Forest	80.4
Scrub	7.2
Paddy	3.7
Other Plantation	1.4
Homestead	1.3
Lagoon	1.3
Jeep or Cart Track	0.8
Marsh	0.5
Chena	0.3
Sand or Beach	0.3
Coconut	0.2
Minor Road	0.1
River	0.1
Source: Landsat- 5 Images, 2010	

2.0 Land Degradation.

Land degradation usually refers to permanent or temporary lowering of productive capacity of land. Man's progress towards development in the Northern Province has, however, considerably damaged our land resource base, probably since 1960s. Land degradation is caused largely by soil erosion in human habituated areas, but also by water logging and excessive salinity in the coastal areas of the province particularly the Jaffna peninsula. The most serious threat to the land is posed by deforestation in Mullaitivu, Kilinochchi and Vavuniya districts during the war and post war resettlement process. Heavy rainfall during monsoon damages the soil fertility and morphology induced by deforestation. Slopes encourage rapid run-off leading to soil erosion, especially on the southern part of districts of Kilinochchi, Mullaitivu, Vavuniya and Mannar in the province. Soil erosion is prevalent in the areas where Chena cultivation is most common such as in Samalangkulam, Oddusuddan, Palampasi, Thadamalai, Katchilaimadu, Muthayankaddu, Karipaddamurippu, Mankulam areas in the district. Deforestation has been the causative factor for soil erosion and land degradation in the Mullaitivu district.

In fact, a major portion of the coastal plain of the North Eastern part of the provinces are prone to flood and erosion. Wind erosion is prevalent in the North of Mannar, and the Eastern part of Jaffna District gully erosion in the Kokilai Kokuthoduvai area in Mullaitivu,. Water logging and salinization which constitute the second major threat to soil have already claimed coastal areas of Jaffna district. Land is also degraded due to mining operations in many parts of the country.

The land area in the Eastern part of Jaffna district and river beds in main land Wanni are under mining. Urban sprawl around Jaffna Town and other small towns centers in Jaffna on agricultural land is another burning problem in Jaffna district by which the amount of land used for agriculture is readily declining. In other words, there is a tough competition amongst agriculture, urbanization in Jaffna district.

The growing population in the post war scenario in the province has placed immense pressure on the dwindling land resources, endangering the very survival of the biome as a whole. The high degree of degradation of existing land resources, the changing climate and increasing diversion of land from agricultural to non-agricultural uses have aggravated the problem. Consequently, productivity of land has suffered to a great extent, sometimes beyond repair and per capita arable land is also decreasing with the progress of time. Sri Lanka, being a large agrarian society, has, therefore, an enormous task to meet the growing demands for food, fuel, fiber together with environmental security for its people in the coming years.

Land, the marvelous product of nature, without which no life would survive, is now at stake. The time has come to sustain it for our sustenance and its bridle must be handed over to our future generation, the children, who will unveil the thousands of wonders above and underneath this creamy layer. They will be amazed with the mystery of various branches of sciences in relation to the land mass on which they are growing and playing day to day. It will also be their prime duty to put into action the knowledge and wisdom acquired by their ancestors as regards various land uses.

Understanding land resources, its potential, utilization and management of the Northern Province reflects the levels of development and standard of living of the region. Improper use of land due to anthropogenic pressure has created many problems like shrinkage of arable land due to encroachment, decline in fertility due to over use of inorganic fertilizers without soil test information and land degradation in the settlement area. In land resource management approach, spatial distribution of land use, intervention of local and scientific decision support system and control and conservation measures are of primary importance.

3.0 Analysis of challenges and opportunities of land resources in the region.

Strength

- 77.5% of land is with natural cover such as forest and scrub in the Northern Province
- 80% of land is owned by the state sector
- More than two thirds is developable land in the Province
- Higher land man ratio in the region

Weakness

- Fragmented responsibilities of land management
- Uncoordinated institutions in land management
- Higher level of unemployment in the region
- Unsustainable agricultural practices
- Weak implementation mechanism of laws and regulations on land resources management

Opportunities

- New land management policies
- Progress in resettlement of displaced people
- New economic opportunities other than the agricultural sector
- Sustainable agricultural methods
- Existing institutions, regulations and laws concerned with management of land resources

Threat

- Unclear vision for land development at state level
- Disposition of land for foreign investment
- Corruption and bribery in the land management sector
- Political instability in the country
- Absence of provincial council
- Unpredictable climatic hazards such as extreme flood and drought

4.0 Need for Proper Land Management.

The development strategy of the province, since independence, has depended mainly upon the exploitation of their natural resources. These include agriculture, minerals, energy, water and other biological resources. Unfortunately, the strategy did not bring about the expected results but created environmental degradation and increased poverty.

After almost four decades of development efforts, the Northern Province is still faced with serious development challenges including rampant poverty, hunger, and environmental degradation. In fact despite its natural resources endowment, the Northern Province is the region where per capita food production and the number of poor are expected to continue to rise over the next decade.

There is a wide range of socio-political, economic and technical reasons for this situation. The Government is aware of these as it continues to address the problem within its limited resources. Measures it has adopted include the enactment of legislation to guide the use of land resources, the formulation of policies and the generation of some of the information required in support of the sustainable management of land resources, the increase of the number of government agencies and line departments dealing with land issues and investments in a wide variety of development projects in the field of land resources management. Despite continuing efforts the problem remains unresolved. With the Government retaining overall control of about 80 percent of the land, it has found difficulty in loosening its top-down approach to land management. How to incorporate the needs and skills of land users working the land at the local level is another problem requiring an answer. What is required is that viable methods of participatory management of land resources are devised and accepted, whereby platforms for negotiation are built between Government and an enabled population.

In summary, the priority issue is to devise and implement programmes such that rational land uses can continue, through the application of sustainable management practices that are supported by the full range of stakeholders. Prime responsibility for addressing this issue must continue to be with the Government, at least whilst state ownership remains at about 80 percent of the total land area, which is a remarkably high proportion in comparison with most countries of the world.

5.0 Vision for Sustainable Management of Land Resources.

"Creating self sufficient agricultural and industrial economy with sustainable social environmental conditions"

Objectives of the Land Resources Management

"To facilitate allocation of land to the uses that provide the greatest sustainable benefits and to promote the transition to a sustainable and integrated management of land resources. In doing so, environmental, social and economic issues should be taken into consideration. Protected areas, private property rights, the rights of indigenous peoples and their communities and other local communities and the economic role of women in agriculture and rural development, among other issues, should also be taken into account."

6.0 Strategy for Sustainable Management of Land Resources.

Three strategies have been proposed to manage and utilize the land resources in a sustainable manner.

- Strengthening existing laws, regulations, policies and institutions
- Land conservation and management
- GIS Based Land Information System
- Land use planning and zoning

6. 1 Strengthening existing Laws, Regulations, Policies and Institutions.

There are ample legal provisions to conserve and manage land resources sustainably in the region but they need to be revised to address the present needs of the community. Legal provisions should be dynamic to cope up with the ongoing socio economic and political climate of the region. In Sri Lanka, the legal provisions are not revised based on the short coming to address issues and challenges of changing socio economic conditions. There are institution to manage the land related matters but they are fragmented and uncoordinated. This situation leads to isolated land use policies and land management activities resulting in overlapping and conflicting land management practices. These short comings should be eliminated through integrated land management practices of the different institutions. All institutions dealing with land resources should be coordinated based on the vision of the land resource management of the region

6.2 Land Conservation and Management.

The lands vulnerable for degradation such as erosion, salinization, alkalization, water logging needs to be conserved with proper methods. Soil conservation methods should be adopted in the areas, south of Mullaitivu, Vavuniya and Kilinochchi where erosion is more prevalent. Measures are necessary to desalinize the lands in Jaffna, such as the coastal areas and lands adjacent to Upparu and Thondamanaru lagoons. Proper measures are required to recharge ground water in the Jaffna district as part of the desalinization process. Environmentally sensitive areas such as low lying lands, marshy lands, paddy lands forest lands should be protected and conserved in the areas such as Nanthikadal lagoon, Upparu lagoon, Thondamanaru lagoon, ecosystem in the major tanks in KIlinochchi, Mullaitivu and Vavuniya districts and paddy and marshy lands that exist under these irrigation tanks.

6.3 GIS based Land Information System.

Sustainable land resource management requires updated information about lands. Lack of information on land leads to inefficient management of lands resulting land degradation and suboptimal utilization. In the Northern Province the land use data are not up to date and accurate. Therefore, up to date information on land is very important for sustainable use of land resources. This information can be collected, processed, managed, retrieved, analyzed and displayed in an interactive method. GIS and Remote sensing techniques are very effective tools for efficient spatial data management. The land data needs to be maintained from grass root level up to regional level that will help to make decision on land uses. There should be village level land information that consist the following;

- Parcel level land extent
- Land ownership
- Land utilization,
- Land cover
- Land value
- Land elevation
- Land capability
- Soil properties
    - Chemical and physical properties
- Environmentally sensitive areas
- Cadastral information
- Infrastructure facilities

These data on land can be collected from various sources and methods such as;

- Conventional methods
    - Land surveying
    - Existing maps
    - Aerial survey
    - Field survey
- Modern Methods
    - Remote Sensing
    - Digital aerial photogrametry

- GPS survey
- Total Station

Land data can be collected through primary and secondary means. Primary methods may involve field survey, GPS survey, Remote Sensing survey, Total Station survey and Aerial survey. Secondary means may employ digitizing from existing maps and aerial photographs, existing reports and statistics. Land data needs to be on digital format that can support to maintain computer based land information. Satellite imageries are very useful data source for small to large scale land use mapping. High resolution images such as Quickbird, IKONOS satellite data provide rich of information on land. Medium resolution images such as SPOT, IRS IC, Landsat TM images provide information for medium scale land use mapping.

6.4 Land Use Planning and Zoning.

Sustainable utilization of land could be achievable through proper land use planning measures. The future utilization of land should be planned considering appropriate factors. Arbitrary use of lands always lead to land degradation and suboptimal utilization. Planned land use prevents the arbitrary use of land. Land use planning will identify the lands to be conserved and protected which is environmentally fragile and sensitive. Land use planning evaluates the capacity of the land and puts the land for best uses. In doing so, there are a number of factors to be considered such as economic development strategies of the region, population growth and labor force, development goals and policies of the government, natural resources of the region, soil fertility and capability, land elevation, land values, environmentally sensitive areas, land needed for infrastructure development etc. Always the land use planning needs to start with public participation at grass root level.

SECTION 2-2

WATER RESOURCES AND DEVELOPMENT

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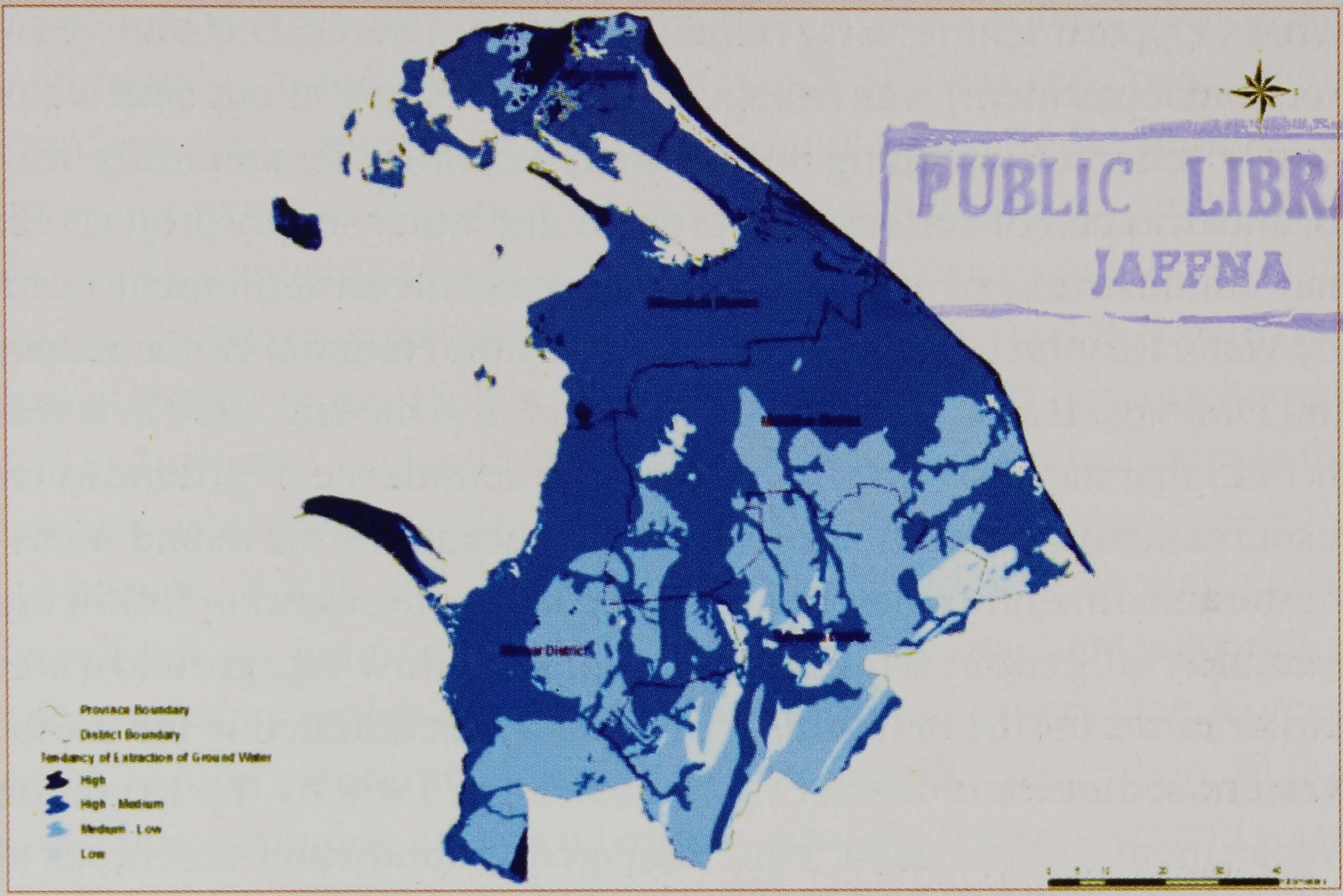
1.0 Groundwater Exploration, Usage and Threats in the Northern Province.

Groundwater is used extensively in Sri Lanka today. It is estimated that 72 % of the rural population in Sri Lanka (approx. 79 % of the population (Central Bank, 2006)) and 22 % of the urban population is dependent on groundwater for domestic water supply (WHO & UNICEF, 2004), in total about 60 % of the population. One third of the approximately 300 urban and rural water supply schemes across the country are based on supplies from shallow and deep groundwater resources (Panabokke & Perera, 2005). The amount of groundwater abstraction of these systems, which do not include the private individual wells, exceeds 16 mill. Cu. m per year (Table,Figure). Groundwater extracted by households without access to piped water supply is estimated at around 400 mill cu. m per year (Herath, 2006). Such extensive groundwater use in entire Sri Lanka is due to the recognition that groundwater provides a relatively stable sole source of water or acts as a reliable complimentary source to surface water during the dry season or longer dry spells. Informed exploration methods, improved drilling technology, cheaper pumps available today and government or NGO investment or subsidy schemes have made groundwater a relatively cheap alternative or supplement to surface water (Senaratne, 2002). As in many parts of the world, groundwater, though having been used for millennia, increasingly is resorted to as population increases, vagaries of rainfall hampers a steady utilization of surface water and these resources tend to become increasingly polluted (Herath, 2006) as clearly seen in some parts of the Northern Province, especially in the Jaffna peninsula. However, no inventory on the numbers of wells and the amount extracted (Other than for water supply schemes) been quantified in the past three decades in the entire northern province, with an exception of the Jaffna Peninsula where a few selected areas were under monitoring.

Furthermore, groundwater from deep limestone or alluvial aquifers (80 – 150 m) in the north-western coastal regions is used extensively for shrimp aquaculture, where fresh or low salinity groundwater supplement water from brackish lagoons and river mouths (Panabokke & Perera, 2005). Springs in the crystalline formations also provide important sources of domestic water in many parts of the country (Panabokke, 2007).

Quantity of groundwater and its percentages of supply over total supply in the urban, rural and industrial supply

District	Total supply of surface and groundwater resources (m^3 /day)	Supply of groundwater resources (m^3 /day)	Percentage of groundwater supply	Percentage of surface water supply
Jaffna	209	209	100	0
Mannar	550	550	100	0
Vavuniya	776	776	100	0



Groundwater potential regions of the Northern Province

Source: Statistical handbook of the Northern Provincial council

Source: WRB, ISEAI, Sri Lanka

2.0 Groundwater Exploration.

Groundwater from shallow wells has been the primary source of drinking water in Sri Lanka for thousands of years and local techniques for groundwater exploration have been developed by clergy men from pre-historic times (Senaratne, 2002). Urbanization and small scale industrial development along with the agricultural development have induced groundwater extraction in the sedimentary basins of the Northern Province prior to the independence though it was not quantified or under intensive study in the early 20th Century. Since then surface water was the main source for irrigation and groundwater irrigated cultivation. Policies on dry zone rural and agricultural development and development on urban water supply schemes based on groundwater and surface water for drinking and domestic purposes were introduced since independence and were managed by the Public

Works Department (PWD) (Cooray, 1983). The GSD (Geological Survey Department) was engaged in engineering geology and water supply schemes including public water supplies, demarcating well localities as part of colonisation projects and water supply projects for major industries and expansion of towns and urban settlements until the Water Resource Unit was undertaken by the National Water Supply and Drainage Board (NWSDB) of Sri Lanka in the late 1960's. It was in 1945 that the GSD first highlighted the abundance of groundwater resources and exploitation of such resources in the north and north-western sedimentary basins and in the sandy formations following a number of geophysical investigations. Following, groundwater explorations for the first time in Sri Lanka was initiated in the north-western sedimentary basin (Vannithavillu) in 1966 by the Irrigation Department of Sri Lanka, who managed groundwater resources at that time, in collaboration with the British Geological Survey (BGS) however, with the setting up of the new (present) Water Resources Board (WRB) in January, 1978, with the Groundwater Branch of the Irrigation Department, then became the permanent institutional home for groundwater studies in Sri Lanka. Alongside the mandate for groundwater studies being assigned to the WRB, the larger NWSDB also carries out special investigations for its specific needs which are more focused on town and country water supply. However, such role had been abandoned after the mid 1980's (Panabokke, 2007) where a few studies were later carried out by INGO investments.

Though groundwater explorations were initiated in the deep confined limestone formations of north-western Sri Lanka (Vannithavillu and Mulangavil), they moved towards the Jaffna Peninsula as serious groundwater problems were first predicted in the limestone and sandy aquifers after the alarming of the Israeli hydrogeologist Aran Arad in 1965. From the time the WRB was assigned the mandate for groundwater studies in this country, Several studies and investigations had been initiated and these include (a) characterization and mapping of the semi-confined aquifers in the North-West sedimentary formations; (b) detailed study and characterization of the Karstic aquifer of the Jaffna peninsula together with its water balance and water quality trends; (c) mapping of some alluvial and coastal plain aquifers; and (d) production of hydrogeological and groundwater maps for new development project areas. In depth research were focused via constructing bore holes, groundwater exploration through resistivity surveys and water level and groundwater quality monitoring and mapping in the 1970's and 1980's by the WRB (Gunasekaram, 1983), however, such investigations were moved to other parts of the country after the instability in the Northern province in early 1980's. At present, WRB and NWSDB are considered the two major state organizations, for groundwater studies, investigations and preparation of consultancy reports and their databases represent more than 30 years of collection effort, and contain information for more than 30,000 well sites, including data on tube wells, shallow water wells and water quality. For over the past 30 years, a few private drilling companies and donor funded projects such as DANIDA, FINIDA and GTZ have also been engaged in the investigation and preparation of consultancy reports pertaining to groundwater.

Groundwater quality problems in relation to geo-genic or anthropogenic sources throughout the island were brought under study after the establishment of the department of Geology in the University of Peradeniya in the 1980's and the inclusion and expansion of groundwater studies in the university curriculum in the past two decades. Such development of groundwater studies highlighted problems in relation to over extraction of groundwater and drying up of wells not only in the sedimentary formations but also in crystalline aquifers in the agricultural development areas (De Silva, 2002; Rajasooriyar et al. 2002) as well as serious groundwater quality problems in agricultural, rural and urban areas, especially in the limestone and sandy formations (Gunesekaram, 1983). However, such studies in the north including the Jaffna Peninsula unfortunately were not carried out in depth due to the ground situation and lack of research facilitation in the northern Province though groundwater studies were introduced at the university curriculum of the university Jaffna in the past decade.

3.0 Groundwater Threats.

3.1 Over Abstraction of Groundwater.

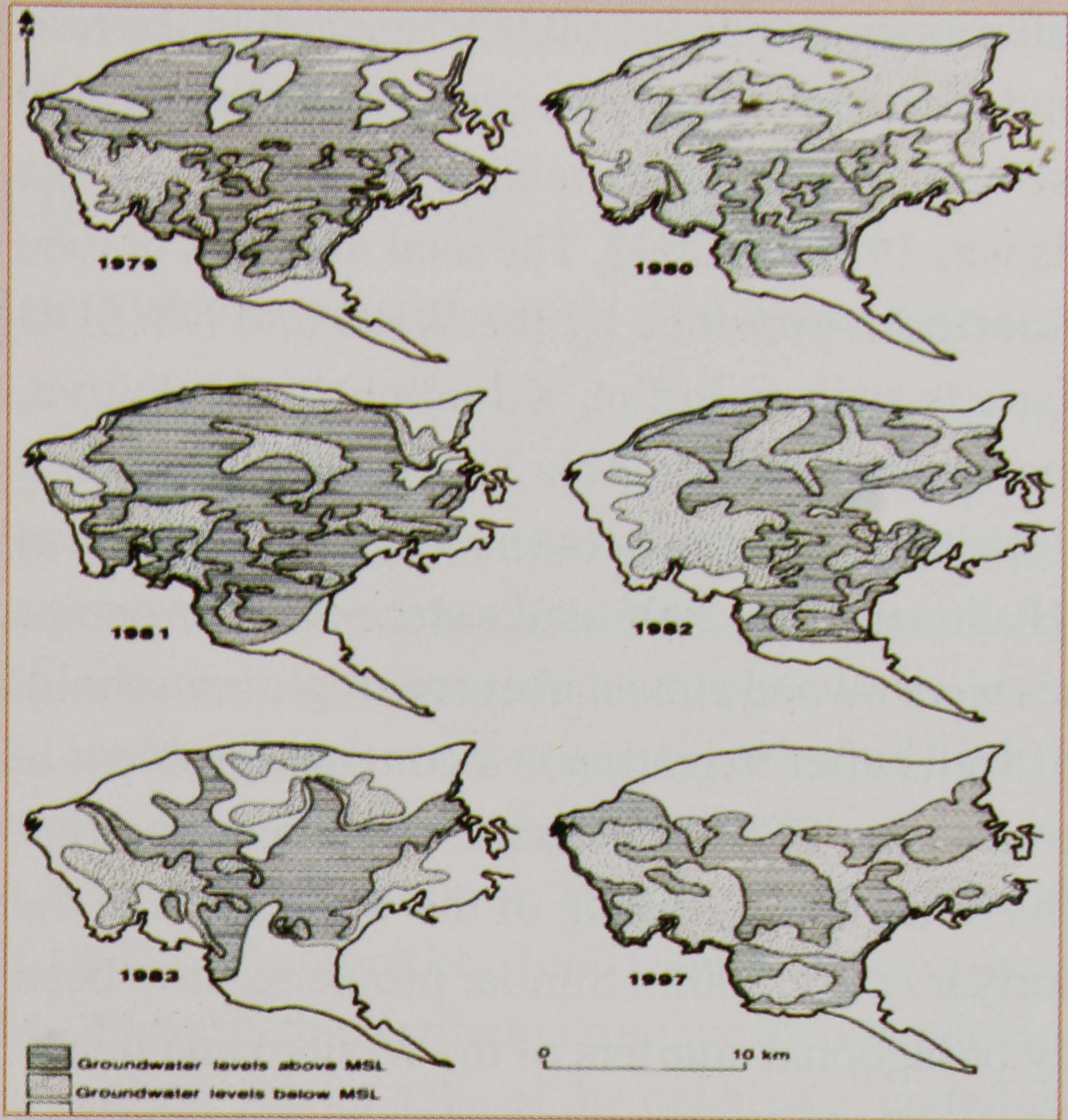
Groundwater irrigation initiated before the independence in the three major basins of north-western region namely Vannathivillu, Mulangavil and Murunkan were brought under investigations in mid sixties and later expanded to Mulaitivu (north-eastern basin) as the above basins, except Mulaitivu, were under intensive groundwater irrigated agriculture tending towards of high value crops. Such situation led to the increase in tube wells (200) and dug wells (800) in late 1970's resulting in salinity problems due to irrigation returns in 1990's (Panabokke, 2007). Groundwater irrigation has gained importance in the Northern Province for other field crops and vegetable cultivation. About 45% of the net area irrigated is covered by wells. Water quality studies have shown enhanced levels of salinity resulting from over extraction and leading towards lowering of water tables and sea water intrusions which has expanded the areas under negative water level elevations (water levels below the mean sea level) especially in the case of the Jaffna Peninsula (Rajasooriyar, et al., 2002) (Figure).

In northern and north-western Sri Lanka, groundwater is the major source of water for drinking and domestic uses and usage of mechanical devices on groundwater irrigation had increased since 1960's. The problem was encountered to be more severe in further north, especially in the Jaffna Peninsula, as groundwater is the only source of water in the Peninsula that lacks perennial rivers and surface water bodies. The Peninsula gained popularity for cash crops and horticulture such as bananas and grapes where yields continued to be high due to systematic use of irrigation and high inputs of agrochemicals (Gunesekaram, 1983). Agriculture in Jaffna had been profitable with the availability of inexpensive irrigation since the out break of civil war. The estimated number of dug wells in the Peninsula (which is approximately 1000 sq km in area) in 1980 was greater than 1,00,000 (excluding the tube wells of the WRB) and recent investigations suggest that there could be a ten fold increase in the numbers of wells in the peninsula. The number of agro wells was 19261 in 2002. The total numbers of tube wells drilled in the northern province by the WRB and NWSDB is around1236 in districts such as Jaffna, Kilinoichchi, Mulaitivu, Mannar and Trincomalee respectively (Table 3). The number of water extraction pumps (electric and other) was estimated to be greater than 25,000 in agro lands (Pathmanathan, 2004) and water extraction pumps for domestic purposes were owned almost in every single household. Though drying up of wells after irrigation is a common problem in this area, faster recovery rates of Miocene aquifers did not interrupt the irrigation patterns other than lowering of the water table in the dry seasons (Rajasooriyar *et. al.*, 2002). Similar problems have been encountered in sandy or lagoonal aquifers of the western and north-western coasts of the Northern province which is under intensive cultivation and where deep tube wells along the coasts of lagoons for shrimp aquaculture have been constructed and where enormous amounts of water is pumped to fill up aquaculture ponds (Vilholth and Rajasooriyar, 2011

Number of tube wells drilled in the Northern Province By the WRB and the NWSDB

District	No. of Tube wells		Total
	Constructed by WRB	Constructed by NWS&DB	
Jaffna	260	-	260
Kilinochchi	14	-	14
Mannar	99	34	133
Mulathivu	44	30	74
Vavuniya	503	498	1001
Total	**920**	**562**	**1482**

Source: after Panabokke and Perera, 2002

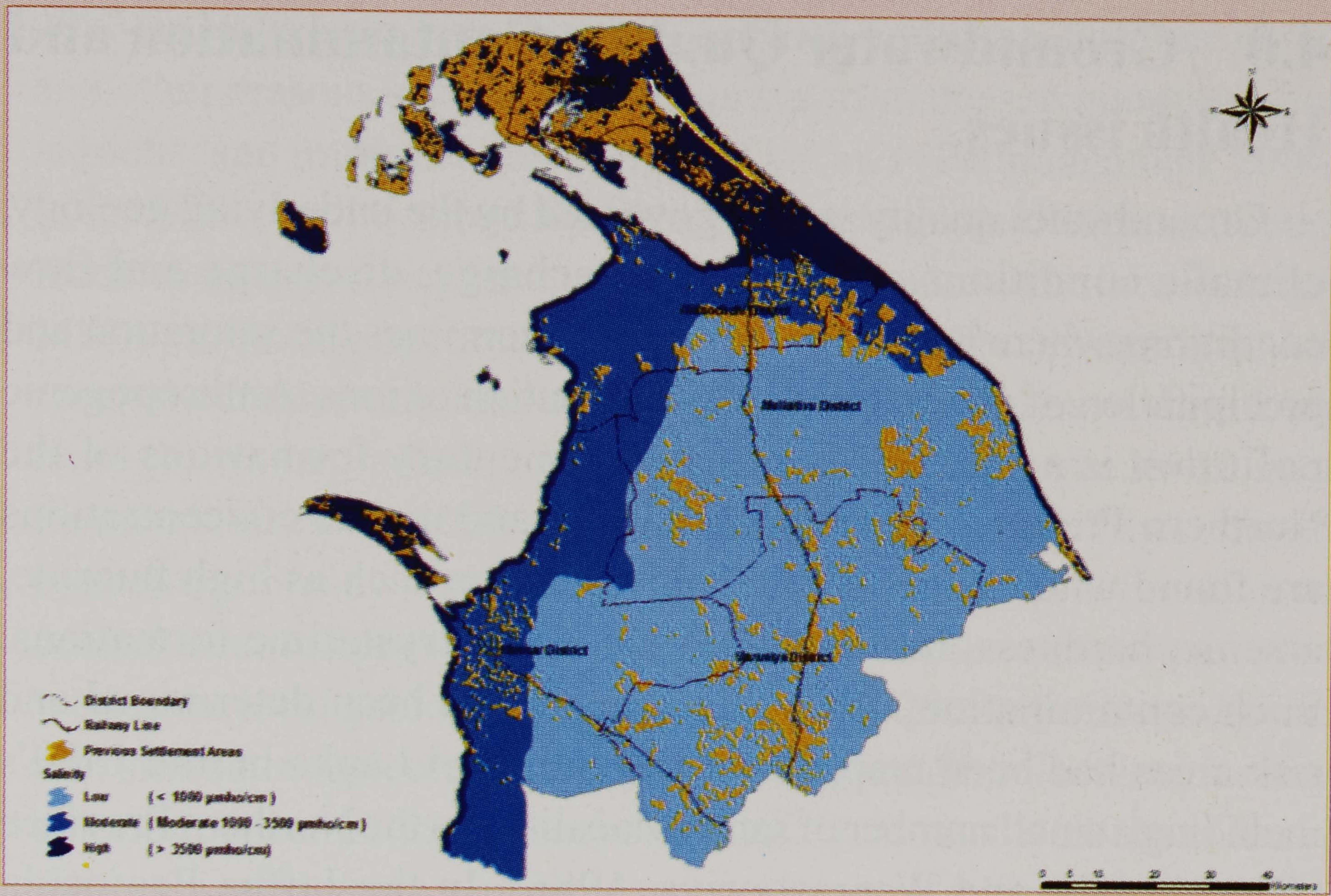


Groundwater levels below the mean sea level at the Valigamam region, Jaffna Peninsula

Source: Rajasooriyar et al., 2002

Furthermore, the occurrence of groundwater problems may be linked to the migration patterns of people caused by the civil unrest. For example, there has been a substantial move of civilians over the last decades from the problem-struck areas in the north and northeast to the central parts and western coastal regions of Sri Lanka. Due to out-migration, the population of the Jaffna Peninsula in the north declined from 918,000 in 1996 to 614,342 in 2010 (Pathmanathan, 2004). This gave rise to an alleviation of groundwater problems related to excessive groundwater abstraction rates in selected source areas of the Jaffna Peninsula in mid 1990's (Nandakoban, 2005) and conversely relatively higher pressure on groundwater in the new settlement regions (Figure). However, problems of contamination persist in Jaffna due to improper protection measures (Rajasooriyar et al. 2002).

The major groundwater problem in relation to its quantity in the crystalline rock terrains is either the fall of water tables (up to 3 -4



Groundwater basins in relation to patterns of settlement

Source: WRB, ISEAI, Sri Lanka

meters) or drying up of wells (De Silva, 2002a; Panabokke, 2002), however, information on groundwater exploration, usage and quality is minimal in the crystalline areas of the Northern Province other than a few information on the Vavuniya district. The quality of this deep groundwater is generally good with little or no fecal contamination, but several areas report a high level of fluoride and iron content in this deep water. The problem has been aggravated with the introduction of subsidy schemes in 1989 during which financial assistance was provided to the farmers for the construction of agro wells (Karunaratne and Pathmajajah, 2002). However, agro well development has not entered in to the upper western Vijayan or Wanni regions of the Northern Province as such subsidy schemes were developed only in the late 1980's, which is after the beginning of the civil war. Drinking water supplies and sanitation project in the district of Vavuniya had been commenced in 1982 at the height of a severe drought experienced due to drying up of conventional shallow large diameter wells of the settlement areas (caring for the environment II, 2008).

4.0 Groundwater Quality, Contamination and Health issues.

Groundwater quality is thus governed by the underlying geology, climatic conditions, groundwater recharge, discharge and flow conditions where mixing and dilution determines the saturation and precipitation of minerals and the distribution of ions. Anthropogenic pollution is a salient feature in sedimentary formations of the Northern Province where high salinity and nitrate concentrations are found whereas geo-genic contamination such as high fluoride, arsenic, hardness, iron and chloride in the crystalline formations. Such contamination, other than arsenic had been determined and risk areas had been mapped for the entire Sri Lanka in mid 1980's including a small number of sample localities in the Northern Province (Dissanayake and Weerasooriya, 1986). In the Jaffna Peninsula monitoring had been carried out involving a few groundwater quality parameters and well head measurements in the 1970's and 1980's. Besides these snapshots of water quality, little continuous monitoring of groundwater quality takes place at regional levels by academic institutions, NGO's, or government water institutions. Assuming groundwater quality problems encountered in the said similar geologic formations outside the administrative boundaries of the Northern Province, present water challenges may be highlighted in this section.

The sedimentary formations yield good quality water with an exception of the Miocene limestone aquifers as pure sandstone and sandy formations acts as natural purifiers, filtering contaminants. High hardness levels due to $CaCO_3$, dissolution is common in the limestone and sandy calcareous formations and high iron in the sandy formations of the north that leach into the groundwater. Two major inorganic water quality problems highlighted in Jaffna are salinity and high nitrate-nitrogen in groundwaters which are mostly due to anthropogenic factors. In general, salinisation of the aquifer due to increased evaporation rates from the wells and shallow groundwater levels, give rise to unacceptably high levels of salinity in the wells (Gunesekaram,

1983) in addition to factors such as, seawater intrusion, fertilizer inputs, and other reasons such as sea salt sprays from the surroundings seas/ lagoons, and improper positioning of latrines (Pathmanathan, 2004). In the Miocene limestone aquifers, excessive groundwater extraction leads to seasonal negative water levels (groundwater levels below MSL) promoting upcoming of seawater into the freshwater lens. As a result the fresh water lens of the Peninsula is said to have shrunk and there too was a gradual increase in groundwater chloride levels in the Peninsula since the 1980's (Rajasooriyar, *et al.*, 2002). High chloride concentrations as high as 20,000 to 30,000 mg/l in some selected coastal locations provide categorical evidence of seawater intrusions as well as the local geology (Rajasooriyar, *et al.*, 2002). Such condition is also similar in agricultural areas where high irrigation returns increase chloride concentrations (Panabokke, 2007). Almost 5, 039 ha of land in the Peninsula is been estimated to have become saline of which 4, 018 ha due to seawater intrusion, 138 ha due to fertiliser inputs and 949 ha due to other reasons such as sea salt sprays from the surroundings seas/ lagoons, improper positioning of latrines, etc (Pathmanathan, 2004).

High nitrate problems in the Miocene aquifers of the north is related to high inputs of artificial and natural fertilisers and congested or improperly planned soak away pit systems in the urban areas. In the Jaffna Peninsula, in early 1980's, more than 80% of the dug wells was estimated to be polluted by high nitrate concentrations and such concentration in selected agricultural and urban wells reached values more than 100 mg/l (Maheswaran and Mahalingam, 1983; Rajasooriyar *et al.*, 2002). Soil nitrate levels in urban Jaffna was found to be up to 1000 mg/l and in agricultural lands it was up to 1200 mg/l (Navaratnarajah, 1994) resulting in health hazards such as blue baby syndromes (Nesiah, *et al.*, 2005). Nitrate concentrations have been declining in selected regions (Nandakoban, 2005) of the north along due to changes in demographic patterns where a sharp decline in the population in 2005 (5,97,000) compared to year 1996 (9,18,000), however, they continue to remain high in the agricultural and highly populated urban areas of the Peninsula (Mikunthan, 2007).

In the crystalline formations, major water quality issues are rather geogenic. High chloride concentrations (>600 mg/l) and iron (upto 10 mg/l) in the crystalline formations, are confined to deep groundwaters, (Jayawardene, 1982). High fluoride concentrations, up to 9.0 mg/l (permissible limit for tropics is 0.8 mg/l), are confined to the low lying areas of the dry zone, Sri Lanka underlain by the major crystalline geologic formations. Similar Vijayan Series rocks of the island, such as biotite, hornblende gneisses, granitic gneisses, charnokite gneisses and scattered bands of metasediments rich in fluoride bearing minerals such as micas, hornblende and apatite along with minerals fluorite, tourmaline, sphene and topaz and contribute to the general geochemical cycle of fluorine (Dissanayake and Weerasooriya, 1986). Though such fluorine is sufficient for an enrichment of fluoride in groundwater upon weathering and leaching as found in North Central, Eastern and in some parts of the South Eastern sector of Sri Lanka (Warnakulasooriya *et al.*, 1990) no such risk areas had been identified in the Northern Province. Fertiliser fluoride contribution to groundwater is rather limited in Sri Lanka, except in a few regions, such as in the north central province (Dharmagunewadene, 1999). Groundwater fluoride levels in similar geologies, correlates well with the incidence of dental fluorosis in the central, north-central, north-eastern and south-eastern regions of Sri Lanka among the young population aged between 7 to 20 (Dissanayake, 1979; van der Hoek, *et al.*, 2003) and also with skeletal fluorosis. Arsenic in groundwater in Sri Lanka is a very recent phenomenon and in a preliminary stage of investigation in a few Vijayan series localities of southern Sri Lanka where high concentrations of arsenic has been found (> 0.35 mg/l) in dug wells (WHO permissible limit is 0.05 mg/l) and such investigations is an urgent requirement of the northern province.

Nitrate is not a risk factor in the crystalline aquifers though high nitrate fertiliser input is rather common (UREA fertiliser application up to 8700 kg/ha along with other nitrate containing fertilises such as NPK and TDM (Top Dressing Mixture, a mixture of nitrogen and potassium)) in paddy, banana and other cultivations, nitrate levels tend to be below 50 mg/l which is less than the WHO's maximum permissible levels of nitrate in drinking water (Dharmagunewardene, 2003). High nitrate concentrations have been controlled by biological denitrification and loss of nitrogen from waterlogged paddy soils (Rajasooriyar, 2003).

In Sri Lanka, quality of potable groundwater is of prime importance in health where the majority of the population depends on untreated groundwater for their drinking and domestic needs. Waters containing high fluoride, nitrate and arsenic are the major threat to detrimental health in majority of Sri Lanka as such ions are not detectable by human senses and have been in use since the time of well construction. Research on environmental entomology in Sri Lanka is in its primary stage of development and though dental fluorosis endemics have already been identified in a few selected regions (Dissanayake, 1991) .Similarly, blue baby syndromes have been identified in the northern high nitrate areas but frequencies of oesophagus cancers in relation to high nitrite has not been under investigation. Though high chloride, iron and total hardness may result in renal failures and other health hazards, they provide little health impacts in Sri Lanka as waters with the above ions in the crystalline formations have been abandoned by local communities due to detectable taste, colour or odour and thus less consumed.

5.0 River Basins and Surface Water Potential.

The Northern Province does not have a single perennial river, but with very limited seasonal streams and rivers. Traditional water storage was through built irrigation tanks. Percentage of inland waters is as given on Table 4. The ground water surveys done prior to the conflict indicate that intensive agriculture, especially paddy, cannot be supported without adequate replenishment of surface water storage as groundwater is in wider use for agriculture in the entire Northern province (Thivani, 2007) whereas 80% of the surface water and 60% of the ground water in the region have been exploited (Master plan for agricultural development, 2010). Water scarcity is a main constraint in many parts of the province, even for drinking and domestic use though the region is supplemented by several seasonal rivers as indicated in Table and Figure.

Extent of inland waters by districts

District	Total Area (sq.km)	Land Area (sq.km)	Inland Waters (sq.km)	Percentage of Inland Water	Total Brackish Water Resources (sq.km)
	8884	8290	594	7.1	
Jaffna	1025	929	96	9.3	884.33
Killinochchi	1279	1205	74	5.8	507.48
Mannar	1996	1880	116	5.8	172.04
Vavuniya	1967	1861	106	5.3	102.68
Mullativu	2617	2415	202	7.7	102.13

Source: Statistical handbook of the Northern Provincial Council

River basin characteristics and water practice in the Northern province

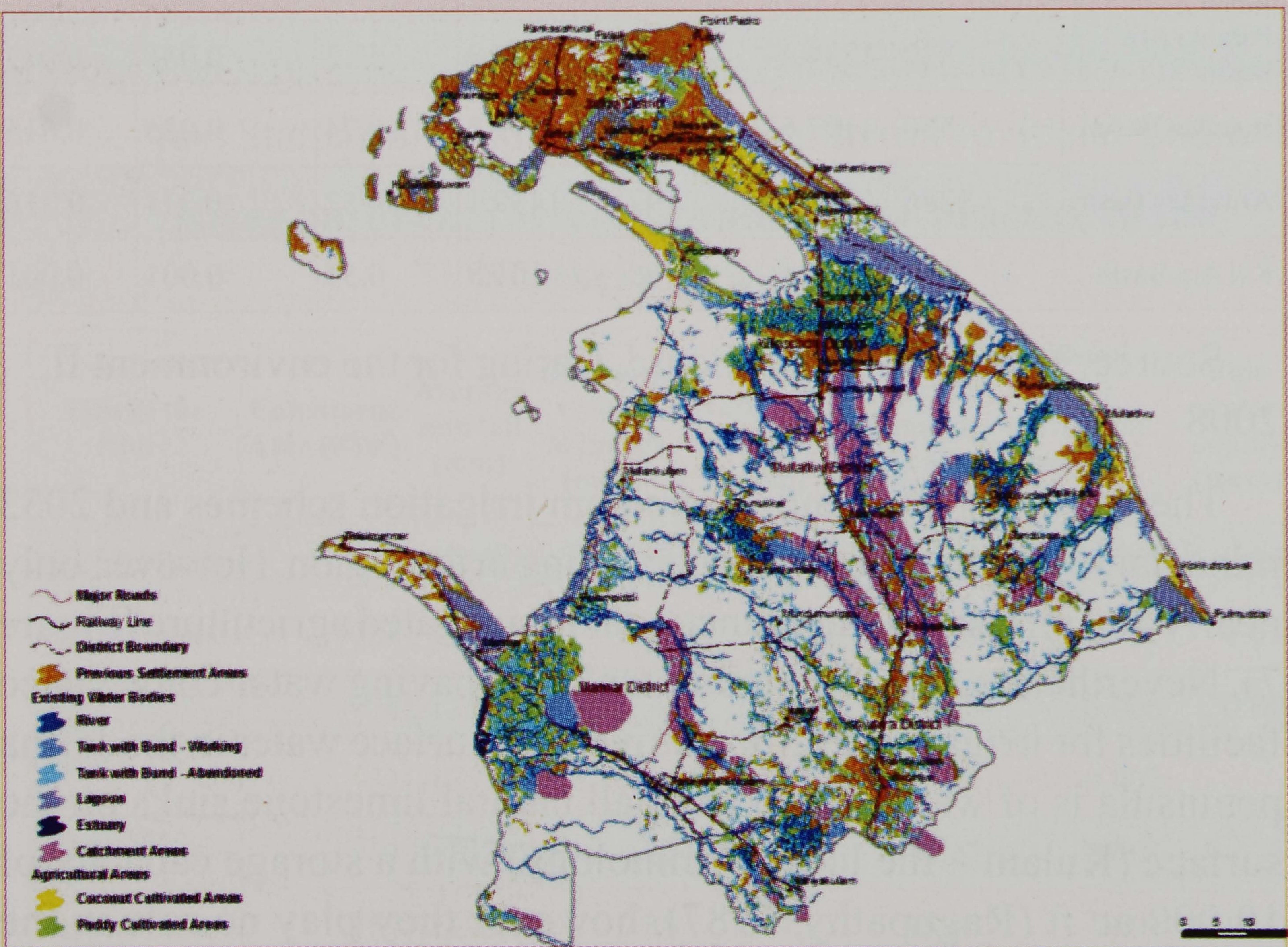
Title of the River	Catchment Area (Km^2)	Average rain fall (mm)	Discharge volume to the sea (mcm)	Water availability (per year) (mcm)	Irrigation demand (mcm)	Ground water extraction from dug wells (mcm)	Pipe water supply (mcm)
Mee Oya Basin	90	1324.2	41	51.1	1.22	0.002	0.004
Ma Oya Basin	1024	1322.8	481	410.1	114.69	0.035	0.027
Churiyan Ara Basin	74	1266.9	33	37.6	7.38	0.008	0.001
Chawar Ara Basin	31	1257.3	14	22.8	1	0.002	
Paledi Ara Basin	61	1237.2	27	22.2	0.27	0.001	
Nay Ara Basin	187	1193.7	84	75.3	35.63	0.01	0.001
Kadalikkallu Ara Basin	74	1221.2	33	38.5	11.68		
Per Aru Basin	374	1248.5	168	178.4	63.21	0.004	0.001
Pali Ara Basin	84	1237.9	38	40.2	1.46	0.004	
Maruthaipilly Ara Basin	41	1281.1	18	19.9	0.91	0.002	

Theravil Ara Basin	90	1288.6	41	47.1	10.58	0.003	
Peramantal Ara Basin	82	1306.8	31	36.9	0.32	0.006	
Nethali Ara Basin	120	1312.6	45	52.5	0.4	0.008	
Kahakarayan Ara Basin	896	1296.1	323	317.5	181.52	0.069	0.005
Kalawalakka Ara Basin	56	1335.1	21	29.1	0.2	0.004	
Akkarayan Ara Basin	192	1293.1	72	103	27.8	0.02	0.002
Mandekal Ara Basin	297	1251.6	111	124.4	4.48	0.026	0.002
Pullawanankadu Ara Basin	159	1222.9	60	62.9	2.82	0.019	0.001
Pali Ara Basin	451	1237.9	169	179.5	65.49	0.028	0.005
Chippi Ara and Punadi Ara Basin	66	1188.1	25	29.4	0.95	0.003	0.002
Paranki Ara Basin	832	1234.4	312	314.8	52.2	0.058	0.012
Nay Ara Basin	560	1197.6	210	119.8	19.74	0.035	0.015
AruviAra Basin	3246	1290.1	192	1439.1	484.52	0.311	0.316
Kal Ara Basin	210	1186.1	66	101.8	0.55	0.001	0.001

Source: Water Resources Board, Caring for the environment II, 2008

There are 15 major and 35 medium irrigation schemes and 2033 minor tanks available for water harvesting in the region. However, only nearly 800 minor tanks are functional for irrigated agriculture (Figure 7). Nevertheless, only 540 minor tanks are having water conveyance facilities for irrigation to crop cultivation. Surface water in the Jaffna peninsula is of water stored in small natural limestone sinks on the surface (Kulam – the local terminology) with a storage capacity of 10,000 ac ft (Ragupathy, 1987), however they play no role in the irrigation ordinance. In the mainland of the Northern Province, the irrigation ordinance is of a network of manmade tanks (generally called reservoirs) connected to the seasonal rivers. The major tank cascade systems and existing major irrigation schemes (Iranamadu, Giant's Tank, Pavakkulam, Kalmadu) play a major role in meeting the water demands for agriculture and other requirements. Though the storage capacity of the major irrigation cascade system is being quantified, major drawback in utilizing the irrigation schemes encountered implies less developed but modernized ways of irrigation systems resulting in poor irrigation efficiency and heavy conveyance loss as well addressed by eminent people, thus emphasize the need for close examination and determination of the productive capacity of agriculture and irrigation as well as quality of drinking water available in the northern districts. In such regard, even the Iranamadu scheme, this is one of the 10 major schemes of the country, needs rehabilitation for potential use of the scheme (Master plan for agricultural development, 2010).

Tanks and irrigation cascade of the Northern Province



Source: WRB, ISEAI, Sri Lanka

The irrigation system in the northern region is yet to be improved for optimum use of water. Most of the tank irrigation system needs modernization though irrigation is managed by participatory concept. The use of water based on plant water requirement has yet to be improved. However, the modernized irrigation infrastructure such as on-farm infrastructure for regulated distribution etc. will optimize the use of irrigation water. Even though irrigation is done for paddy crop by the schemes, some schemes - Iranamadu, Piramathal-aru and Akarayan irrigation schemes is also meant to supply water for cultivation, too.

Rivers and their percentage discharge of the Northern Province

Indiscriminate use of water due to several factors is the major impediments for effective utilization of irrigation water for cultivation of crops. Derelict water management infrastructure in the existing developed irrigation schemes causes unproductive loss of irrigation water and thus results in deficit in irrigation water availability towards advancement of agricultural lands (Thivani, 2007). There is a need to increase the productivity in rain-fed land, particularly in the context of exploitation of surface and groundwaters in a reconstruction scenario in the Northern Province.

Source: National Atlas of Sri Lanka

6.0 Requirements for Water Resource Management in the Northern Province.

Water resources inventory, planning and management is one of the major areas need focus towards the development of the Northern Province in the post war rehabilitation and reconstruction scenario. In the event, neither the surface water nor the aquifers were stabilized through deliberate development policies and administrative measures regulating limestone mining, land use, water use, agrochemical use, investment in forestry and pond rehabilitation, disinvestment in industries consuming limestone, and comprehensive municipal reforms, but as an unintended consequence of the civil war (Nesiah et. al., 2005). The following issues should be brought under the focus of the general public of this nation, government and non-governmental water managing and development agencies, policy makers and researchers of the well reputed academic institution.

6.1 Legislation and Institutional setup.

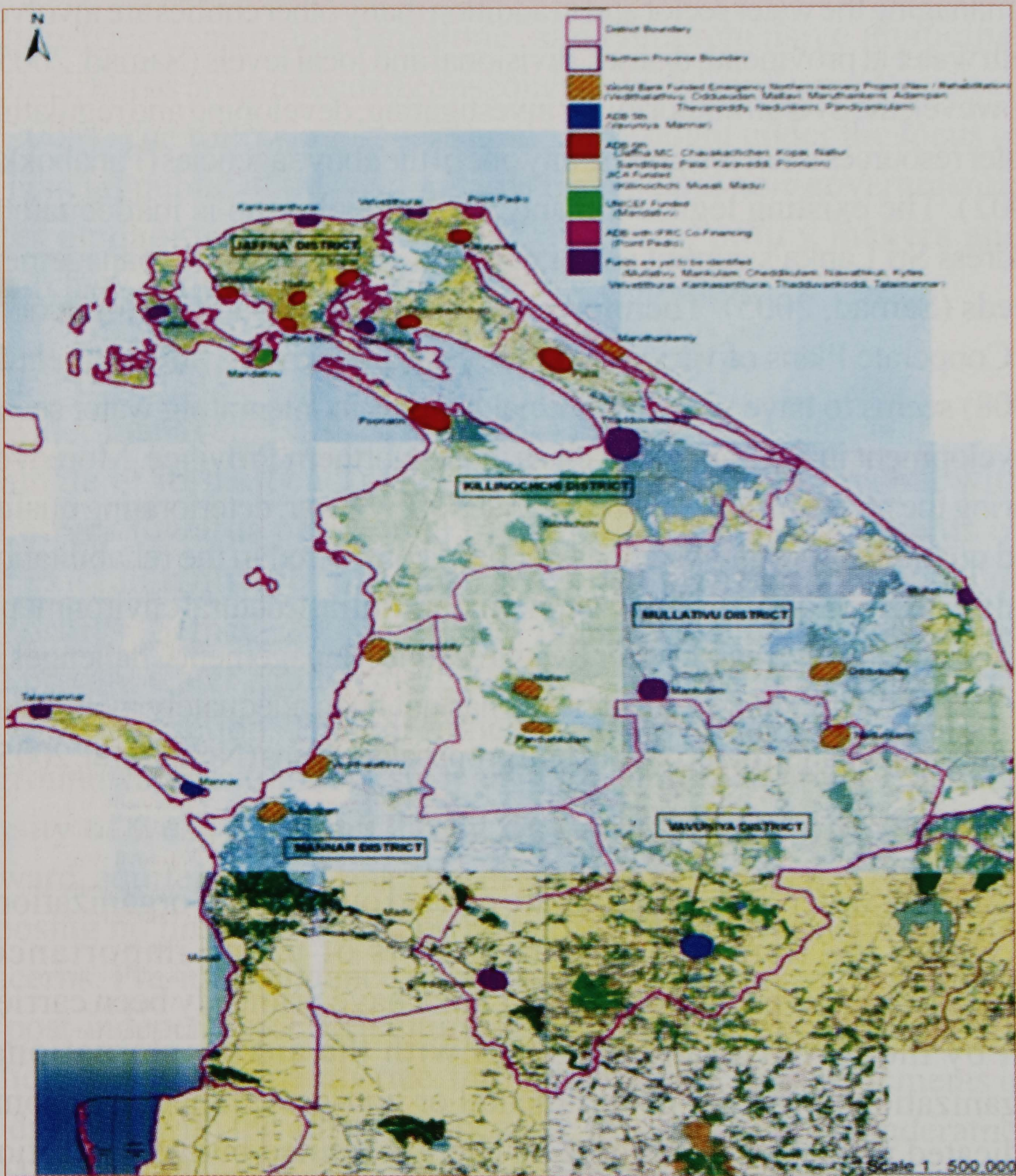
Water management in Sri Lanka is in its infant stage as there is no single or formally accepted water policy or water law but with initiatives towards policy making at present. Only fragments of law exist in a number of legislative enactments among various authorities (Samad, 2005). Prior to independence, laws on public and private water rights emerged but no permission was required for water extraction. Though some initiatives to define upper limits to groundwater extraction, such as in the hard rock areas, based on density of wells (Nagarajah and Gamage, 1998), have been put forward, aquifers in Sri Lanka are in practice freely open to everyone, imposing no limits governed by resource availability and protection concerns. Pre-independence policies of 1931 continued to dominate the post-independence agricultural policies focusing on attaining self-sufficiency in food, mainly rice, through extensive land settlements in the dry zone with the aid of inexpensive irrigated water (Sanderatne, 2004). The policies and practices devolved in the post-independence era towards land settlements, agricultural development, and unplanned urban growth have resulted in the increase of wells and exploitation of groundwater. Attempts of imposing legislation on water use has had little impact on changing the agricultural policy as the institutional setting of the water sector in Sri Lanka includes both the 'general institutional environment' (constitutional, political, and economic arrangements) as well as specific 'water institutional structure' (water related laws, policies and organizations) (Saleth and Dinar, 2004).

In total, at a national level, more than 25 government agencies play a role in managing the water sector and in addition many other entities are involved with water at provincial, district, divisional and local levels (Samad, 2005). However, the overall authority for investigating, developing and regulating water resources is not assigned to any one of the above agencies (Panabokke, 2002). The existing legislation and institutional setup is inadequate to address Sri Lanka's current and anticipated water resources management needs (Samad, 2005). Therefore, accommodating water sector actions in Cooperate Plans of various institutions (caring for the environment II, 2008) seems to have yielded minimal benefits in integrating water sector development in Sri Lanka as well as in the Northern Province. Moreover, during the recent history of three decades of civil war, deteriorating quality and quantity of groundwater has not been considered in the rehabilitation and reconstruction of the socio-economic and infrastructural environments and considered the major Water Resources and Management Challenges in Sri Lanka. Water management hence has not been adequately included in recent rehabilitation or reconstruction proposals or plans (Nesiah et al. 2005).

6.2 Monitoring, Research and Training.

Surface water investigations are carried out of many organizations of which the Irrigation Department is of prime importance. Groundwater investigations in Sri Lanka have primarily been carried out by the NWSDB and the WRB with the aid of international organizations, whether governmental or non-governmental as some indicated in Table 6 and Figure 9. There is limited budget allocation from national public funds for water resources research and nor the data originated by the government and non-governmental organizations are shared among the academic research activities. Most studies are of a localized and fragmented nature with relatively little reporting in national and international scientific literature. As a result there is inadequate exchange of knowledge between Sri Lankan researchers and the planners of the water related agencies again as well as with the international research community.

Recent activities of the NWSDB and their localities in the Northern Province



Source: NWSDB, 2011

Recent activities of the NWSDB in districts of the Northern Province

Project / Scheme District / DS	Division	Source of Funds	No of Benefi ciaries	Estimate (Rs. mln)	Expen diture up to 31-05-2011 (Rs. mln)	Progress in detail
Ground water projects (2010)						
Drilling of bore holes, installation of pumps in new bore holes, rehabil itation of dug wells.	**Province**	UNICEF	10000	14.61	14.61	
						• Hydrogeological & Geophysical Investigations - 69.
	Vavuniya					• Drilling of successful boreholes – 31.
	Mannar					• Supply & Installation of Hand Pumps –
	Mullaithivu					19
						• Cleaning of existing dug wells – 334.
						• Rehabilitation of existing Hand Pump
						Tube Wells – 44.
						• Drilling of (60m) boreholes – 04
						• Repairing of existing hand pumps – 33

Source: NWSDB, 2011

Past studies and investigations on groundwater resources conducted in Sri Lanka have been reviewed by Panabokke (2007). A bibliography exists of 327 published and unpublished groundwater-related studies for the period of 1955 to 1999 (WRD, 2000). A significant body of data relating to quantitative and qualitative aspects of groundwater has been gathered by individual organizations (like WRB and NWSDB) as well as by various scientists over the past 30 years (Panabokke and Perera, 2005). However, no central, comprehensive and coordinated database exists. A database at WRB contains information on more than 30,000 well sites, primarily collected at the time of construction of the wells, and mainly for deep wells (Panabokke and Perera, 2005).

There is no consistency in data collection, well numbering systems, well coordinate systems, and GIS software used between institutional groundwater databases (JICA, 2002). A significant barrier to proper water management is the lack of continuous and long term monitoring of water levels and quality at local and national level (Panabokke and Perera, 2005). However, progress on combined and integrated use of in-situ monitoring data with remotely sensed data of hydrological and water resources parameters support better understanding of larger-scale basin-wide water balances and availability and irrigation performance (Bastiaanssen and Makin 2003; Roerink et al. 1997).

The establishment of the Department of Geology at the University of Peradeniya in the 1980's has promoted groundwater investigations and research focused on groundwater related problems. Similarly, progress is due to the inclusion and expansion of groundwater studies in the university curriculum of geology, chemistry, geography and agricultural engineering, at the universities of Peradeniya, Jaffna and the Open University of Colombo during the last couple of decades. Though such development has helped in the training of hydrogeologists and geochemists recruited to the academic and administrative water sector institutions at a smaller level, such universities that rely on national funds face many obstacles in promoting research activities mainly due to lack of physical infrastructure for research. However, they have still supported incipient regional and national level groundwater management. As an example, most investigations related to the geo-genic contamination of groundwater have emerged as a result of the establishment of these research environments. A research field which has not really taken off in Sri Lanka is that of integrated and distributed groundwater modeling (Senarath, 2002), which is partly explained by lack of present technical capacity and adequate data. Some projects of more developmental nature have components of groundwater management and protection included, as part of community social and welfare development programmes on drinking water and sanitation issues. Unfortunately, these efforts and experiences are seldom properly assembled, published and disseminated to users and groundwater professionals (Panabokke, 2001).

6.3 Public Awareness and Participation.

Very little public awareness programmes or community level participatory programmes on groundwater resources have been initiated in Sri Lanka (Panabokke, 2001) including the Northern Province where serious water quality and quantity problems in relation to human health and livihood had been emerged. Despite the initial water quality analysis and monitoring of new wells, limited measures have been taken to alarm the public on toxic waters and prevent them from consuming this and make them understand the future perspectives of water demands. There is hardly any integration between the scientific community and the decision makers and implementators and such hinders general awareness on protecting the resource.

Compared to surface waters, groundwater is a poorly understood resource by the public, and for the most part, farmers consider groundwater as a separate, disconnected, and unlimited resource. There are no documented cases of farmers joining forces for the shared responsibility of optimizing use and protection of groundwater resources.

Water related studies have not been included in the school level curriculum as well, except in selected university curriculum. Learning from other nation's experience towards utilization of surface and groundwaters and guiding policies towards groundwater rights and protecting groundwater is expected to be of great importance (Pathmarajah, 2002).

7.0 Vision and Mission towards promoting Water Resource Management in the Northern Province.

Incorporating legislation towards protecting and serving for the optimum usage of surface and groundwater resources justifies scientific knowledge in problem identification and management. Such needs demands participation of public and private stakeholders such as the major water resource institutions, experts of the NGO's and INGO's academics at universities and schools, administrators and inhabitants of the local region and sharing of knowledge and research infrastructure towards commitment on managing water resources. The prime needs of managing water resources in the Northern Province are as follows;

1. Developing a water resource inventory covering the entire Northern Province via scientific inquiry, incorporating stakeholders at all levels. Though such measures have already been taken by the WRB and the NWSDB in selected regions of the Jaffna Peninsula, integration and stakeholder participation is considered as an initial requirement for involving people and bringing primary awareness among the community, academics and administrators.

2. Developing hydrometric networks designed in a justified scientific manner relying on the physical and human environments of the Northern Province including at least precipitation, evaporation, surface water and groundwater networks for monitoring and problem identification in the light of the new era.

3. Relying on the data collected by the 2nd activity, incorporating monitoring at school levels, small scale water related research at undergraduate levels and in-depth water research at postgraduate levels and sharing knowledge at local, regional, national and international levels for identifying proper tools for managing water resources and for funding.

4. Brining public awareness and contributing via scientific inquiry for developing legislation towards optimal usage but efficient management of the resource towards economic and social development and protect the resource for the future community.

SECTION 2-3

DEVELOPMENT OF FISHERIES SECTOR IN THE NORTHERN SRI LANKA

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1.0. Trends in Marine Fish Production.

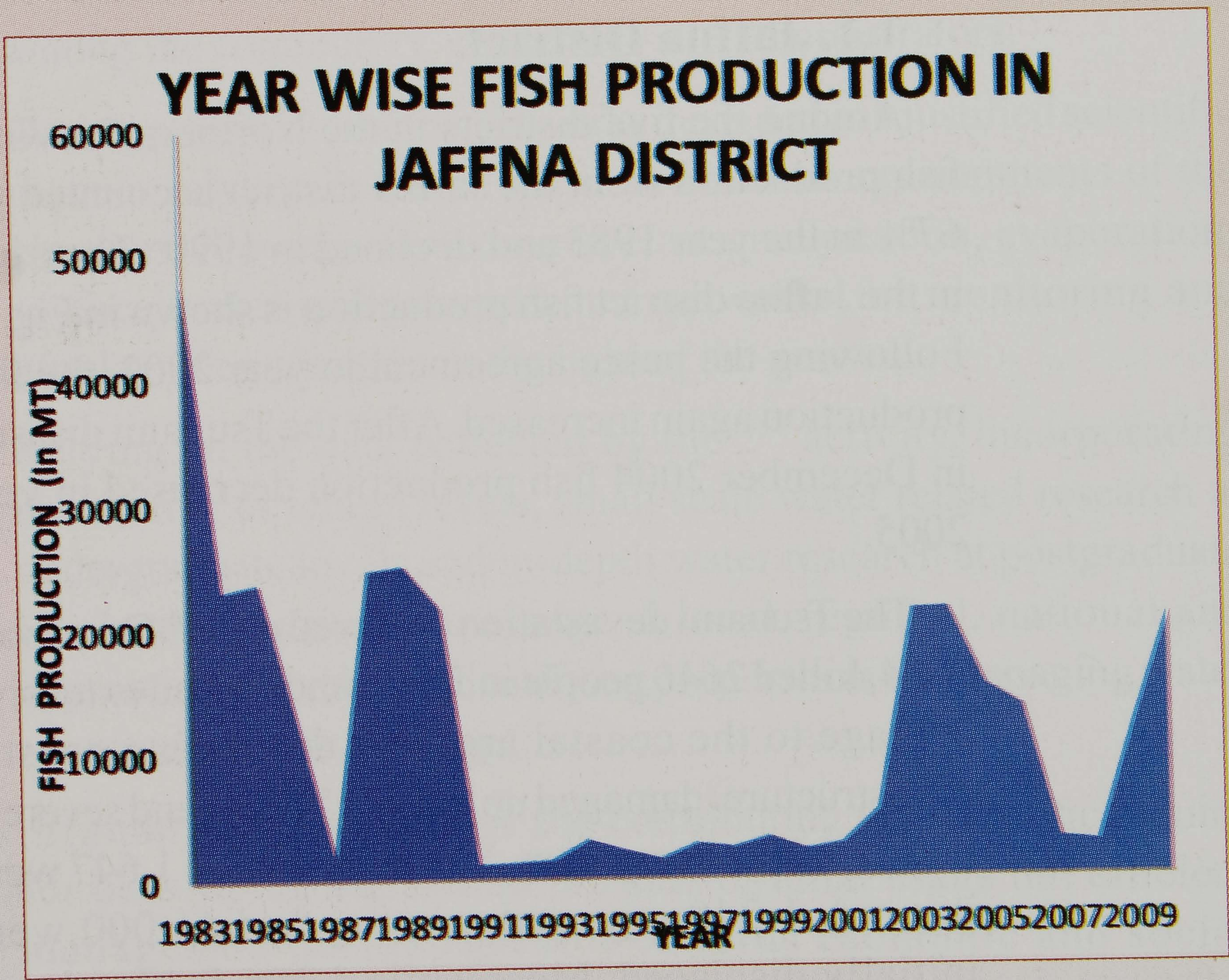
1.1. Jaffna District.

Among the five districts in the Northern Province fish production from the Jaffna district accounted for 67% in the year 1983 and declined in 1990. The trend in the Jaffna district fish production is shown in Fig. 1. Following the peace agreement in year 2002, the fish production again increased. After the Tsunami disaster in December 2004 fish production decreased in year 2005.

The Tsunami devastation occurred on 26th December 2004, killed 2640 people in Jaffna and caused extensive damage to the coastal areas by destroying coastal infrastructure, damaged up to 3469 houses and severely destroyed the ecosystem. Further a total of 1,647 were injured, 1,240 reported missing and 41,000 were initially displaced. Meanwhile 4,206 fishing boats and crafts and been previously damaged as a result of conflict and another 2,279 were affected by the Tsunami. In addition, much of the fishing infrastructure along the coastal areas has been damaged. Thus the Tsunami has increased the vulnerability of a large proportion of fishermen whose incomes were to be uplifted under the poverty reduction programme.

In Jaffna harvesting levels more or less related to subsistence needs, while technical and economic limits prevented the stock being overexploited. Mainly after the Tsunami devastation, need for sustainable development plans became intense. Apart from the Tsunami, fishing industry is the sector most affected by the conflict. Fishing has been severely restricted for several years and nearly totally banned since October 1995. A large number of boats and fishing gears were damaged during the civil war.

Trends in annual fish production in Jaffna district (Source: DFAR, Jaffna).



Figiure.1

During the pre-conflict period, in 1983, there were 24,000 fishing families, and a total fishing population of 112,000 of which 27,000 were active fishermen. The scale of population displacement in Jaffna first escalated again to an unprecedented level from October 1995. Consequently, in 1997 the number of fishing families was reduced to 8390 and the fishing population was reduced to 41,115 of which active fishermen were only 9276. These figures are nearly one-third of the figures in 1983.

Once Jaffna district was brought under the control of Government forces, the displaced population gradually returned to their place of origin. This was the time several international aid agencies, such as UNDP, UNHCR and CARE had commenced rehabilitation projects in Jaffna. In 2001, the number of active fishermen, fishing families and population increased up to around half of the figure before the conflict.

After signing the Memorandum of Understanding (MoU) in 2002 and the cease-fire agreement, the main A9 road was opened for traffic. Trucks brought ice from Colombo moved directly to the coastal areas of Jaffna district to buy fish for Colombo market whereas earlier goods were transported to and from Jaffna mostly by ship and rarely by flight. Since fishermen were allowed to do fishing day and night without restrictions on distance, it facilitated more production of fish, especially during the latter months of the year 2002. In such situation the Tsunami devastation occurred in December 2004.

Fishermen slowly resumed fishing around July 2005 and independent fishing occurred from August to December 2005. Again in December 2005 fishing with mechanized boats was prohibited in some places of Jaffna due to security restrictions. Fishing nos allowed only with traditional craft and, catamarans. Since then a fluctuating fishing activity was found due to intermittent restrictions.

Again fishing was totally banned from August 2006 as soon as the A9 route was closed. Later severe restrictions prevented fishermen from regular active fishing, due to the abrogation of CFA in February 2007. Again suddenly dropped in 2007 due to closure of A9 road and fishing restriction. From 2009 the fish production is steadily increasing. It was 13080, 20890 and 25670 metric tons in 2009, 2010 and 2011 respectively.

1.2 Other Districts in the Northern Province.

Marine fish production in Mannar, Mullaitivu and Kilinochchi districts in year 1982, 2009, 2010 and 2011 are tabulated in Table.

Marine fish production in Mannar, Mullaitivu and Kilinochchi (in Mt) in 1982, 2009, 2010 and 2011.				
District	**1982**	**2009**	**2010**	**2011**
Mullaithivu	8 290	--	1 360	2 580
Kilinochchi	--	-	560	5 260
Jaffna	43 550	13 080	20 890	25 670
Mannar	13 403	8 130	10 790	12 860

2.0 Need for Rehabilitation and Development.

The fisheries sector has been recognized as an important component of the livelihood system of communities in the Northern Province. The fishing families of 19 055 and fishing population of 78 147 live in scattered coastal communities in the Jaffna district with 18 596 active fishermen, in year 2010. Fishing was severely affected by the conflict that prevailed in the region in the last three decades and in need of rehabilitation and development.

Human resources involved in marine fishery in the four coastal districts in year 1982, 2009, 2010 and 2011 are summarized below in Table .

Human resources in 1982, 2009, 2010 and 2011 in northern province (Source: Fishery statistics DOF).					
		Kilinochchi	Mullaitivu	Jaffna	Mannar
1982	Active fishermen	1103	3183	24839	5684
2009		750	1200	15195	8392
2010		2670	730	20603	7541
2011		3900	3775	21243	8193

The number of active fishermen has not achieved the status that was in 1982 still. This is due to displacement, migration and death of human beings due to the situation that prevailed in the Northern region.

3.0 Increase of Fishing Boats.

Fishing boats along coastal areas in the Northern Province sustained extensive damage during the Tsunami in 2004. Due to the intervention of government and Non Governmental Organizations (NGOs) in Jaffna district the number of boats increased rapidly in numbers. These increases however concentrated on traditional craft and 17.5 to 23 foot fiberglass reinforced plastic mechanized boats, with the main type being 18 foot boats. This is actually due to the fact that the fishermen of Jaffna were unable to build up the sufficient capital to invest in multi-day boats. The situation has changed recently. The number of multiday boats increased to 09 in late 2010 whereas it was only 01 in December 2009. According to DFAR in Jaffna it was 21 in 2011. Status of number of boats in 1982 and 2011 is given in Table.

Availability of fishing boats in 1982 and 2011 (Source: Fishery statistics DOF)

	Kilinochchi		Mullaitivu		Jaffna		Mannar	
Year	1982	2011	1982	2011	1982	2011	1982	2011
Multi-day boats	--	--	--	--	--	21	--	0
Day boats (1 day)	--	--	--	--	60	171	24	82
FRP boats	82	407	196	515	298	2385	86	1747
OBM traditional (MTRB)	24	15	138	1	192	412	81	185
Non mechanized traditional boats (NTRB)	221	187	221	76	3562	2677	607	610
Total	**327**	**609**	**555**	**592**	**4112**	**5666**	**798**	**2624**
Beach seines (NBSB)	5	--	70	--	110	--	115	--

4.0 Infrastructure Facilities

A fishery harbour is a complex of facilities that acts as an interface between capture of fish and its consumption. A comprehensive fishery harbour includes fish processing facilities, cold storage, ice plant, administrative office and several other facilities in the harbour complex including fuel supply unit, repair unit with slip way, servicing unit, roads, parking areas for private and commercial vehicles, space around halls for loading and unloading, net repair halls and areas for future expansion. At present there are no adequate harbour facilities in the Northern region. The only fishery harbor located in Myliddy, is currently not in operation. Ocean Perlynn moors at Karainagar Navy base which is far from the fishermen's residences.

There are 128 fish landing centers found in the Jaffna district. With the end of the conflict and the relaxation of the restriction imposed, fishing activities have resumed or expanded in many landing sites, even though most facilities are in need of restoration. Few of the sites are still within the HSZs and inaccessible for fishing communities. The Fishery Inspector division in the Jaffna and Point Pedro are the most productive area in Jaffna district and therefore strengthening fisheries infrastructure is essential there. The status of fish auction halls and fish markets seems to be poor, most fishermen sell fish in the open air and without shade, which quickly spoil the quality of fish.

Availability of fishing harbours, anchorages, fish landing centers, fishermen cooperative societies and members of fishermen cooperative societies in year 2009 and 2011 are given in Table.

Availability of fishery infrastructure by 2009 and 2011 (Source: Fishery statistics DOF & MFARD); NA: Data not available

	Kilinochchi		Mullaitivu		Jaffna		Mannar		Vavuniya	
Year	2009	2011	2009	2011	2009	2011	2009	2011	2009	2011
Fishery harbour	0	0	0	0	0	0	0	0	0	--
Anchorages	0	0	0	0	0	0	0	0	0	--
Fish landing centers	17	42	26	18	128	118	50	57	23	NA
Fisheries Cooperative Societies (FCS)	25	24	24	21	117	117	35	39	12	NA
Members of the FCS	2405	3800	2848	2775	18046	17970	6817	8659	400	NA

As at December 2011, 15 ice plants with the capacity of 35.9 Mt/day are in operation in the Jaffna district. The production capacity of these plants is still deficient to meet the demand for ice in the Jaffna district. Fishermen feel that the ice produced in the ice plants operated in the Jaffna district is highly expensive than the ice they bought from fish buyers from the south. Status of ice-plants in year 2009, 2010 and 2011 is shown in Table.

Status of ice supply units in 2009, 2010 and 2011						
District	No. of ice plant			Total production capacity (Mt/day)		
	2009	2010	2011	2009	2010	2011
Jaffna	7	12	15	10	22.4	35.9
Kilinochchi	--	--	--	--	--	--
Mullaitivu	--	--	--	--	--	--
Mannar	5	09	11	40	--	--

There were only four fish purchasing centers in the Jaffna district and one in the Mannar district in the year 2011 (Table). There is a need to increase the fish purchasing centers to raise the marketing facilities of the fishermen.

Availability of fish purchasing centers (regions) in 2011	
District	No. of dedicated units to collect fish
Jaffna	04
Kilinochchi	03
Mullaitivu	01
Mannar	01

There were nine boat yards in the Jaffna district in year 2011. Many of these boat yards build 18-foot FRP boats or the traditional type of FR boats. Only one boat yard commenced building 28-foot one-day boats and started to build 32-foot multiday boats in 2011 without any outside assistance in terms of finance and technology.

5.0 Challenges in Reconstruction and Development of Fisheries Sector.

The coastal fisheries contributes more than 60% of the total marine fish production which is still the back bone of the fishing industry. It is generally believed that coastal fishing has now reached optimal level of production except a few underutilized species. Most of the fishermen engaged in fisheries in the North are dependent on coastal fisheries as their sole source of income.

In the past, improvement and expansion of coastal fisheries were selected as the first priority in the development strategy in view of the fact that the coastal fisheries:

i) offered the best prospects for a rapid expansion in the fish supply

ii) were main source of employment and income in most coastal areas

iii) had the lowest input cost per ton of fish produced and

iv) had the minimum foreign exchange cost per job creation.

In the past, development of offshore fisheries ranked next in the order of priority was carried out by local private sector with its own resources or in collaboration with foreign investors. Deep sea fisheries received lower priority as heavy capital outlays and advanced technology are involved. Now it is the time to think about offshore/ deep sea fishery and aquaculture for getting more production from the marine sector to satisfy the ever increasing demand for fish protein.

The major challenges involved in reconstruction and development of fisheries sector are listed below.

5.1. Investment Cost.

A multiday boat including gears and other accessories costs about Rs.15 million. In the present state, it is not possible for fishermen in the region to own a multiday boat without financial assistance.

5.2. Suitable Harbours.

The navy base harbour at Karainagar appears to be suitable, however, it will not be possible to use it for more numbers of fishermen . The fishing harbour at Myliddy has not been in use for the last 20 years owing to high security zone. It will be a boon to deep sea fishing if Myliddy harbour is completed and made available for use or construction of new fishing harbour in Point Pedro.

5.3. Trained Crew.

Crew knowledgeable in Navigation and seamanship to the multiday boats in the deep sea are badly needed. Such trained personnel are not available in the North at the moment. Energetic youngsters who are willing to undergo this training and engage in deep sea fisheries are in plenty in the North.

The Department of Fisheries and the Department of Geography, University of Jaffna and the College of Fisheries and Nautical Engineering, Jaffna and NARA could collaborate in this matter. Some steps have already been initiated in the programme of the College of Fisheries and Nautical Engineering, Jaffna.

5.4. Marketing Facilities.

At present, the catches of Ocean Perlyn and the other multiday boats are taken in cooler trucks to Colombo for marketing. Opening-up of suitable purchasing centres in the North will have to be given top priority.

5.5. Poaching.

Trawlers from India illegally engage in fishing in the territorial waters of the country and is a long term problem. Necessary steps should be taken to solve this problem amicably.

5.6. Sustainable Management.

Sustainable fisheries management must go hand-in-hand with fisheries development for ecological security, conservation of bio-diversity and social security. A comprehensive management plan has to be formulated and strictly followed.

Coastal fishery is the most important component in the fisheries sector in the Jaffna district till now. Fishermen were engaged in restricted coastal fishery for the past three decades especially due to the civil disturbances and declaration of certain areas as high security zone. Findings of our research under high risk on population dynamics and stock assessment though few in numbers express that the coastal fishery resources are now over exploited and therefore it is essential to implement management measures to sustain the resources for future generations.

Community-based fishery management teaches us the scale of importance of the community, their fishery, their social and economic structures and dynamics. It seeks to develop and implement new practices of sustainable fisheries management. If community-based management is to work, managers will need to pose and address science and science related research findings to the grass-root level of the community with priority.

The devolution of management responsibilities may impose too heavy a burden on local managers if they do not prioritize what aspects of the management job they can best handle, and understand the information implications of the jobs they are willing to take on. Unless local managers take this step there is a danger that management outcomes will show little or no improvement. Hence it is the duty of the Department of Fisheries Science, Faculty of Science, University of Jaffna either with or without the collaboration of the National Aquatic Resources Agency, Colombo to perform and continue scientific research on fishery resources and disseminate the findings to the community through Fishermen Co-operative Societies.

The process of identifying relevant research problems is another fact and it is a time consuming process but has demonstrated at several instances the effectiveness when arrived at a final stage. Findings of these research projects have to be disseminated through a series of seminars, workshops and Fisheries Extension Services. Fisheries Extension Services could play a major role in the dissemination of useful information.

5.7. Alternate Employment.

Among the factors that contribute to over exploitation and sustainability in fisheries is the existence of over capacity leading to lower production resulting in reduction of economic benefits generated from a fishery. Lack of alternate employment was identified in the first International workshop on factors contributing to unsustainability and over exploitation in fisheries as the most significant single pressure on fisheries resulting in unsustainable fishing practices.

Alternate employment opportunities are limited in the north. The following considered as suitable for alternate employment have been identified. i. Processing, preservation and sales; ii. Culture of fish, prawn and crab; iii. Ornamental fish collection and culture; iv. Dress making; v. Vocation training in motor mechanism, handicrafts.

A large number of minor tanks in the north have been renovated. Culture of fish in these lands could be a profitable venture. Action in this direction has to be initiated by government or non- governmental organizations.

5.8. Training and Education.

The need and understanding of fishery resources and fishing industry are far more complex today than ever before. The reasons being:

i. Fisheries have expanded and intensified,

ii. The present income from fishing is barely enough for survival, particularly for traditional fishermen,

iii. Fishing related or non fishery activities are lacking,

iv. Lack of understanding of fishery resources and management matters,

v. No co-operation due to lack of understading.

Training and development for employment have not been appreciable and in dispersed way. Fishing skills are self taught or learned "on the job" for the majority of fishermen. As fishing technologies have developed and the demands for greater efficiency of harvesting have increased, Government assisted and industry supported training schemes have to be started.

In this regard the role of the Department of Fisheries of the University of Jaffna providing Fisheries Science as a principal subject and an opportunity to do specialization in Fisheries Science has to be mentioned. Schools are also paying greater attention in including marine fisheries and fresh water fisheries as technical subjects in their curriculum.

6.0 Recommendations for Rehabilitation and Development.

Now the situation in Jaffna has improved, restrictions on fishery withdrawn, night fishing allowed, A9 road opened and therefore marketing is possible, bringing fishing material such as nets, boats and other accessories from Colombo are possible. Excessive fishing inputs in coastal areas and valuable stock depletion in Jaffna district can be avoided by moving to the next step that is by enhancing off shore / deep sea fishery in Jaffna. The next avenue to increase the fish production is to exploit the resources in the offshore /deep sea and oceanic regions where the level of exploitation is only marginal and to introduce aquaculture in the district. Improving deep sea fishery could include the incentives such as establishing shipping industry, establishing new industries in backward areas and fuel supply at fishing harbours. In addition to these, attention should be paid to handling fish catches hygienically, fish processing and preservation technologies.

Introduction of multiday boats and establishment of a fishing harbor in Point Pedro and completion of the Myliddy harbour are the urgent issues; promotion for local production of multiday boats is the short term issue and establishment of fishing vessel monitoring system could be a midterm issue in the Jaffna District. Short term issue such as promotion for local production of multiday boats appear to be another important venture as this could ensure employment for youths and help to increase the status of economy. According to the boatyard owner who participated in the discussion there is an urgent need to develop slip way, mold and technical skills. It was also identified that training on Engine mounting and mold making have to be developed in the Jaffna district.

The critical issues essential for the rehabilitation and development of fisheries sector discussed were considered as three important categories coastal fishery, offshore / deep sea fishery and aquaculture. Each and every category was characterized as urgent, short term and midterm issues. Respective issues are tabulated in Table 8.

Establishment of fishing vessel monitoring system (VMS) is the critical midterm issue. In the context of fisheries the Food and Agriculture Organization (FAO) of the United Nations defined monitoring, control and surveillance (MCS), as a broadening of traditional enforcing national rules over fishing, to the support of the broader problem of fisheries management. Obtaining and maintaining a functional VMS at all times is mandatory, and as such owners could ensure that their equipment are properly working and logged in at all times.

The other avenue to increase the fish production is introduction of possible aquaculture practices in the Northern region. Critical urgent issues identified under aquaculture development are implementation of various types of aquaculture project including seaweed and sea cucumber and involvement of socially vulnerable members to aquaculture activities. Critical short term issues are continuation of various types of aquaculture operation and formulation of master plan for aquaculture development. Critical midterm issue is establishment of seed production centre.

There are no successful aquaculture systems at present in the Jaffna District except the one under taken recently at Karainagar. Time to time there were some activation by different organizations to initiate successful aquaculture systems in the Jaffna district. But due to some reason all ceased at one point. In the year 2007 World Vision, an International Non Governmental Organization took steps to culture fish in perennial tanks in Jaffna. Later they were struggling to get permission to initiate the activity and finally their effort was abandoned. Recently in mid part of year 2010, Rural Development Organization / Karainagar in association with Assistant Divisional Secretariat initiated a shrimp farm at Karainagar. Trained personnel from Chilaw was assisting them in technical aspects. For the first time they stocked post-larvae of black tiger shrimp (*Penaeus monodon*) supplied by hatcheries in Chilaw and it was reported to be a successful event in Jaffna.

Later in year 2011, JICA initiated some activities for culturing sea cucumber and seaweeds. So that needless to point out that implementation of various types of aquaculture projects and involving socially vulnerable members to aquaculture activities are prominent in Jaffna district. At the same time it is important to ensure the continuation of various types of aquaculture operations and its formulation of a master plan for it by experienced skilled personnel. While implementing these aquaculture practices we should not depend for the post-larvae /

fingerlings from other parts of Sri Lanka. It has to be produced here itself and therefore there is a need for establishing a seed production centre.

Long term fisheries development plan must rest on a firm base of information and action in the following sequence:

i. Determination of the nature of available resources – their location in time, space and magnitude

ii. Determination of the most efficient and economic methods of exploitation of resources and training of appropriate personnel

iii. Establishment of shore facilities required in relation to i) and ii), including fishing vessel monitoring system, for monitoring, control and surveillance of fishing vessels.

iv. Organization of an efficient purchasing, storage, processing and marketing system

v. Scientific monitoring of catches and effects of fishing on stocks.

vi. Conducting training and advisory programmes to build human resource capacity and to increase levels of knowledge, skill and expertise.

vii. Awareness building through educational programme for better participation and co- operation from those involved in the fishing industry and to students at school level.

viii. Conducting training and advisory programme to build human resources capacity and to increase levels of knowledge, skills and expertise through fisheries extension services.

ix. Making available easy loans financial assistance or subsidies.

This report is intended to highlight suitable strategies for sustainable marine resources development in the Northern region.

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xviii. Making available easy loans financial assistance or subsidies.

This report is intended to highlight suitable strategies for sustainable marine resources development in the Northern region.

Critical actions for the rehabilitation and development of fisheries sector in the northern Sri Lanka			
No	**Category**	**Time span**	**Critical activities**
1	Coastal	Urgent	Rehabilitation and Improvement of fish auction hall
			Providing loans to assist fishermen to procure their equipments
2	fishery		Development of fish landing sites
3			Formulation of fishery infrastructure development plan such as water supply facilities, ice storage, fishermen's locker, access road, etc.
4			Establishment of new FCS model

5			Improvement of mutual assistant system for socially vulnerable members
6			Establishment of fisheries data base
			Empower women in Fisheries sector
7		Short term	Outreach of community-based fisheries management
8			Implementation of research on coastal fishery resources
9			Continuation of rehabilitation and Improvement of fish auction hall
10			Implementation of fishery infrastructure development plan such as water supply facilities, ice storage, fishermen's locker, access road, etc (Phase 1).
11			Initiating model project for the new FCSs
12	Offshore	Urgent	Introduction of multi-day boats
13	/deep sea fishery		Formulation of fishing harbor development plan in Point Pedro and Myliddy
14		Short term	Promotion for local production of multi-day boats
15			Construction of fishing harbor in Point Pedro and Myliddy
16		Mid term	Establishment of fishing vessel monitoring system (VMS).
17	Aqua-culture	Urgent	Implementation of various types of aquaculture project including seaweed
18			Involvement of socially vulnerable members to aquaculture activities
19		Short term	Continuation of various types of aquaculture operation
20			Formulation of master plan for aquaculture development
21		Mid term	Establishment of seed production center

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