

UNDERSTANDING THE RIVER BASIN CLASSIFICATION OF SRI LANKA

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ABSTRACT : Since ancient times, the population of Sri Lanka has depended on the island's vast network of river basins. It was crucial to their survival and the human civilization was built around them. With time human lifestyle became more complicated and environmental stress induced by human activities became more severe. Therefore, the need has arisen to understand the subject for achieving related policy making, development, conservation and management goals. The interpretation of the river basins concept was first attempted by Hunting Survey Corporation Limited, Toronto, Canada, and Surveyor-General of Ceylon (Sri Lanka) in 1962. Arumugum in 1969 explained that the island could be divided into 103 components of natural river basins. Unfortunately, misunderstanding of river basins with rivers has been found in decades' worth of studies and even in the Sri Lankan educational system. Most have misinterpreted the number of rivers in Sri Lanka as 103, and they flow radially from the Central Highlands to the sea. The present study is focused on providing clarifications of the river basin concept, rivers and the drainage system of the island. Therefore, river basin maps and digital elevation models were developed to understand the river basins, river origin locations and flow patterns. These data coupled with previous field observations were then used to critically evaluate existing scientific literature. Accordingly, there are 29 rivers (15 perennial and 14 seasonal rivers) that flow directly to the sea, and their estuaries were categorized as drowned river valley, bar-built perennials, bar-built seasonal, perennial delta estuaries, and seasonal delta estuaries. Considering the origin of these 29, only 8 rivers begin from the central highlands and its margins (>1200 m contour line), and most rivers/Oya emerge below the 1200 m contour line. Another 64 rivers/Oya found out to be emptied into lagoons even though traditionally classified as flows directly to the sea. Following 4 rivers; Mahsilawa, Katupila Ara, Pallakutti Ara and Rathmal Oya connect to other rivers or salt marshes while, Bolgoda lake, Madu Ganga, Madampe lake, Telwatte Ganga, Rathgama lake and Koggola lake turned out to be back-barrier coastal lagoons mistakenly identified as rivers in the traditional classification. And all these originate below <100m contour line. Hence, it is clear that there are some misreading of river basins and rivers in existing scientific studies. As this information is valuable in many ways to the country, misreading of these subject matters must be corrected immediately.

KEY WORDS: River basins, Central Highland, radial pattern, misunderstanding, Sri Lanka,

INTRODUCTION

Sri Lanka is a tropical island located between latitudes 5°55' -9°51'N and longitudes 79°41' -81°53'E in northern hemisphere. It has long journey from Southern Hemisphere to present position from Precambrian to Holocene Epoch (Katupotha 2019). Nine-tenths of the Island of Sri Lanka are underlain

by Paleoproterozoic gneisses (3,000-2,000 Ma; from U-Pb and Nd model ages), and Pan-African ultrahigh-temperature metamorphic rocks of Neoproterozoic Era between 610 and 550 Ma (Braun and Leo 2003); the Cambrian to Quaternary sediments being restricted to the coastal regions. The basement rocks in Sri Lanka could be in the Precambrian age

(lasted a long time, 2.8 billion years), but it is very difficult to identify basement rocks due to the palaeo metamorphism and deformation episodes. Showing the location of Sri Lanka, during Lower Permian (299.0 - 275.6 Ma) and Upper Permian (260.4 - 253.8 Ma) due to drifting it moved further northwards. There were breaking-up signs of landmasses namely, Antarctica, South America, Africa, Madagascar, Australia-New Guinea, and New Zealand, as well as Arabian and the Indian subcontinent (Segev 2002; Scotese, 2002; Katupotha 2019). Diagrammatic section across Sri Lanka from west to east showing the four planated surfaces (Katupotha 2013) as: (i) Submerged, (ii) Flat terrain to Undulating terrain, Rolling and Hilly Terrains, (iii) (Dissected Rolling and Hilly; Steeply Dissected Rolling and Hilly Terrains, and (iv) Mountainous and Rugged Central Highland (Figure 1). From mountainous and rugged Central Highland to towards the coastal lowland (II– second (Flat terrain to Undulating terrain, Rolling and Hilly Terrains), the landforms of Sri Lanka form by mountain and peaks, plains, plateaus, waterfalls, gaps, inselbergs etc.

children and teachers. This misinterpretation can be seen even in school text books. If carefully investigation of Sri Lanka's rivers flow pattern of the Mahaweli river and other rivers show different directions owing to regional geology and geomorphology, and "On the basis of above understanding there is a need to describe the physiographic features of Sri Lanka in a more meaningful manner to avoid confusions reflected from past literature"

The prime motivation to write this paper was the observation that, although a plethora of research papers that address the drainage pattern and system misinterpretation and use the scientific explanation incorrectly repeat by users. For is purpose available in the scientific literature, only a very few exist that makes reference examine very briefly, at best. The articles, maps, and different interpretations in scientific papers and limited fieldwork undertaken with past experience to reach the conclusion are also very significant.

WATERSHEAD AND RIVER BASINS

A river can be wide and deep, or shallow enough for a person to wade across, and river is

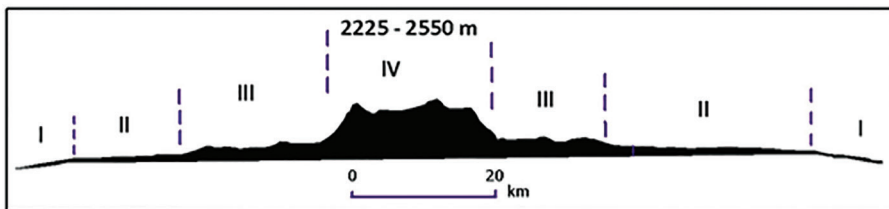


FIGURE 01: Diagrammatic cross section of Sri Lanka from west to east showing the four planated surfaces concept (Source: Katupotha 2013).

These features further carve, erode, and evolve due to the existing drainage system of the country. Because of this situation, many scientists, researches, policymakers are professed amiss the drainage pattern which flow in Central Highland to the sea. This misinterpretation is undertaken continuously by professionals from Universities, ministries and from government departments and even school

a ribbon-like body of water that flows downhill from the force of gravity representing different drainage patterns. Drainage pattern is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Geomorphologists and hydrologists often view streams as being part

of drainage basins. Thus, a drainage basin is the topographic region from which a stream receives runoff, through overland flow, and groundwater flow. Drainage basins are divided from each other by topographic barriers or dividing ridge called a watershed.

Characteristics of the drainage basin depict the area of land drained into a river. It is identified as the catchment area, which the area within the drainage basin, and a watershed is identified as the edge of highland surrounding a drainage basin which marks the boundary between two drainage basins. Accordingly, a watershed is a high area of land where rain collects, some of it flowing down to supply water for rivers, lakes, etc., at lower levels. The path water takes across the land is determined mainly by gravity and regional geology. High places, like ridges, mountains, and hills form divides between adjacent watersheds. Water always flows downhill and therefore the outer boundary of a watershed is formed by the ridges and hills surrounding a given water body. Streams originate from overland flow and from saturated zones according to the watershed geology, topography, and vegetation, as well as to the precipitation system and the gradient of the land.

According to the configuration of the channels, drainage systems can fall into one of several categories known as drainage patterns. Drainage patterns are classified on the basis of their form and texture. Further, some common types of drainage patterns, such as: dendritic, deranged, centripetal and trellised. Sri Lanka's a few rivers rise in the Central Highlands, from 2400m or more elevation. However, they do not flow in a radial pattern toward the sea as mentioned by many scientists. In Sri Lanka most of these rivers are short. There are sixteen principal rivers longer than 100 kilometers in length, while twelve of them carry about 75 percent of the mean river discharge in the entire country. Once they reach the plain, the rivers slow down and the waters meander across flood plains and deltas.

MATERIALS AND METHODS

Many local and foreign researches and scientists address the drainage pattern and system in Sri Lanka depicting as "there are 103 distinct rivers that begin from the Central Highlands and flow radially towards the sea". But like this statement is totally incorrect. Therefore, the prime motivation to write this paper is to reveal the proper drainage pattern and system emphasizing geology, geomorphology, elevation and behavioral characteristics of the Central Highland. The articles, maps, and different interpretations in scientific papers and limited fieldwork was undertaken with experience to reach the conclusion, which is very significant.

River Basin Map Preparation

Since river basin maps were crucial to examine the true nature of the river basin concept, base maps developed by Survey Department of Sri Lanka were used to create necessary maps. Further, contours (< 150m, 300m, 600m, 1200m and > 2400m) were added to categorize each river basins and rivers according to origin area to understand whether each river starting from the Central Highlands as the most literature claims.

Digital Elevation Models (DEM)

Digital elevations models are computer generated representations of elevation of a terrain. With DEM representation of Central Highland, river flow patterns could be easily understood. Therefore, in order to develop DEM for Sri Lanka and central highlands freely available Shuttle Radar Topography Mission (SRTM) data were used and processed in ArcMap 10.1 geographic information system. Flow chart for the DEM preparation process is shown in Figure 2.

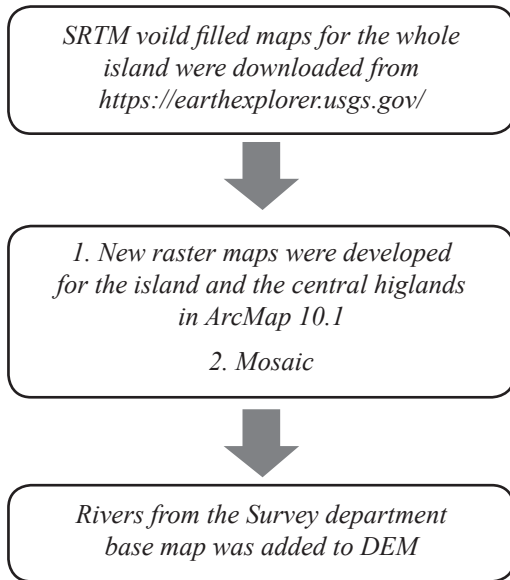


FIGURE 02: Digital elevation model preparation flowchart

Analysis

Developed river basin maps and digital elevation maps were then examined carefully to understand the river basins, flow patterns and river origin areas. With this data and previous field observations, existing scientific literature was critically evaluated to arrive at the conclusions of this present study.

RESULT AND DISCUSSION

Uplands and Central Highland (Massif) of Sri Lanka

The Central Massif is composed of four main ranges of mountains: Adam's Peak Range on the west, Namunukula Range on the east,

Pidurutalagala Range in the center, and Knuckles Range on the north (Erb 1984). Erb describes that the World's End Ridge and Haputale Ridge extend from Adam's Peak Range on the west, almost to Namunukula Range in the east, and are joined to Pidurutalagala Range at its most southern point to form World's End Plateau. These structurally controlled mountain ranges and ridges are in part surrounded by, and in part surround or include, an assemblage of high level (1,200 to 2,200 m), medium level (500 to 1,060 m) and low level (270 to 480 m) plateaux (Figure 1). Wadia (1945) and Leiter (1946) discussed the denudation chronology and the drainage pattern of the Central Massif of Ceylon (Sri Lanka) based on Peneplain Theory and stated that uplift forming three steps (Figure 3). The drainage system of the Central Massif is of considerable interest to observe that except on the coastal plains towards the north of the Island, the rivers flow in two well defined directions: that is in north-south direction, and in east-west direction (1946).

This is quite contrary to expectation, as the drainage from a Central Massif should be radial. But, this radial pattern is completely effaced by upper Mahaweli drainage system. Katupotha mentions in present study there is no prominent radial drainage pattern in the Central Highland. Leiter (1946) depicted that the trellis pattern drainage is especially conspicuous in the south-western part of the Island, and has most probably been determined by the fracturing of the rocks during the epeirogenic periods.

but it was redrawn and add new concept "Planated Surfaces" by Katupotha (2013) based on Global Glacial retreating, which followed the drastic palaeo climate changes.

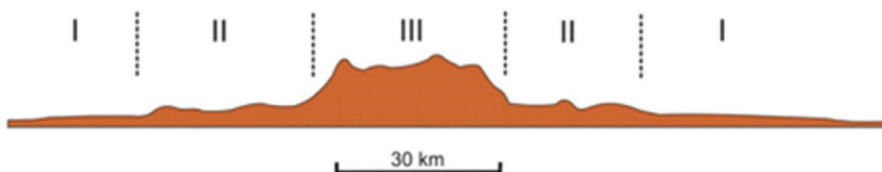


FIGURE 03: Diagrammatic cross section of Sri Lanka showing three Peneplains (modified after Wadia 1945) I-Lowest; II-Middle and III-Highest.

Although the island of Sri Lanka presently lies in the Indian Ocean between 5° 52'N-9° 54'N and 79° 30'E-81° 55'E, to the southwest of Bay of Bengal and southeast of Arabian Sea, Katupotha mentioned (2013) that it was positioned within 67° S-65° S and 34° E-43° E during the Lower and Middle Jurassic Era (201.3-166.1 Ma). Huge rocky blocks (erratic boulders) have been transported to different places by continental ice sheets due to climatic fluctuations in the Permian, Triassic and Jurassic Periods, but erratic pebbles (4cm pebbles to 8 cm and several meters or more in size) and streams fed deposits have been transported by glaciofluvial processes. These glaciofluvial processes occurred on four occasions during the Jurassic Period, Eocene, Miocene and Pliocene Epochs on Sri Lankan landmass, which followed the palaeo climatic changes and sea level fluctuations that broke up the sedimentary beds, initiating establishment of the present topography and structural configuration. As a result, the earlier sedimentary deposits were obliterated from greater part of Sri Lanka. During the Quaternary Period the erosional rate increased and the resultant erratic boulders along with glaciofluvial deposits can still be found on Planated Surfaces of Sri Lanka. The rugged Central Highland morphology was formed (IVth planated surface) due to the final phase of the climatic and sea level fluctuations after Oligocene Epoch.

Erb (1984) describes in details: The Central Highland has been cut by a complex pattern of faults, joints, and unclassified fractures; have been subjected to a high temperature, high precipitation climatic regime, with its associated intense weathering and erosion activity; have been dissected by several major and many intermediate and minor rivers and streams; and have, as a result, developed a terrain often characterized by a great range in local as well as regional relief (Figure 4). According to these geological characteristics and geomorphology there is no radial drainage pattern in Central Highland.

The uplands with elevations from 270 to 1,060 m above mean sea level (MSL) consist of mainly ridge and valley topography and

are highly dissected plateaus with narrow amphitheaters (arenas) and domes. Nearly one third of the country occupies uplands where the average slope varies from 10 to 35°. Well-developed steep scarps are common, particularly in the southern border of this unit. However, the boundary between lowland and uplands is rather abrupt in which a narrow transitional zone occurs in some places. The arena structures are the main physiographic features that can be observed in this part of the land. Arena floors are relatively flat and undulating. Parallel ridge and valley topography is common in certain parts particularly in the southwest and north of uplands.

The highlands with a series of well-defined high plains and plateaus rimmed by high mountain peaks and ridges with elevations of 910–2,524m, characteristically developed in the central part of Sri Lanka. The main landmark features of this terrain are the high mountain peaks such as Pidurutalagala (2,524m), Kirigalpotta (2,388 m), Thotupola (2,359m), and Adams Peak (2,243m) (Figure 4).

This morphological unit are not continuous but separated from the intervening dissected low plateaus by steep escarpments and deep valleys. Two distinct highland mountain massifs namely, knuckles (2,035 m) and Rakwana (1,490 m) are located northeast and southwest of the highland, respectively. These massifs are detached from the main central highland by deep eroded valleys carved out due to heavy erosion by the Mahaweli, Kalani, and Kalu Ganga rivers. These valleys probably follow the old and new series of lineaments (Vitanage 1985). The large arena shaped depressions located around Kandy are most notable morphological features in the lower part of the highlands. The highlands is made up of N-S running high plains with a well-connected E-W mountain wall in the south, giving rise to an anchor shaped feature (Fig. 3) (Cook 1931). These high plains are bounded by two important geomorphic features named as the Uva basin and Hatton plateau which are located east and west of High Plains. The flat appearance of plateaus is due to the nearly horizontal attitude of the rocks within much of the area (Cooray 1984). The Kandy

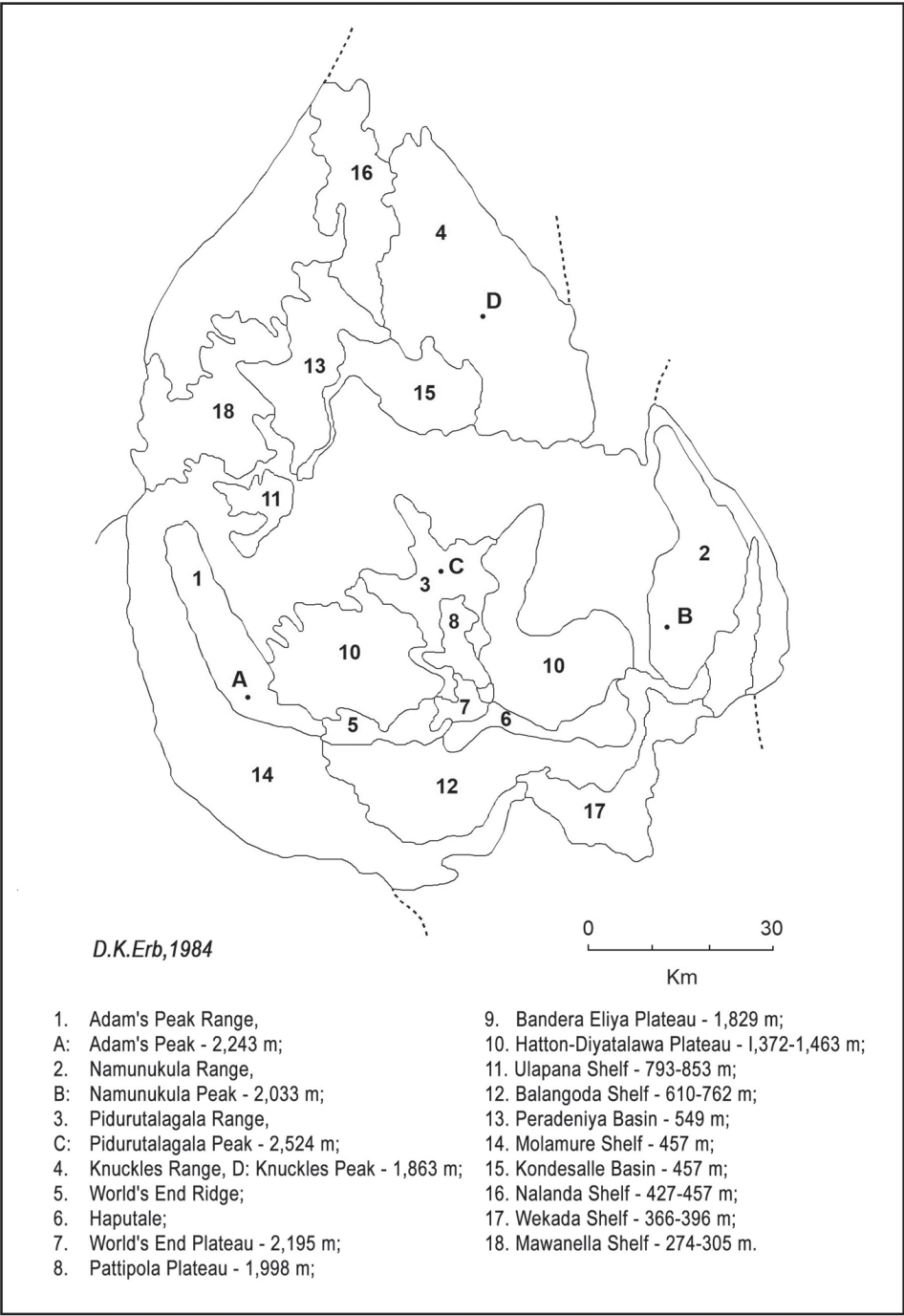


FIGURE 04: The Central Massif and the major landform units comprising it

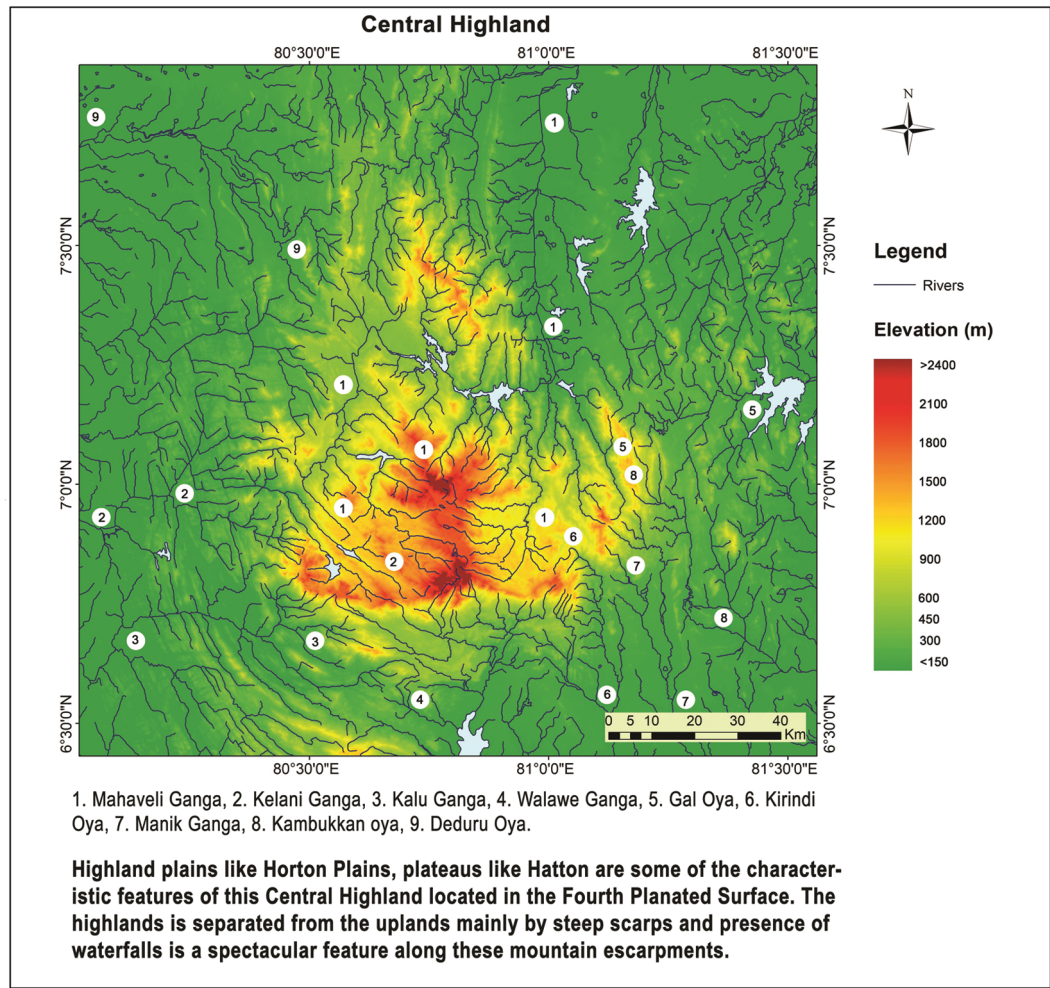


FIGURE 05: Morphological features of the Central Highland.

plateau is located north of the highlands that are surrounded by N–S and E–W running Mahaweli River, which is the longest river in Sri Lanka. All these clearly indicate that it is impossible to identify radial drainage pattern from Central Highland due to the different directions of sub watersheds of the upper Mahaweli River surroundings.

Misunderstanding of Drainage pattern of Sri Lanka

Many scientists from Universities, Government Departments, Foreign Collaborators for e.g. FAO, UNESCO etc. and other institutions use the drainage pattern of

Central Highland misleadingly. The followings common examples are such misunderstanding or misreading statements in published article, books, reports etc.

- There are 103 perennial rivers in Sri Lanka, of which over 90% radiate from the central highlands into the western, eastern and southern coasts (De Silva 1988).
- Sri Lanka has 103 rivers radially draining into the sea. The country underwent an extensive water resources development phase during the 1960s through to the 1980s, which included the building Eriyagama *et al.* (2015).

- Even though Sri Lanka is a small island, it has about 103 river valleys. Water from these rivers is utilized to fulfill the basic water requirements of the country. The earliest settlements were established in these river valleys to obtain water for their needs (Geography Grade 11, Third Print – 2019)
- There are 103 rivers in Sri Lanka, almost all flowing from the central mountainous massif in a radial pattern through various directions. Some of these rivers are perennial, flowing continuously throughout the year during both the wet and dry periods (National Atlas, Survey Department of Sri Lanka 2007, page. 62, see also pages 60 and 38).
- Sri Lanka's radial network of rivers begins in the central highlands. There are about 103 distinct river basins covering 90 percent of the island. The southwestern part of the island has seven major basins with catchment areas ranging from 620 to 2700 km² (AQUASTAT Survey – 2011).
- Sri Lanka does not have any natural lakes. There are 103 perennial rivers in Sri Lanka, of which over 90% radiate from the central highlands into the western, eastern and southern coasts. There are 28 rivers with a basin area exceeding 500 km² (Survey Department, 1983) (De Silva 1988).
- Sri Lanka is blessed with 103 perennial rivers which are fed with numerous headwater streams radiating from hill country region towards Indian Ocean (Sanjaya *et al.* 2015), Page 212.
- Sri Lanka is prosperous in water resources with 103 rivers, more than 20 major wetlands, exceptionally designed minor and major irrigation systems and significant groundwater resources (Ministry of Environment and Natural Resources, 2008). Rainfall as the main form of precipitation brings an average (E.R.N. Gunawardena, 2013).
- Surface water from the high watersheds is transported by 103 distinct natural river basins, of which 9 cover 90% of the island; the remaining 94 small coastal basins contribute only marginally to water P.B. Dharmasena. (In) I. P. Martini, W. Chesworth (eds.), *Landscapes and Societies*, 2010. 347 page).
- There are 103 distinct rivers that begin from the central highlands and flow radially towards the sea. Their basins cover 90 per cent of the island. (Geekiyana *et al.* 2015.)
- There are about 103 distinct river basins covering 90 percent of the island. The southwestern part of the island has seven major basins with catchment areas ranging from 620 to 2 700 km². Irrigation in Southern and Eastern Asia in figures – AQUASTAT Survey – 2011, Page 4.
- There are 103 distinct natural river basins and over 90 small coastal basins (Figure 2). Thirty-six of these watersheds have catchments areas greater than 256 sq. km (100 sq. ml) and are usually termed as major river basins (Arumugam, 1969). In: SRI LANKA NATIONAL WATER DEVELOPMENT REPORT. General Context, Page 1.
- The Island has a central massif with its tallest peak rising 2500 meters above sea level. 103 river basins spread radially from the central hills outward to the coastal plains (in addition to there are 94 small coastal basins). The Island receives an average of 6 feet (1800 mm) rainfall from the two distinguished monsoons..... (Udula Bandara Awsadahami, (In) REGIONAL PUGWASH WORKSHOP, 85 page).
- Sri Lanka is a country blessed with water resources including 103 rivers, exceptionally designed minor and major irrigation systems and significant groundwater resources (Ministry of Environment and Natural Resources, 2008). According to Leach (1959), Sri Lankan ancestors had unique hydraulic civilization (S.S.K. Chandrasekara and E.R.N. Gunawardena, 2011).
- There are 103 distinct rivers that begin from the central highlands and flow radially towards the sea. Their basins cover 90 per cent of the island (Sachidananda

- Mukherjee, Debashis Chakraborty - 2015).
- Surface water from the high watersheds is transported by 103 distinct natural river basins, of which 9 cover 90% of the ... There are six main type of groundwater aquifers demarcated and identified in Sri Lanka (Peter Martini, Ward Chesworth - 2010).
 - Surface water from the high watersheds is transported by 103 distinct natural river basins, of which 9 cover 90% of the island; the remaining 94 small coastal basins contribute only marginally to water resources. River basins originating in the wetter parts of the hill country are perennial while the majority of those in the dry zone are seasonal (Dharmasena 347 page).
 - Sri Lanka has 103 distinct natural river basins, covering almost 90% of the land area of the country. The Mahaweli River (335 km) is the longest river in the country that originates at an altitude of Most of the other rivers of Sri Lanka also originate from either highlands or uplands, displaying a radial pattern of drainage. Ranjith B. Mapa, World Soils Book Series, Page 29.

Concerning the all above the mentioned statements, it is clear that many scientists “rivers, river basin, radial drainage pattern, natural lakes” etc. are used as misread or misunderstood terms without understanding the relationship between Sri Lanka’s geology, geomorphology, drainage system and configuration of the Central Massif. Like these misinterpretations can be

TABLE 01: Runoff from wet zone basins

Serial No.	Basin Name	Area in Sq.Mis.	Maha season	Yala season	RUN OFF in 1000 Ac. ft. (Annual Total)
2.	Bolgoda	146	326	343	669
3.	Kalu Ganga	1,050	2,801	3,493	6,294
4.	Bentara	243	663	764	1,427
5.	Madu Ganga	23	63	74	137
6.	Madampe Lake	35	95	110	205
7.	Telwatte Ganga	20	53	67	120
8.	Ratgama Lake	4	11	12	23
9.	Gin Ganga	360	734	816	1,550
10.	Koggala Lake	25	63	74	137
11.	Polwatte Ganga	91	125	130	225
12.	Nilwala Ganga	375	625	585	1,210
13.	Sinimodara Oya	15	24	22	46
14.	Kirama Oya	87	100	68	168
15.	Rekawa Oya	29.5	32	23	55
16.	Urubokka Oya	136	143	63	206
100.	Karambala Oya	230	205	87	292
101.	Ratmal Oya	84	83	60	143
102.	Maha Oya	590	795	775	1,570
103.	Attanagalu Oya	284	300	318	618
Total: Wet Zone		4,712.5	9,613	11,319	20,932

Source: Arumugam 1969.

TABLE 02: Runoff from wet zone basins

Serial No.	Basin Name	Area in Sq.Mis.	Maha season	Yala season	RUN OFF in 1000 Ac. ft. (Annual Total)
1-16	In the wet zone	—	—	—	—
17.	Kachigala	86	73	27	100
18.	Walawe Ganga	954	1,126	658	1,784
19.	Karagan Oya	22.5	11	9	20
20.	Malala Oya	156	105	26	131
21.	Embilikala Oya	23	15	4	19
22.	Kirindi Oya	455	438	99	537
23.	Bambawe Ara	31	21	5	26
24.	Mahasiliwa Oya	5	3	0	3
25.	Butawa Oya	15	11	3	14
26.	Menik Ganga	497	437	87	524
27.	Katupila Aru	33.5	30	6	36
28.	Kuranda Ara	51	43	9	52
29.	Namadagas Ara	42	35	8	43
30.	Karambe Ara	18	26	7	33
31.	Kubukkan Oya	476	516	70	586
32.	Bagura Oya	36	44	11	55
33.	Girikula Oya	6	3	3	6
34.	Helawa Ara	20	4	4	8
35.	Wila Oya	189	179	13	192
36.	Head Oya	236	273	29	302
37.	Karanda Oya	165	187	9	196
38.	Simena Ara	20	25	2	27
39.	Tandiadi Ara	8.5	12	2	14
40.	Kangikadichi Ara	22	25	2	27
41.	Rufus Kulam	13.5	12	2	14
42.	Panel Oya	72	113	3	116
43.	Ambalam Oya	45	68	2	70
44.	Gal Oya	700	13,23	95	1,418
45.	Andella Oya	204	310	14	324
46.	Thumpankeni	3.5	3	0	3
47.	Namakada Aru	4.5	6	0	6
48.	Mandipattu Aru	39	62	1	64
49.	Pattanthu Dephue Aru	39	62	2	64
50.	Vet Aru	10	20	1	21

51.	Unnichchai	135	145	8	153
52.	Mundeni Aru	500	578	31	609
53.	Miyangolla Ela	88	95	6	101
54.	Maduru Oya	602	1,062	71	1,133
55.	Pulliyanpota	20.5	24	3	27
56.	Kirimechi Odai	30	69	3	72
57.	Bodigoda Aru	64	139	5	144
58.	Mandan Aru	5	13	3	16
59.	Makarachchi Aru	14.5	36	3	39
60.	Mahaweli	4,034	2,836	1,470	4,306
61.	Kantalai	174	214	7	221
62.	Palampotta Aru	27	44	2	46
63.	Panna Oya	56	87	3	90
64.	Pankulam	147	216	7	223
65.	Kunchikumban Aru	80	69	2	71
66.	Palakutti Aru	8	8	0	8
67.	Yan Oya	594	611	25	636
68.	Mee Oya	35	35	1	36
69.	Ma Oya	400	372	12	384
70.	Churian Aru	29	29	1	30
71.	Chavar Aru	12	12	0	12
72.	Palladi Aru	24	25	1	26
73.	Munidel Aru	73	89	1	90
74.	Kodalikallu Aru	29	41	1	42
75.	Per Aru	146	181	4	185
76.	Pali Aru	33	43	1	44
77.	Maruthapilly Aru	16	23	0	23
78.	Thoravil Aru	35	38	1	39
79.	Piramenthal Aru	32	40	1	41
80.	Nethali Aru	47	50	1	51
81.	Kanakarayan Aru	350	325	12	337
82.	Kalawalappu Aru	22	34	0	34
83.	Akkarayan Aru	75	106	1	107
84.	Mandekal Aru	116	120	1	121
85.	Pallararayan Kadu	62	51	0	51
86.	Pali Aru	176	160	3	163
87.	Chappi Aru	26	18	0	18
88.	Parangi Aru	325	260	6	266
89.	Nay Aru	219	141	4	145

90.	Aruvi Aru	1,268	962	42	1,004
91.	Kal Aru	82	92	2	94
92.	Moderagoma Aru	364	243	9	252
93.	Kala Oya	1,083	795	64	859
94.	Moongil Aru	17	11	0	11
95.	Mi Oya	592	109	12	121
96.	Madurankuli Aru	28	5	2	7
97.	Kalagamuwa Oya	59	11	1	12
98.	Rathmbala Oya	84	94	10	104
99.	Deduru Oya	1,022	968	254	1,222
100-103	In the wet zone	—	—	—	—
Total: Dry Zone		18,158	17,350	3,311	20,661

Source: Arumugam 1969.

found in hundreds of documents published by Government Department, Institutions, University Staff Members, International Agencies, NGOs etc. using same sentence or slightly modification of it.

Arumugam (1969) described that the pre-requirement of water resources development in the collection of comprehensive data. Knowledge of not only the water available for use, but also its conservation and distribution is highly required from season to season due to the water requirement in Sri Lanka. For this purpose, the Island has to be considered in small units, provincially or district wise or what is more natural, by river basins. Arumugam (1969) mentioned that river basin is a natural unit and lends itself ideally for water resources studies concerning rainfall, stream flow water use, drainage etc. Accordingly, Arumugam (1969) explains *“The territory of Ceylon (Sri Lanka) can be divided into 103 component natural river basins and another 94 small coastal basins.* The 94 low lying coastal basins are small and have problems of their own; they do not make an effective contribution to the water resources of the island. Several of even the 103 river basins are not appreciably large (Arumugam 1969). This explanation (Table 1& 2 and Figure 6) is somewhat suitable to present Drainage Basin System in Sri Lanka.

DISCUSSION

According to our desk study, the Table 1 & Table 2 and Figure 6 in Arumugam (1969) should be the first attempt to discuss the river basins of Sri Lanka. “Hydrometeorology of Ceylon” prepared by Hunting Survey Corporation Limited, Toronto, Canada in Co-operation with the Surveyor General of Ceylon, Author: R.L. Walker has been responsible for development River Basin Concept and it sees that the words “river basin” used by Hunting Survey Corporation Limited. Later Arumugam (1969) developed the River Basin Map and prepared the “list of 103 river basins” accordingly. However, with careful observation, some misreading can be observed and depict, for e.g. river Numbers 2, 5, 6, 7, 8 and 10 in Tables 1 and 2 and Figure 7 can be identified as lagoon basins. As well, Numbers 24, 27, 66 and 101 are do not meet the sea directly. Number 24 flows into a marshy land and 27 is connected as a stream to the Menik Ganga. Number 66 and 101 also do not meet the sea directly (Figure 7). Likewise, Table 3 depicts the relationship between contour lines and mentioned river basins

According to the watershed and river basin definition, the number 103 mentioned by Arumugam (1969) can be categorized as follow:

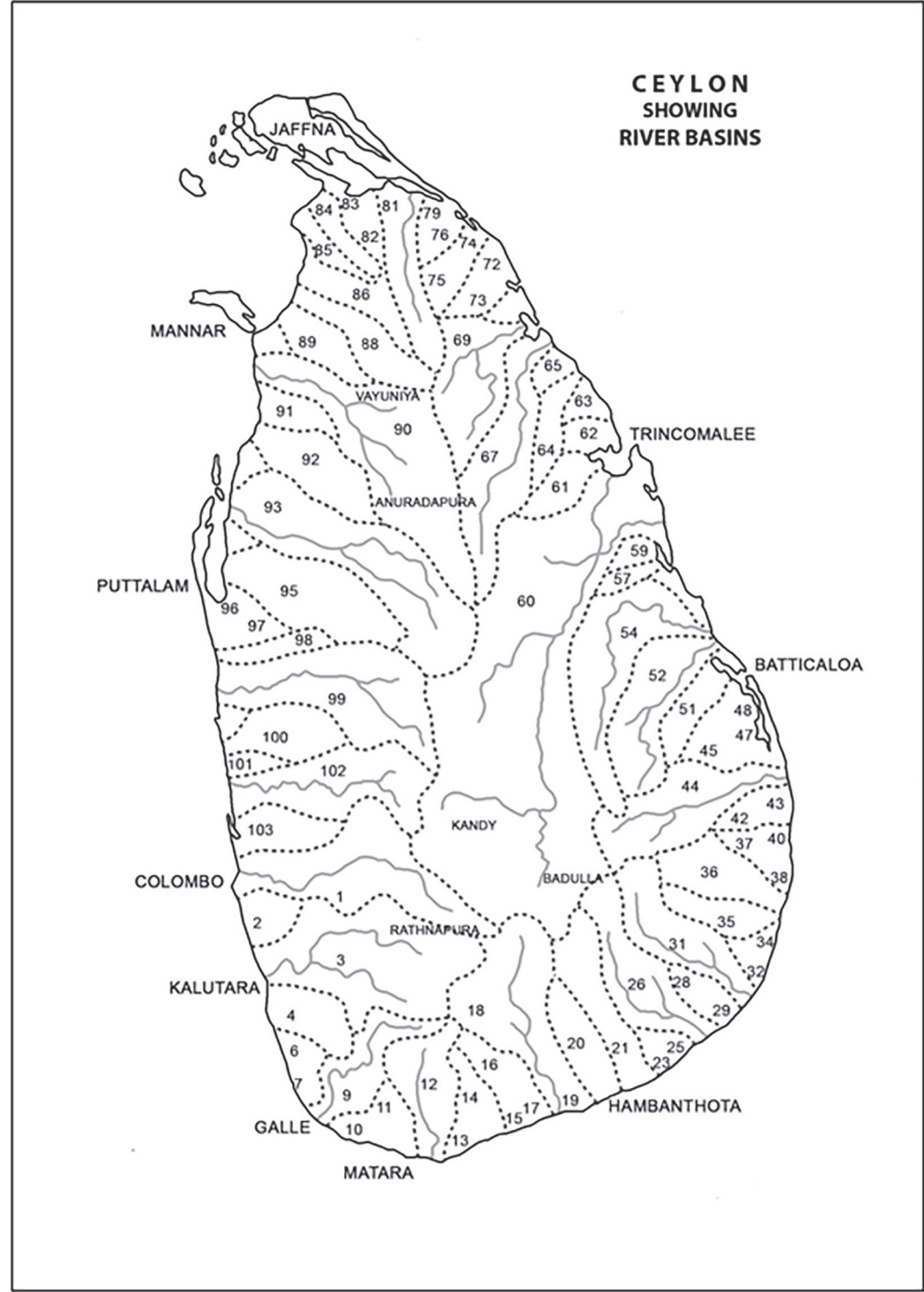


FIGURE 06: River Basin map of Arumugam (1969). Basin No.80 is missing in original.

TABLE 03: Relationship between Contour lines and River watersheds

< 150m	46 Thumpankeni Tank	84 Mandekal Aru	52 Mundeni Aru
2 Bolgoda Lake	47 Namakada Aru	85 Pallavarayankaddu Aru	54 Maduru Oya
5 Madu Ganga	48 Mardipattu Aru	86 Pali Aru	61 Kantale Aru
6 Madampe Lake	49 Patande Aru	87 Chippi Aru	64 Pankulam Aru
7 Telwatta Ganga	50 Wedi Aru	88 Parangi Aru	67 Yan Oya
8 Ragama Lake	51 Magalawatawan Aru	89 Nay Aru	90 Aruvi Aru
10 Koggala Lake	53 Miyangolla Ela	91 Kal Aru	103 Attanagalu Oya
13 Sinimodera Oya	55 Puliyanpotha Aru	92 Modaragam Aru	300-600m
15 Rekawa Oya	56 Kirimechchi Odai	94 Moongil Ara	16 Urubokka Oya
19 Karagan Oya	57 Bodigoda Aru	95 Mi Oya	45 Andella Oya
21 Embilikala Oya	58 Mandan Aru	96 Madurankuli Aru	93 Kala Oya
23 Bambawe Ara	59 Makarachchi Aru	97 Kalagamu Oya	600-1200m
24 Mahawilawa Oya	62 Palapotta Ara	98 Rathambala Oya	9 Gin Ganga
25 Butawa Ara	63 Pan Oya	100 Karambalan Oya	12 Nilwala Ganga
27 Katupila Ara	65 Kunchikumban Aru	101 Ratmal Oya	99 Deduru Oya
28 Kurunda Ara	66 Pulakutti Aru	150-300m	102 Maha Oya
29 Namadagas Ara	75 Per Aru	4 Bentota Ganga	1200-2400m
30 Karambe Ara	76 Palu Aru	11 Polwatta Ganga	3 Kalu Ganga
32 Bagura Oya	77 Maruthapilly Aru	14 Kirama Oya	22 Kiridi Oya
33 Girikula Ara	78 Toravil Aru	17 Kachigal Ara	26 Menik Ganga
34 Helawa Ara	79 Piramenthal Aru	20 Malala Oya	31 Kumbukkan Oya
38 Seymena Ara	80 Netheli Aru	35 Wila Oya	44 Gal Oya
39 Tandiadi Ara	81 Kanakarayan Aru	36 Heada Oya	> 2400m
40 Kangikachchi Ara	82 Kalavalappu Aru	37 Karanda Oya	1 Kelani Ganga
41 Rufus Kulam Aru	83 Akkarayan Aru	43 Ambalam Oya	18 Walawe Ganga
			60 Mahaweli ganga

1. There are six water bodies located in back barrier of coastal area had been depicted as rivers, for e.g. Bolgoda Lake (2), Madu Ganga (5), Madampe Lagoon (6), Telwatta Ganga (7), Ratgama Lake (8) and Koggala Lagoon (10). This is misinterpretation, and these do not flow from Central Highland (Figure 7). Another four streams numbers namely Mahasilawa Oya (24), Katupila Ara (27), Palakutti Ara (66) and Ratmal Oya (101) are not connected directly with the sea (Figure 7). The MahasilawaOya flows into a salt marsh, while Katupila Ara connected to Menik Ganga. The Palakutti Ara is connected to the lagoon and Ratmal Oya flows into the Gin Oya (Figure 7). All these four are not originated from Central Highlands.
2. Of 103 flow, there are 64 river/oya sending at lagoon or lakes (Figure 8)
3. There are 29 rivers directly flow the sea (Silva and Katupotha 2018), (Figure 9)
4. The headstreams of the Mahaweli River start from Central Highland, but the headstreams of Kelani, Kalu and Walawe begin from western and southern flanks of the Samanala Mountain Range (Figure 10).

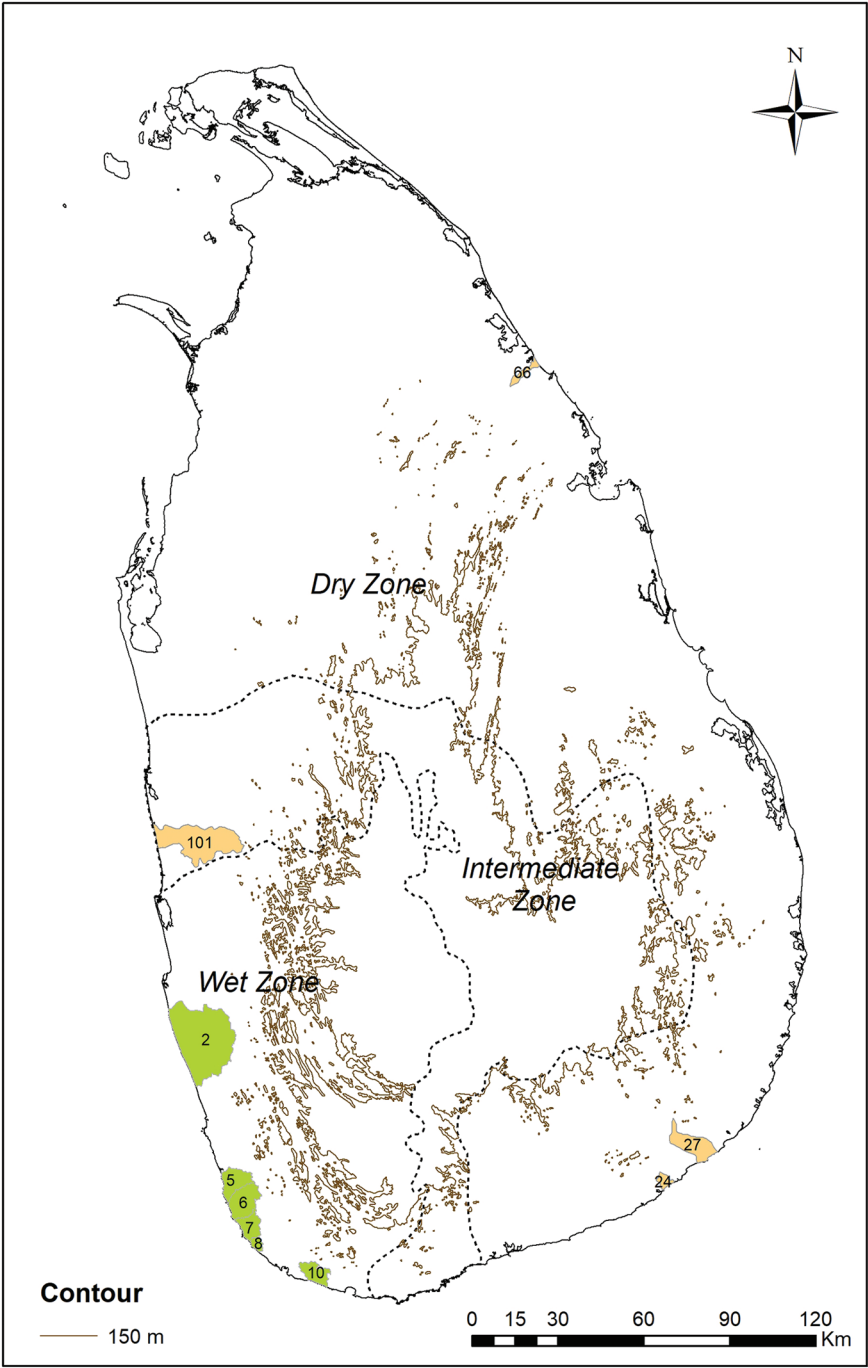


FIGURE 07: Bolgoda Lake (2), Madu Ganga (5), Madampe Lagoon (6), Telwatta Ganga (7), Ratgama Lake (8) and Koggala Lagoon (10). Another four numbers for e.g. Mahasilawa Oya (24), Katupila Ara (27), Palakutti Ara (66) and Ratmal Oya (101) and see Table 3.

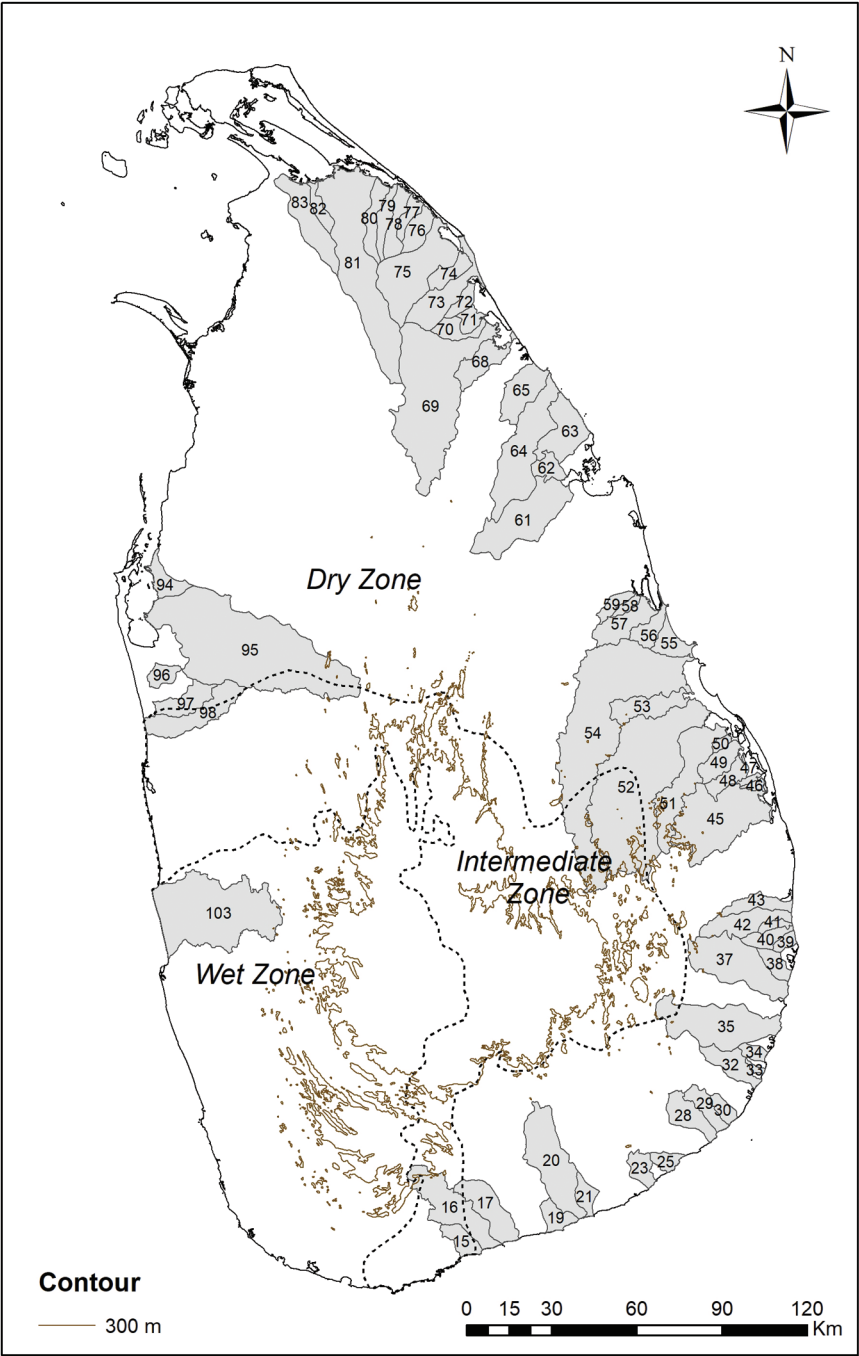


FIGURE 08: Rivers, streams (Aru, Ara, Odai etc.) drainage into lagoons, lakes or connected with other rivers. Majority of these are below 300m contour line, and indicate that these are not drainage from Central Highland.

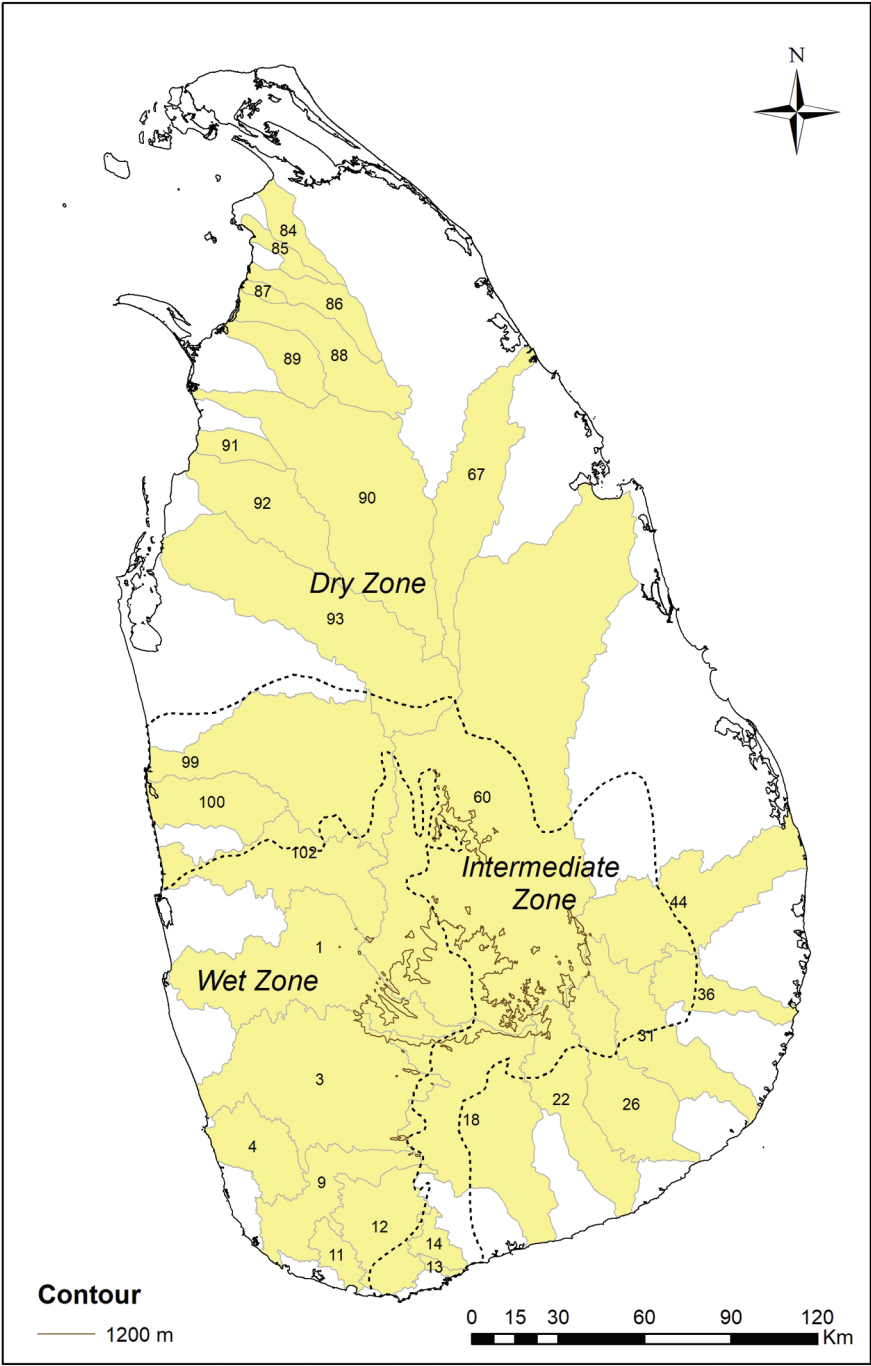


FIGURE 09: There are 29 rivers directly flow into the sea (Silva and Katupotha 2018), but many of them are not drainage from Central Highland.

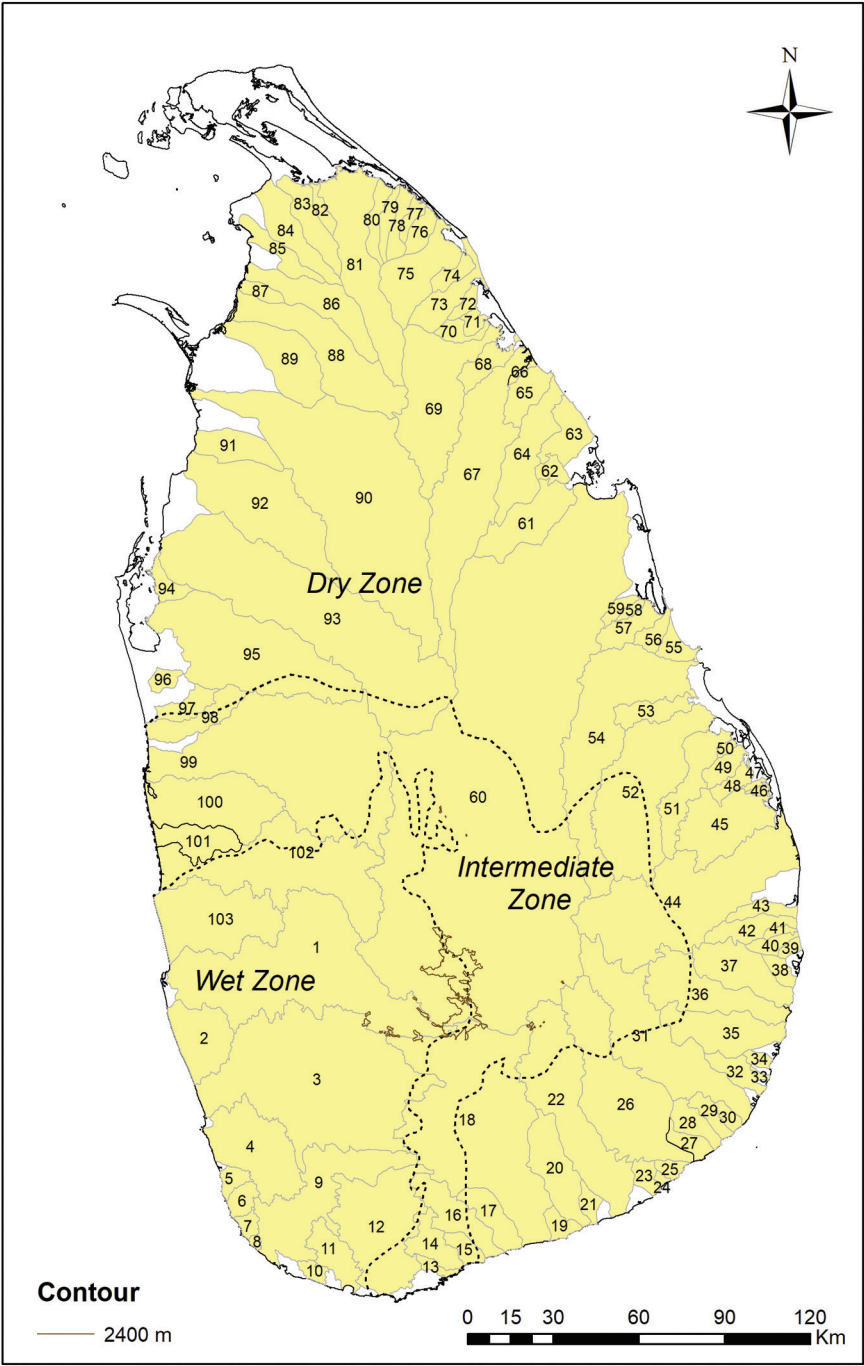
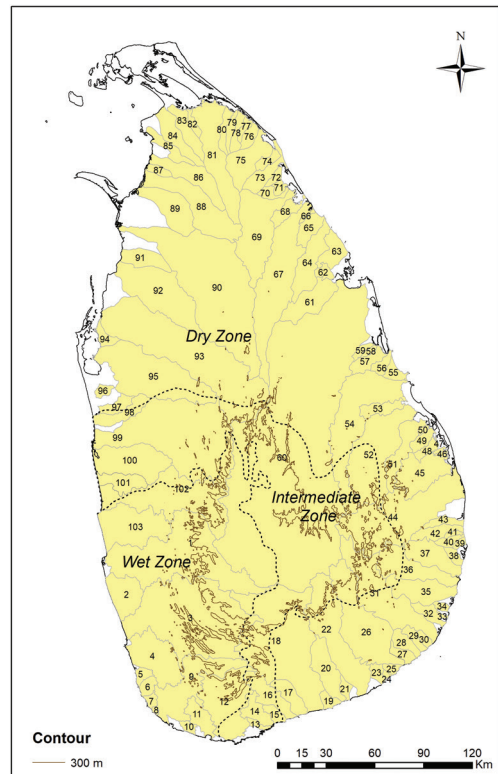
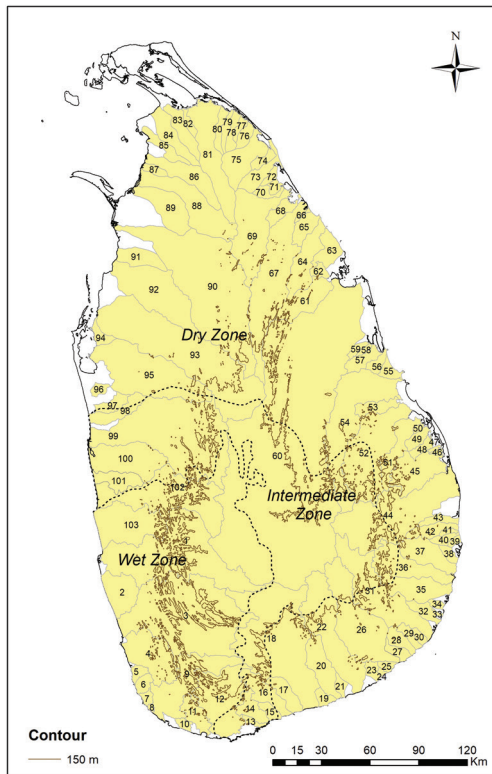


FIGURE 10: Depict the all 103 drainage basins in Sri Lanka. The headstreams of the Mahaweli River start from Central Highland, but the headstreams of Kelani, Kalu and Walawe begin from western and southern flanks of the Samanala Mountain Range (see Table3).



FIGURES 11& 12: Many river and stream basins are located on the Intermediate, and Dry Zones are below the 300mand 150m contour lines.

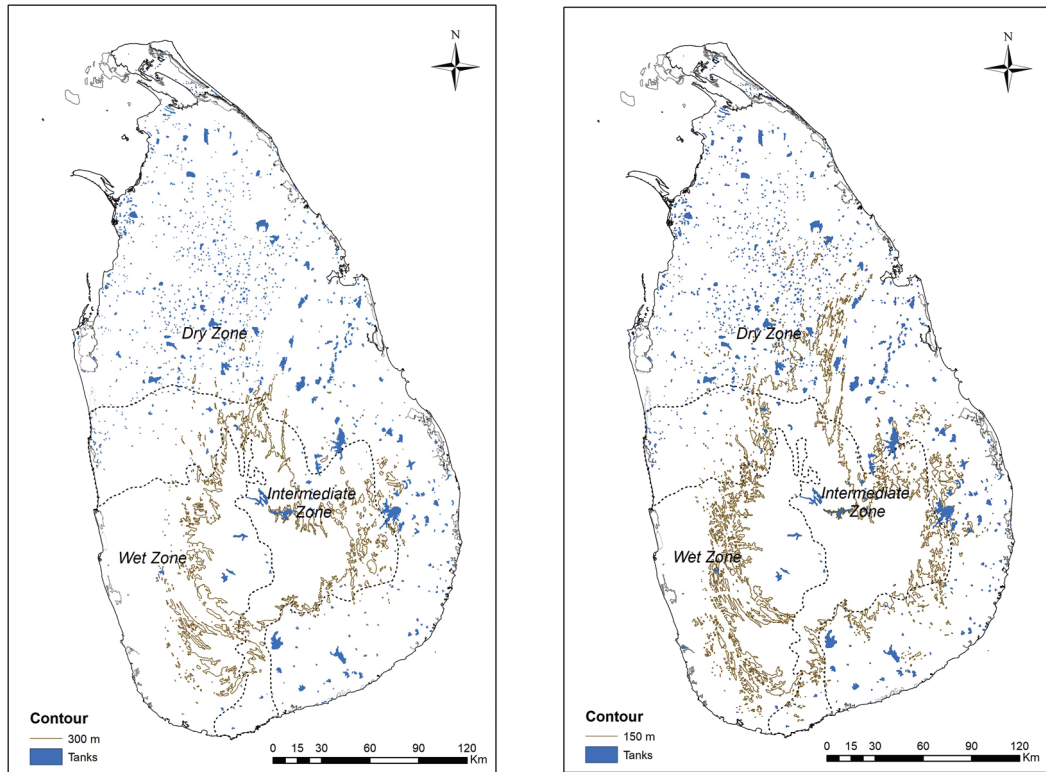
The Figures 10 and 5 reveal that headwater streams of the Mahaweli River are very complicated. Most of the headwater streams flow to northwards from Sanmanala-Namunukula Range as well as Pidurutalagala Peak area. From Peradeniya-Getambe, it flows to the east up to Rantambe seizing of streams of Knuckles Range. Later, it flows via Mahiyanganaya (Minipe) to the north up to Kalahagala (Dimbulagala), and then to Koddiiyar Bay (Tricomalee). From headwater stream to Minipe, Mahaweli has no radial drainage pattern. If compared the relationship between contour lines and river basins (Arumugam, 1969) with attached Figures it is very clear that in Sri Lanka, the statement, *“There are 103 rivers in Sri Lanka, almost all flowing from the central mountainous massif in a radial pattern through various directions”* is a phantasm.

Many river and stream basins are located on the Intermediate, and Dry Zones are below the 300mand 150m contour lines (Figures 11 & 12). As well, distribution of about 85% village tanks are below 300m contour line and more than 90% village tanks are located below the 150m contour line (Figures 13 & 14).

The Figure 15 clearly emphasizes that river basins 103, identified by Arumugam (1969) and fallowed by others, have not flowed from Central Highland to sea and obviously no radial drainage pattern.

CONCLUSION

The present study is intended to provide a broad clarification on river basin concept and rivers in Sri Lanka while reviewing and highlighting the misunderstanding, interpretation and misreading of river basins

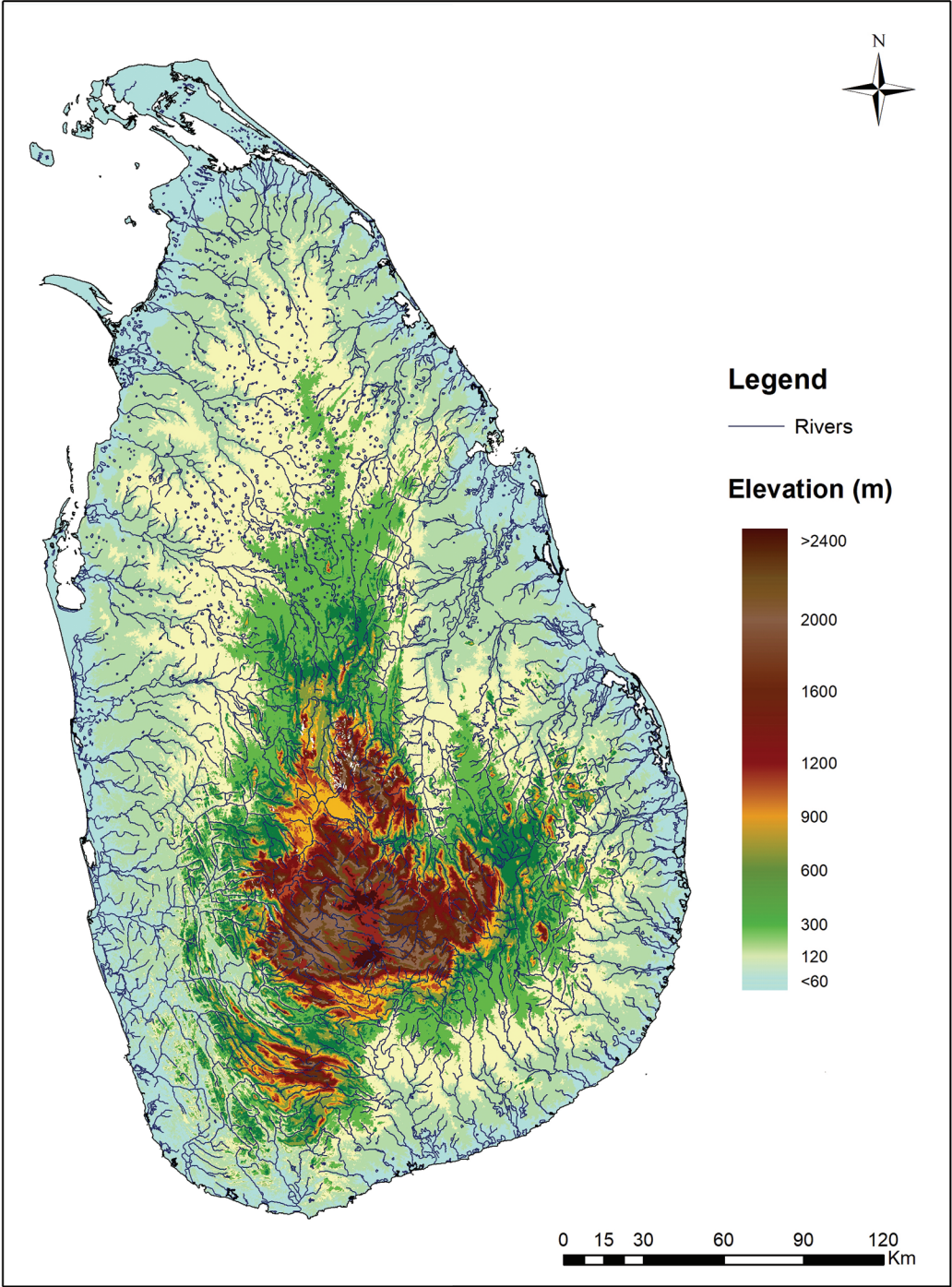


FIGURES 13 & 14: Distribution of about 85% village tanks are below 300m contour line and more than 90% village tanks are below the 150m contour line.

with rivers of the island. Upon examining the related scientific literature of the subject, Arumugum in 1969 introduced the 103 river basin concept that later misinterpreted by most scholars. Therefore, unlike most local and foreign scientific literature that claim Sri Lanka has 103 rivers that flow radial from Central Highlands to the sea, the present study only identified 29 rivers (Kelani river, Kalu river, Bentota river, Gin river, Polwathumodera river, Nilwala river, Sinimodara oya, Kirama oya, Walawe river, Kirindi oya, Menik river, Kubukkan oya, Hada oya, Gal oya, Mahaweli river, Yan oya, Mandekal aru, Pallearayan kaddu aru, Pali aru, Chippai aru, Parangi aru, Nay aru, Aruvi aru, Kal aru, Uppu aru, Kala oya, Deduru oya, Karambalan oya and Maha oya) that flow directly to the sea while originating from the wet zone, dry zone and intermediate zone (Silva and Katupotha 2018). Among these rivers, only 8 rivers (Kelani river, Kalu river,

Walawe river, Kirindi oya, Menik Ganga (river), Kubukkan oya, Gal oya and Mahaweli river) start from the central highland and its adjacent areas (>1200 m contour line). Apart from these 8 rivers none of the rivers mentioned in the traditional river classification do start from the Central Highland. Considering the origin, the most rivers and oya start below 1200m and most notably, around 85% of the rivers and oya found on the island start below 600m contour line. Even though number of scholars stated that all rivers flow radially from central highlands, the Mahweli river does not follow the radial drainage pattern.

Rivers such as Mahasilawa oya, Katupila ara, Palakutti ara and Rathmal oya do not connect to the sea at all. They either connect to a major river or a salt marsh. Further, 6 water bodies located in back-barrier coastal areas (Bolgoda lake, Madu river, Madampe lake, Telwatte river, Rathgama lake and Koggala



FIGURES 15:The relationship between altitude drainage pattern of Sri Lanka.

lagoon) have been misunderstood as rivers in the traditional classification. Finally, the remaining 64 rivers/oya in the classification connect to either lagoons or lakes.

With these findings it is clear that misreading the Sri Lankan rivers and river basins has taken place in a large number of scientific literature. All are cut and paste Arumugam (1969) statement without any consideration deeply. Since this information is valuable in a number of ways to the country, misreading of these subject matters must be corrected immediately. Further studies on the subject of river basins concept must be used in analytical manner and the context of Sri Lankan education system should be updated accordingly.

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