The Small Tank Cascade Systems of the Rajarata:
Their Setting, Distribution Patterns, and Hydrography

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Contents

It is only after you have properly understood the essential nature of those things you've seen, that you will be able to perceive their true form and order
- A fifth century BC Chinese saying -

PREFACE

At a meeting held in July 1996 between some of the senior professionals of the MASL and its Director General, a consensus emerged on the need for MASL to sponsor some kind of scholarly enquiry into certain aspects of the ancient and medieval hydraulic irrigation systems, especially those situated within the various Mahaweli systems. It was the shared view of this group that MASL should also consider supporting such studies and enquiries that could have long-term implications for the future extension plans of the present Mahaweli Project.

It was around this time that I had, quite fortuitously, begun to assemble and interpret a substantive body of information on the settings of small tank cascade systems across the various landscapes of the Anuradhapura district. This body of data was essentially a by-product of the main studies that were carried out by an interdisciplinary team of senior professionals of the International Irrigation Management Institute (IIMI), including myself, on approaches to the rehabilitation of small tanks. These studies were conducted under the auspices of the Participatory Rural Development Project (PRDP) of the Anuradhapura district, which was supported by the International Fund for Agricultural Development (IFAD). It should be unequivocally acknowledged here that it was this IFAD-funded study carried out during the latter part of 1994 that made it possible for me to garner the seminal knowledge base that was so essential to understand the role and setting of these small tank cascade systems across this landscape.

I gave three lectures from 1995 to 1998 on the outcome of these studies: the first in 1995 under the auspices of the Sri Lanka Association for the Advancement of Science (SLAAS) and the Institute of Fundamental Studies (IFS); and the second in 1997 under the MASL and the Royal Asiatic Society (RAS); and third in 1998 under the SLAAS and the National Academy of Sciences (NASSL). The reactions and responses of the very enlightened audiences present at these lectures helped further refine and sharpen the focus of these studies.

I have presented the key information arising from these studies in a straight forward manner in this publication, in order to help other researchers and scholars to further interpret and draw their own conclusions. I have attempted to organize and present, in a systematic manner, the wide range of information that was gathered; and I have also attempted some measure of analysis and interpretation of these data from the standpoint of my own disciplinary interests on soils, land forms, hydrology, and geomorphology.

I am most grateful to the then Director General MASL, Mr. J. Samaranayake, Dr. Ranjith Wanigaratne and Dr. Herath Manthrithilake, for taking the initiatives that helped me to both realize and complete this study. I am also grateful to Mr. Tissa Senaratne, former Secretary General of MASL for obtaining the funding from the Japanese donors to conduct this study, and to DFID, UK for publishing the same.

I would like to record my special appreciation to Dr. Doug Merrey who was then Head, Sri Lanka National programme of IIMI, for providing the necessary support and facilities within IIMI for completing this study. I record a special word of thanks for Dr. Manthrithilake, Director, Environment and Forest Conservation division of MASL, for his special interest and commitment in taking the responsibility for the digital cartographic work and layout of the master map together with the rest of the supporting maps. I owe much to Messrs. L. Amarasinghe and L. D. Jinadasa, Land Use Planners who carried the main burden of the cascade and sub-watershed demarcations by topo sheet analysis and air photo interpretation, the preparation of the master maps, and also assembling the tables given in Annex 1. My thanks also go to Miss Janitha Godamuduna for typing the text and creating the tables of this publication.

And last, but by no means least, I am much beholden to Dr. Ranjith Wanigaratne, Director Planning and Monitoring Unit (PMU) of the MASL for writing the Foreword for this publication.

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FOREWORD

Sri Lanka's irrigation heritage draws upon two main traditions: The 'Greater Tradition' *(Mahasammatha)* follows the construction and management of thousands of small village – based tank and anicut systems. The tradition contains elements of what was once a more wide spread phenomenon of a small tank based village paddy culture. This small tank culture with its customs, norms and rules governing irrigation management and paddy production has endured the intervening centuries upto the present.

The 'Lesser Tradition' *(Chulasammatha)* emerges from the construction and management of large storage reservoirs, anicuts and canal complexes. It represents a later and higher evolutionary step in the development of irrigation works in Sri Lanka. The irrigation technology of the 'lesser tradition' behind the construction of stupendous irrigation works and the institutional base of their management has not survived. It is likely that these major works were managed by the central government. Consequently, they may have been particularly sensitive to the foreign invasions, civil strife and physical hazards that periodically disrupted the central authority of the ancient kingdoms.

Small tanks in earliest times may have been discrete constructions of initial village settlements. Through their construction a modicum of assurance of water supply was derived for food crop production. As time went on the settlements, their populations and their food needs expanded. A concomitant need arose to secure irrigation water supplies to an expanding agricultural land frontier. As a response to such challenges the individual small tanks in micro catchments were linked together into tank cascade systems in larger meso-catchment areas and which later developed into large-scale storage reservoirs and canal networks. Each succeeding stage in this upward linkage development process denoted a rising sophistication in engineering skills as well as a complex differentiation in management disciplines.

Under limitations of a village resource base, the tank systems probably underwent autopoesic changes in their original management mechanisms as they responded to multi-dimensional stresses over the centuries. Unique irrigation management mechanisms evolved in these tanks systems that were particularly resilient to such stresses, some of which have endured to this date. An example lies in the regulated riparian mechanism of *Bethma* that ensured and equable use of water under conditions of water scarcity. It entailed a temporary subordination individual stakeholder rights in the common water resource of the village to the group interests of the community. The land and water share entitlements of individual stakeholders as well as the mechanisms of enforcement that could maintain such subordinating action were well defined and institutionalized. Yet, the *Bethma* mechanism was also malleable enough to extend its application to modern day large multi-purpose irrigated development projects such as the Mahaweli.

From another perspective, the volume of accretionary capital in labour effort and material invested in the small tanks systems would have been colossal. This capital represented the continuous development and management effort by successive generations of village families in thousands of small villages using resources within their reach. Such an investment would have bred a particularly strong common property sense over the use of the village water resource. This sense of common property would have generated appropriate institutional mechanisms that maintain order and stability in the management of these small tanks over hundreds of years. They also develop a high degree of resilience to both externally and internally introduced stresses. Thus, while central governments of ancient kingdoms and the management bureaucracies of the larger irrigation systems succumbed to such stresses, the village level tanks systems and their management mechanisms survived.

Yet, it was a survival that was attained through their disconnection from the main systems. This disconnection process was further deepened my mass movements of the dry zone population to the southwest regions of the island between the 13th and the 15th century A.D. With increasing isolation from the main stream changes in the national political and socio-economic settings, these systems move into a path of slow entropic decline.

Large modern day capital intensive major irrigation projects such as the Galoya, the Walawe scheme, the Lunugamwehera scheme and the Mahaweli programme seemingly re-link and activate, once again, the ancient major irrigation nuclei with their small tank cascades and major works. Once again the ancient need of national food security dominates, with modern day new needs such as hydro power generation, communication and regional development added on as other *raisons d'etre* of their being. Yet, the implications of such a re-link, in the context of historical causalities behind the breakdown of similar irrigation system linkages in the past has not hitherto emerged as a subject of either wider academic debate or irrigation policy deliberation.

Scholarly writings, memorabilia travelogues, official reports and notes, besides historical manuscripts and epigraphic evidence, legends and folklore exist on the hydrological, agro-demorgraphic, economic, socio-institutional, cultural and historical importance of the small tank irrigation systems in the island. Yet, since the past authoritative works of Brohier in the early 1930s, in the history of Ceylon and Senarath Paranavitane Commemoration volumes published by the University of Ceylon, Peradeniya in the 1960s no further attempts has been made to put together the contemporary knowledge on the small tanks systems gathered over the last three to four decades.

Small tanks systems, in view of their histo-cultural significance in Sri Lanka's national heritage have always occupied a priority place in its national pride and conscience. Currently, these systems face new challenges of direct and large-scale state interventions and infiltration of commoditising influences of a liberalising economy. Other new challenges arising through globalisation of national economic processes will be faced by these systems in the coming years. The resiliency of the systems to such changes and their implications upon the sustainability of small tanks based irrigated agriculture in the future are other important areas about which no in-depth research or applied development policy dialogue has ensued within the last three decades.

In this context, the current monograph by Dr. C. R. Panabokke, is a timely bench mark for furtherance of both research on indigenous irrigation systems as well as of policy making on their future role in national agro-economic development. The monograph performs a yeoman services in mapping the boundaries of all small tank cascades that make up the catchment basins of the major river complexes that served the ancient Rajarata. In examining the hydrological issues arising from the spread and performance of small tanks cascades systems and their implications upon the future of large irrigation works such as the Mahaweli systems this monograph seeks to extend the contemporary local and international knowledge base on the possibilities and pitfalls that confront future irrigation investment policies.

It is hoped that the current volume will be the first of a series of monographs covering the small tanks systems in the intermediate and dry zone regions of the country. A completion of the latter task would finally bring out the total spatial configuration of the greater irrigation tradition. An authoritative monograph series on small tanks systems is also considered timely, to link up with the monumental undertaking of R.L. Brohier, in charting and examining the distribution of major irrigation works (of the lesser irrigation tradition), completed over sixty years ago. Above all, it was thought that a series of authoritative techno-analytical works on the total indigenous irrigation systems in the island would invite the much needed domestic and global research and policy attention on the role of such systems in catering to priority development issues of the future.

In 1996 the Planning and Monitoring Unit (PMU) of the Mahaweli Authority of Sri Lanka (MASL), in response to a renewed global and national policy interest on the contemporary importance of small tanks systems in promoting food security and equity considerations in allocating scarce water supplies, undertook to develop a compendium of research writings on the subject. Several round of discussions were held with academic and policy makers of the country to identify the range of expertise and willingness to contribute to such a compendium.

A consensus was reached that the MASL should sponsor further scholarly enquiries on the subject in view of possible long-term implications upon the furtherance of future spatial extension objectives of the Mahaweli Programme.

In early 1997 the MASL having considered the relevance of the studies that the International Irrigation Management Institute (IIMI) had conducted in the Anuradhapura district, invited the IIMI to provide it with a set of master maps of the demarcated cascades covering the full area of the seven river basins that comes under the Rajarata region which extends beyond the present Anuradhapura district boundary. Dr. C.R. Panabokke, as a Senior Research Fellow of the IIMI responded through a proposal to map the small tanks and tank cascade systems that formed the hydrological boundaries of the ancient *Rajarata* which largely came within the present-day administrative boundaries of the North Central and North Western Provinces. This mapping exercise was to be accompanied by a technical write-up of the hydrography and other salient characteristics of these systems.

Dr. Panabokke's proposal was accepted on behalf of the MASL by Mr. Tissa Senaratne, the former Secretary General. The responsibility of facilitating the compilation and final publication of the study was vested with the Planning and Monitoring Unit (PMU) as the MASL agency responsible for sponsoring and assisting research on irrigated settlements. The past two years of involvement has been quite rewarding. The author was successfully prevailed upon to consider a three-volume monograph series on the total spatial distribution of small tanks in the Dry and Intermediate agro-ecologic zones of the island.

Through the office of the Secretary General financial assistance was sought to complete the cartographic work of mapping the small tank systems and to defray the costs of the final publication. In this instance Mr. Yukinori Sano, team leader of the Nippon Koei Co. Ltd., of Japan, magnanimously volunteered to provide the funds for the cartography work in mapping the small tanks. On account of this assistance the small tank systems of the North Central and North West provinces indicating the hydrological borders of the ancient Rajarata were mapped and completed on schedule. These maps form the base of the current monograph.

The cartography work on small tanks of Sabaragamuwa, Uva and Southern and Eastern Provinces defining the hydrological borders of ancient Ruhunurata and other residual small tank areas in the country were similarly funded by Mr. Sano. The initial maps of Ruhunurata small tank systems have now been completed. They will form the base of succeeding monographs in the future.

My MASL colleague Dr. H Manthrithilake, Director, Environment and Forest Conservation Division (EFCD), assisted in digital mapping of the initial cartography work for publication purposes. He was also successful in obtaining funds for the publication of the first monograph through the good offices of Mr. Roger White, Team leader, ENDEV Project of DFID, UK.

Personally, it has been an intellectually rewarding experience in collaborating with Dr. Panabokke in the development of this important monograph on the small tank cascade systems of the Dry Zone regions of the country. I trust that the monograph would provide ample intellectual stimuli to reactivate a national debate and further contemporary research on the small tank systems.

Ranjith D. Wanigaratne
Director
Planning and Monitoring Unit
Mahaweli Authority of Sri Lanka

Chapter 1

Scope and Purpose

The International Irrigation Management Institute (IIMI) has been engaged in studies on the small tank cascade systems of the Anuradhapura district of the North Central Province since mid-1994. The results of these studies have been reported in the following IIMI publications.

1. Guidance Package for Water Development of Small Tanks Cascade Systems. December 1994. IIMI-SLFO. (IIMI 1994).

2. Natural Resources Management Study of the North Central Province. Vol. 1. Main Report 1995, IIMI-SLFO. (IIMI 1995).

3. Nature of Small Tank Cascade Systems and a Framework for Rehabilitation of Tanks within Them, 1996. IIMI Country Paper No. 13. (Sakthivadivel et al. 1996).

The above studies were carried out within the framework of the administrative boundaries of the Anuradhapura district of the North Central Province, and therefore did not include all the nine river basins that traverse this region.

The Mahaweli Authority of Sri Lanka (MASL), having recognized the importance of these studies, especially with regard to the future development of those areas that fall beyond the present System H, requested IIMI to provide it with a set of *master maps of 1 inch to 1 mile scale* showing the *boundaries of the main watersheds, sub-watersheds and individual cascades*, together with a supporting explanatory text.

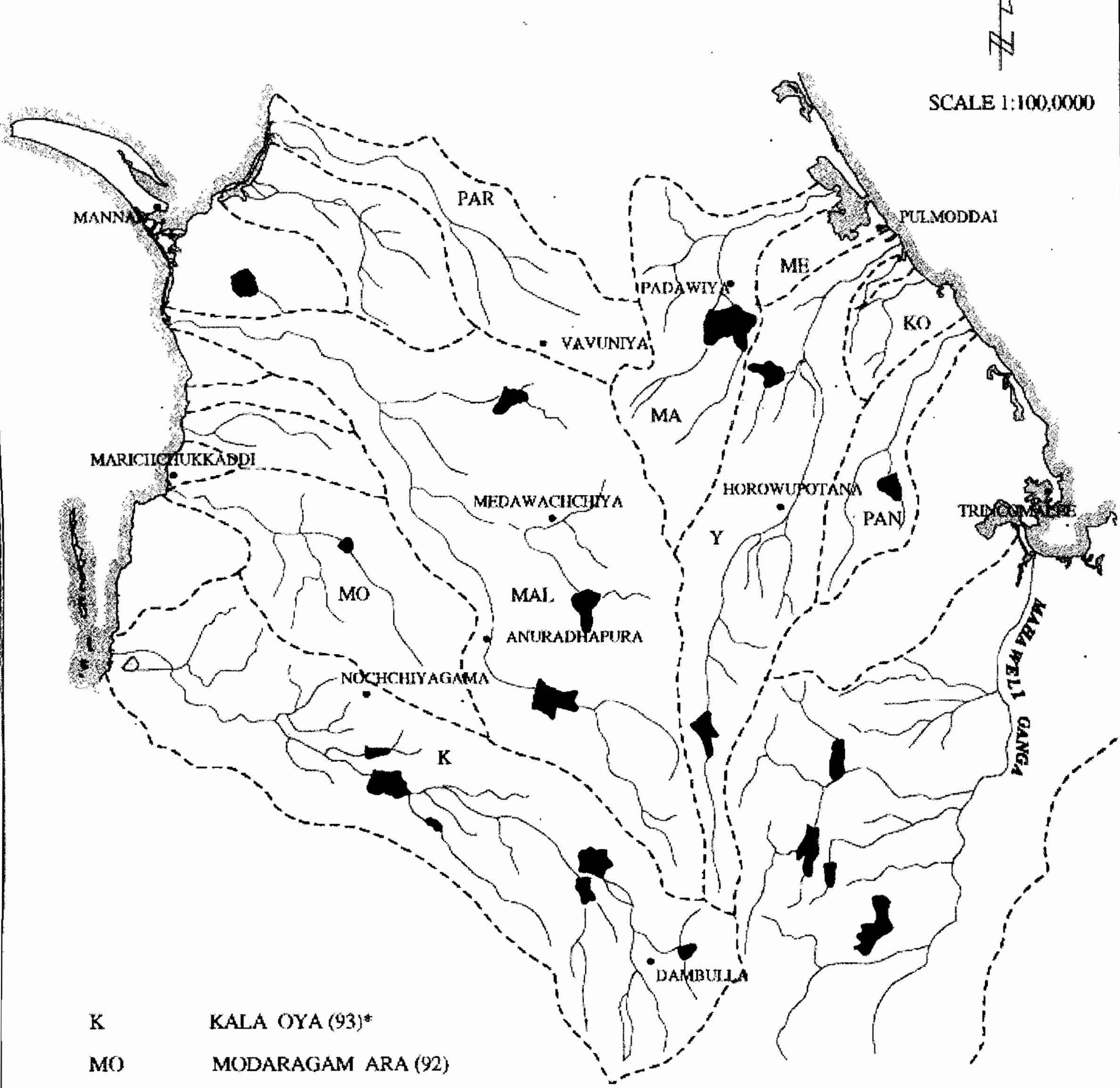
The MASL's requirements covered the whole basin or watershed area of each of the river basins: Kala Oya, Modaragam Ara, Malwathu Oya, Parangi Ara, Ma Oya, Mee Oya, Yan Oya, Koddikkaddi Ara and Pankulam Ara, because future development of the Mahaweli project beyond the present System H traverses either the full extent or part of each of the above river basins. The earlier IIMI studies were therefore extended beyond the administrative district boundaries of Anuradhapura to include the whole basin or watershed areas of all the rivers that traverse this region.

The *Rajarata* as defined in this paper includes the whole area occupied by all the foregoing river basins as shown in **figure 1**. This is understood to be the traditional demarcation of the ancient Rajarata, and as seen in this figure, it extends — well beyond the boundaries of the present Anuradhapura district—to the western and eastern coasts.

The main purpose of this publication, together with the set of supporting master maps, is to provide the MASL professional staff with a clear depiction of the *hydrography of the Rajarata* based on properly demarcated *main and sub-watershed boundaries* together with the individual *small tank cascades* that make up each of the sub-watersheds.

This text is a straightforward presentation made for the benefit of the general user who could make further analyses and interpretations for specific purposes by reference to the three IIMI publications cited earlier in this chapter, together with the set of maps that accompanies this text. It is the shared view of both MASL and IIMI that such a set of maps and text which depict the distribution of the small tank cascades would be of immense value to all professionals connected with planning, design and layout of a rational irrigation network in the future development areas beyond the present System H in the Rajarata region.

THE MAIN RIVER BASINS OF THE RAJARATA



K	KALA OYA (93)*
MO	MODARAGAM ARA (92)
MAL	MALWATHU OYA (90)
PAR	PARANGI ARA (88)
MA	MA OYA (69)
ME	MEE OYA (68)
Y	YAN OYA (67)
KO	KODDIKKADDI ARA (65)
PAN	PANKULAM ARA (64)

REFERENCE

- - - - - - Watershed Boundary of Main River Basins

Wewa, Kulam, Tank

Stream, River, Ara, Oya

* The numbers in this brackets denotes the standerd basin numbers given in the National Atlas of Sri Lanka

Figure 1

Prepared by Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka, Polgolla.

Chapter 2

The Environmental Background of the Rajarata

Although the Rajarata is located wholly within the dry zone of the north central region of the country, its natural environment is by no means homogeneous as commonly perceived. There is a distinct variation in the annual and seasonal rainfall as well as in the natural hydrology as one proceeds from the eastern part of the north central province to the western part. Similarly, a variation in landforms, soils and underlying geology could also be recognized between the eastern and western parts of the Rajarata.

The foregoing variations in the natural environment have an important bearing on the distribution patterns as well as on the density of small tank cascade systems that cut across this landscape. They also have a significant influence on the stream flow characteristics of both the lower order and higher order streams that traverse this region.

One of the most striking features in the tank distribution pattern in the Rajarata is the decreasing density of small tank cascades and medium size tanks as one proceeds from the eastern segment of this region to the western segment. This feature could be clearly observed in the Master Map (on a scale of 1:250,000) that accompanies this text.

The reasons for this striking variation in tank density are now fairly well understood. The three main factors that contribute towards this variation in tank density are:

- The nature of the dominant soils of the area together with the geology, especially the lithology of the underlying substratum.
- The nature of the seasonal rainfall and the total amount of reliable rainfall.
- The shape and form, or the morphology of the landscape.

The overall soil distribution pattern of the Rajarata is shown in **figure 2.** This is a highly generalized version, which shows only the dominant soil groups representative of the different portions of the Rajarata, that readily explains the soil-tank density relationships.

A comparison of this General Soil Map of figure 2 with the small tank cascade distribution pattern, as seen in the Master Map that accompanies this text, shows a total absence of tanks within the latosol soil region which occurs in the western coastal and the adjacent inland portions of the Rajarata. The latosols are very deep, coarse- textured soils with a very high infiltration rate and with a very porous substratum which, therefore, cannot hold up any water in the form of tanks or small reservoirs. This is why man-made tanks are not found in this soil region; however, there are occasional *villus* (grasslands of swamps) that are formed on the sink-holes of the underlying Miocene limestone formations.

As one proceeds eastwards form the latosol region, one traverses a belt of rocky, gravelly and highly eroded land as seen in figure 2. Although such land can hold up water for tanks, the quality of the soil is very poor and unsuitable for productive agriculture. There are very few tanks within this belt and a very high percentage, if not all, of these tanks falls within the category of abandoned tanks as could be seen in the 1 inch to 1 mile sheets that accompany this text. These have been abandoned in the past and are not considered suitable for restoration.

SOIL DISTRIBUTION OF RAJARATA
GENERAL SOIL MAP

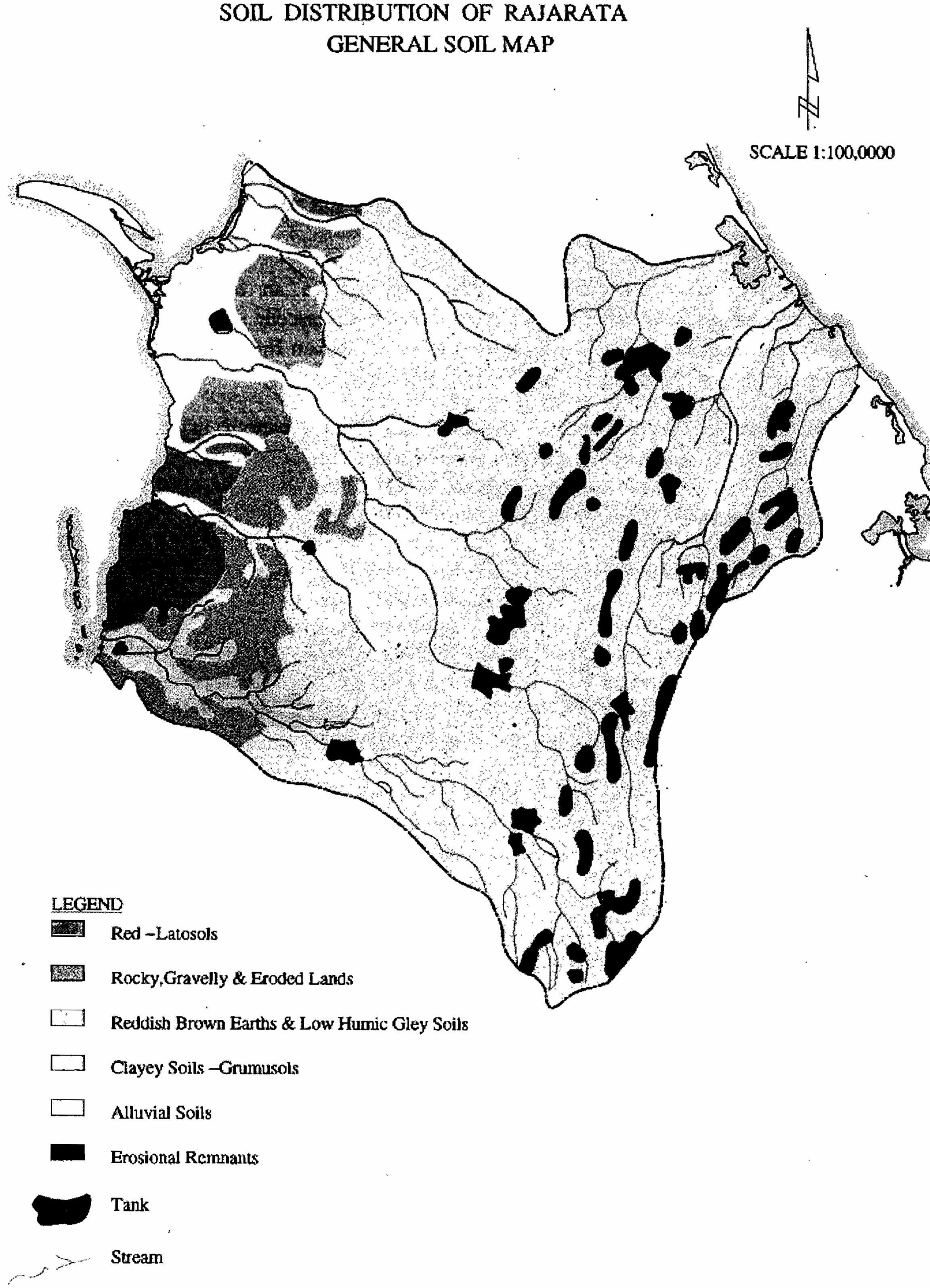


Figure 2

Prepared by Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka, Polgolla.

Proceeding further eastwards from this rocky and gravelly land one enters the reddish brown earth (RBE)-low humic gley (LHG) soil region that extends to the eastern coast. Because this soil region has the essential attributes for holding up water in the form of tanks or reservoirs, it constitutes the heart of the Rajarata tank civilization. Similarly, the narrow tracts of alluvial soils, and some parts of the very clayey soils as shown in figure 2 are also well-suited for tank construction and water retention.

In addition to the nature of the soil and underlying substratum, the amount of rainfall received during the *maha* (wet) season has a significant bearing on both the tank density and the hydrological endowment of the tank cascades. **Figure 3** shows the 75 percent probability of the maha season rainfall in mm for 12 locations including the modal value for DL1 agro-ecological region which makes up the major portion of the Rajarata. It also shows a distinct increase in rainfall from the western segment (Nochchiyagama-Tambuttegama area) of the Rajarata to the eastern segment (Horowupotana-Kebithigollewa area). As a result, both the tank density and the hydrological endowment of small tank systems are higher in the eastern segment than in the western segment.

It is also observed that despite the higher rainfall experienced east of the Yan Oya, the tank density there is lower than in the west of the Yan Oya. This could be attributed to the more rolling-to-highly undulating landforms present east of the Yan Oya, compared with the more subdued and gently undulating landforms present west of the Yan Oya. A higher tank density is possible in the gently undulating relief than in the rolling relief.

Because of the differences in the amount of rainfall and in the morphology of the land forms, significant differences could be observed in respect of the stream flow characteristics of both the lower and higher order streams that traverse the eastern portions of the Rajarata as compared with those that traverse the central and western portions.

The natural vegetation of the Rajarata has been described as a `dry mixed evergreen' forest. The standard or the *dry fasciation* is the dominant climax in the central and eastern portions of the Rajarata, and the *very dry fasciation* is the dominant climax in the western drier portions. The main vegetation is the *wira-palu-buruta* association mixed with other species such as *milla, welang, halmilla, kolon, madan, wewarana, hurimara* and *godakirilla* to form the truly "dry mixed evergreen forest." The very dry fasciation has a similar composition with a greater mixture of *mayila, wa, kihiriya* and *lunuwarana* and the vegetation on the whole is more sparse and stunted here. The forest floor is relatively clean with only a thin cover of leaf litter and forest debris.

LOCATION OF RAINFALL STATIONS & 75% PROBABILITY VALUE OF MAHA RAINFALL

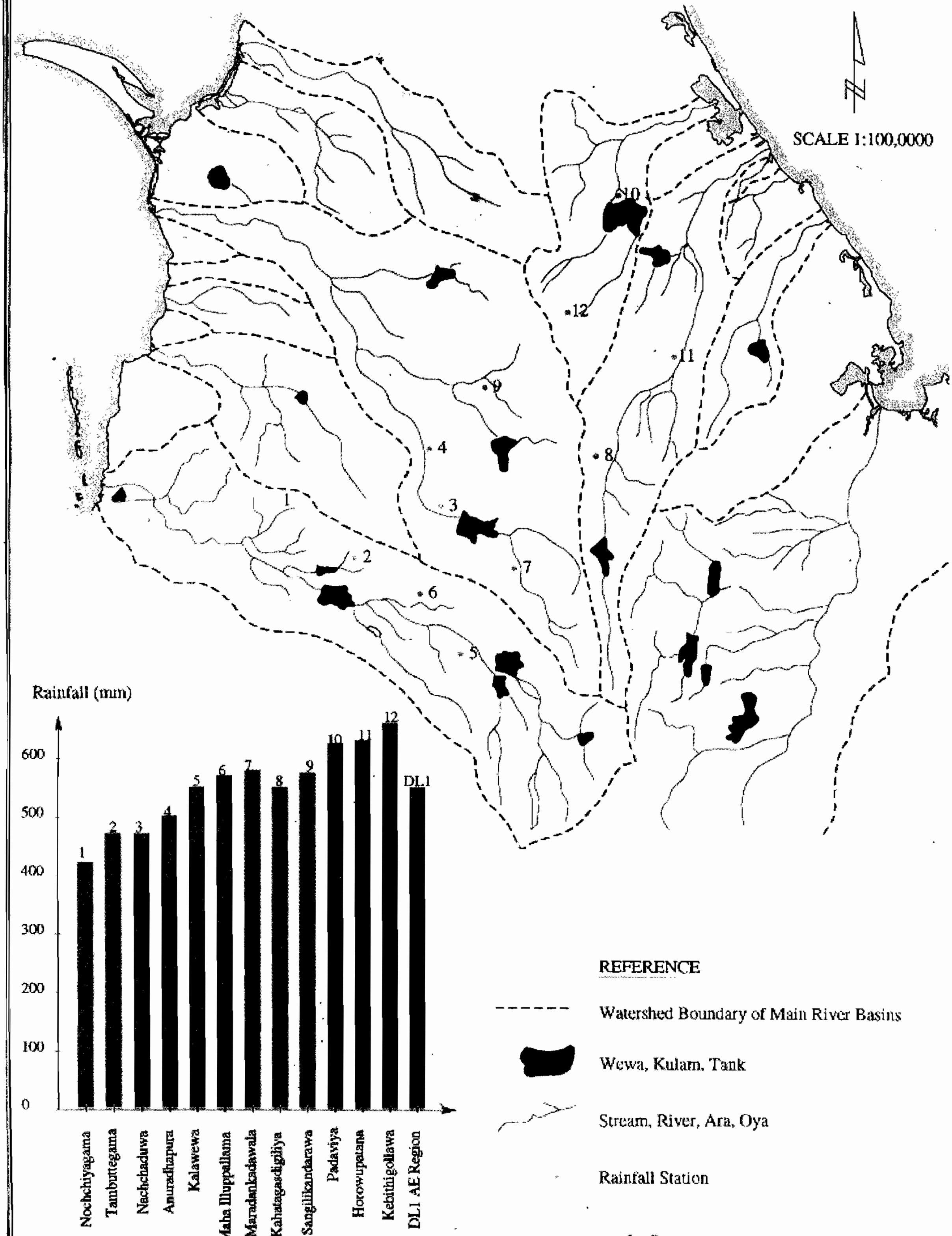


Figure 3

Prepared by Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka, Polgolla.

Chapter 3

The Small Tank Cascade Systems

Of all the small tanks in the Rajarata, approximately 90 percent is clustered into cascades. Each of these cascades forms a distinct small watershed ranging in extent from 5 to 10 square miles with a modal value of around 8 square miles. While each of the individual small tanks located within a cascade has its own *micro*-watershed, the cascade or the cluster of several tanks will have its own *meso*-watershed whose modal extent or area will be around 8 square miles.

A cluster of such small tank cascades forms a sub-basin or *sub*-watershed of a *major* river, and these sub-watersheds could range in size from 40 to 100 square miles, with a modal value of around 75 square miles.

Table 1 shows the number of sub-watersheds within each river basin and the corresponding number of small tank cascades that make up each of the nine major river basins of the Rajarata.

Table 1 : **Number of sub-watersheds and small tank cascades within each river basin.**

Main River Basin	Number of Sub-Watersheds	Number of Cascades
Kala Oya	12	68
Modaragam Ara	3	42
Malwathu Oya	15	179
Parangi Ara	4	34
Ma Oya	4	40
Mee Oya	1	01
Yan Oya	7	74
Koddikkaddi Ara	1	08
Pankulam Ara	3	11
Total	50	457

A cascade, according to the definition by Madduma Bandara (1985), is a "connected series of tanks organized within the micro-catchments of the dry zone landscape, storing, conveying and utilizing water from an ephemeral rivulet." Minor refinements in terminology to the above definitions have been proposed by Panabokke (Sakthivadivel et al. 1996: p.3), who suggests the use of the term *meso*-catchment in place of *micro*-catchment so that the former term represents the total watershed area of the cascade of tanks, and the use of *micro*-catchment is restricted to the immediate catchment of each individual minor tank within the cascade **(figure 4)**. It is also proposed to replace the term *ephemeral rivulet* with either *second order* inland valley or *first order ephemeral stream*. It should also be borne in mind that there is no significant dry season flow in these ephemeral streams from May to October, and again from mid-February to early April.

In a more recent study, Itakura and Abernethy (1993) describe a tank cascade, or a chain of tanks, as a "series of small reservoirs that are constructed at successive locations down one single common watercourse."

SCHEMATIC REPRESENTATION OF A SMALL TANK CASCADE

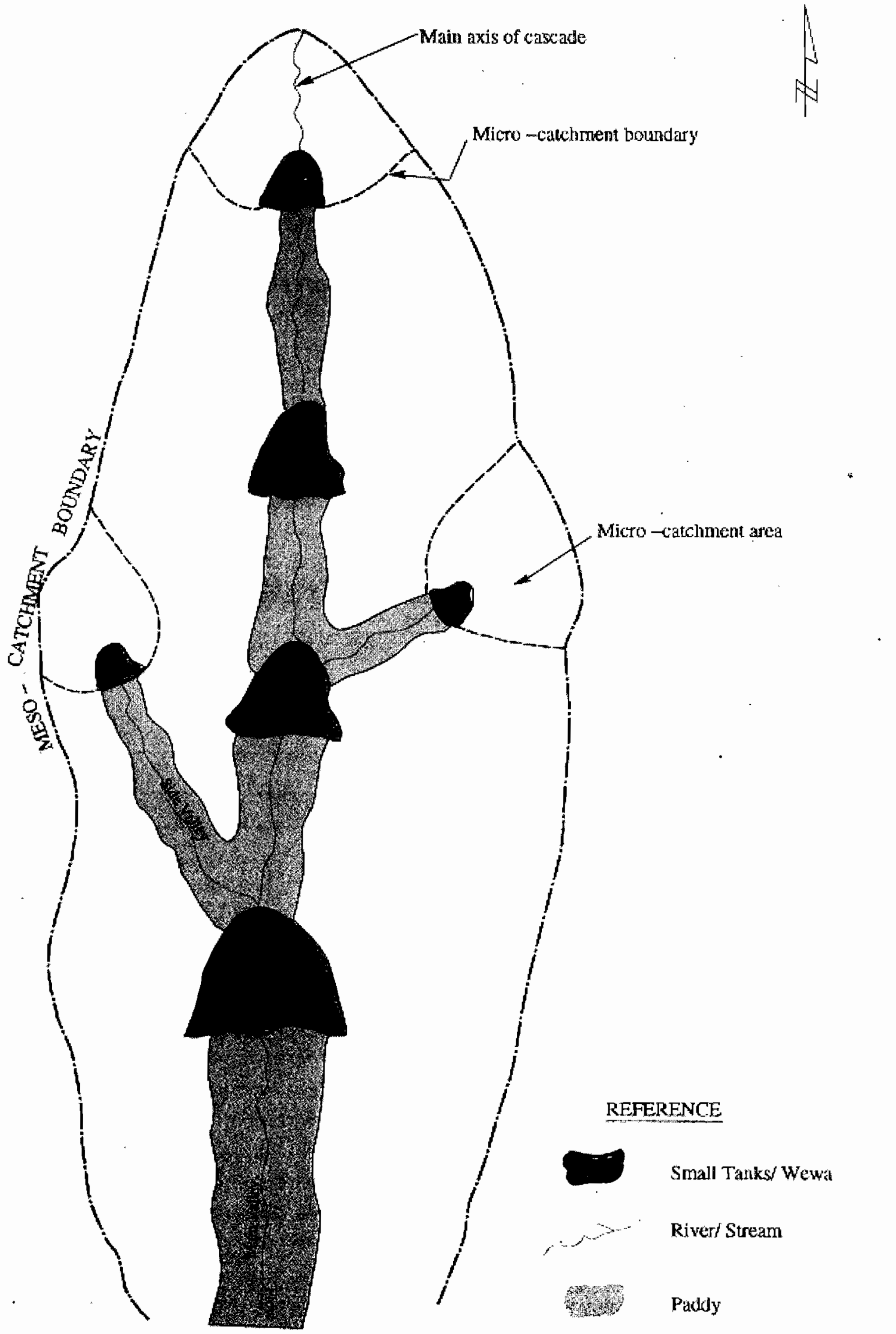


Figure 4

Prepared by Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka, Polgolla.

A schematic representation of a typical small tank cascade system at a scale of 1:50,000 is shown in **figure 4.** The main elements that make up a cascade, namely (a) the watershed boundary of the meso-catchment, (b) the individual micro-catchment boundaries of the small tanks, (c) the main central valley, (d) side valleys, (e) axis of the main valley, and (f) the component small tanks as well as the irrigated rice lands are shown in the same figure.

Itakura and Abernethy (1993) have made the following observations: " In Sri Lanka what are called tank cascade irrigation systems have developed as ultimate stock-type irrigation systems. These systems are interconnected storage and regulating reservoirs which serve multiple functions of resource management including irrigation, domestic water supply, water for livestock and sub-surface water for perennial cropping. Some of these tanks have very long histories which date back over a thousand years, and were once the backbone of an ancient hydraulic civilization which flourished in the north central part of the country."

Three small tank cascades close to Anuradhapura that lie adjacent to each other and are easily observed on the Maradankadawala-Tirappane road with the aid of the 1 inch to 1 mile topo sheet of Anuradhapura are depicted in **figure 5.**

Some of the more important indigenous and traditional understandings of small tank cascade systems have been described by Tennakoon (1994) in an unpublished manuscript of restricted circulation from which some key extracts are reproduced below.

"In the small valleys of the undulating dry zone terrain, less rapidly moving water cascades from the crests of the low ridges to the keels of the small valleys are intercepted with man-made small and narrow earth bunds of low elevation, to create reservoirs big and small. The small reservoirs are constructed in the upper slopes of the small valleys and the bigger reservoirs are constructed in the keels of the valleys. Furthermore, it is to be noted that the tanks in a keel usually become bigger and bigger as one moves downstream of a valley. Water in these reservoirs in a valley, cascades from one to another, starting from upstream, towards downstream into a considerably large reservoir far below, and, finally the volume of water spilled over from that large reservoir at the far end being too much to be held yet in another man-made reservoir, enters a large stream usually termed Oya.

"The Sinhala folkloristic term for the English term cascade is *ellangawa*, formed of the two Sinhala words *ellan* and *gava*, *ellan*, meaning hanging; and *gava* meaning after one another. A cascading valley has four limits or boundaries—the two water divides or the crests of the two ridges on either side of the valley, the upper most point of area from where the main stream of the valley begins and the confluence downstream where that main stream of the valley under reference joins with the mainstream of yet another valley to empty into a larger stream usually called oya (e.g., Sangilikandara Oya, Weli Oya, Kala Oya, etc.)."

Based on the study of the Government Agent's diaries maintained in the Anuradhapura Kachcheri (office of the Government Agent) from the middle of the nineteenth century onwards, Tennekoon (1994) concludes that the cascade concept had been well-entrenched in the minds of the ancient farmers and water resources managers. He further observes that "one of the cardinal strategies adopted in tank construction in a cascading valley seems to be the strict adherence to: (a) having an adequate volume of water in every tank of the settled village in a cascading valley even in a year of below-average rainfall; (b) instituting a regulated flow of water from one tank to another down-stream, avoiding a sudden influx of large volumes of water in order to minimize the risk to tank bund breaching, and (c) have some reservoirs in reserve, as *Olagama* tanks to meet irrigation shortfalls of the main village field as well as *godawalas* as water holes for wild animals and village cattle."

Tennakoon further records "that tanks upstream were never allowed to raise their bunds to impound more water than originally intended to. An arbitrary bund raising has two negative consequences—submerging tail-end fields of the immediate upstream village and the denial of some water to the tank downstream of it, causing irrigation water shortages. Thus, spill levels, diameter of sluices as well as the levels of their placement, bund levels, release of water for field irrigation were all done having in mind the entire network of reservoirs in a cascading valley."

In conclusion, Tennakoon (1994) observes "it is to be reiterated that the cascade concept is an age-old concept. It had been the linking thread of irrigation development and management throughout the irrigation history of this country. However, this has gone out of the screen in the 1950s, 1960s and 1970s, where short-sighted efforts have been increasingly made by the water resource managers and land developers to develop each tank in isolation."

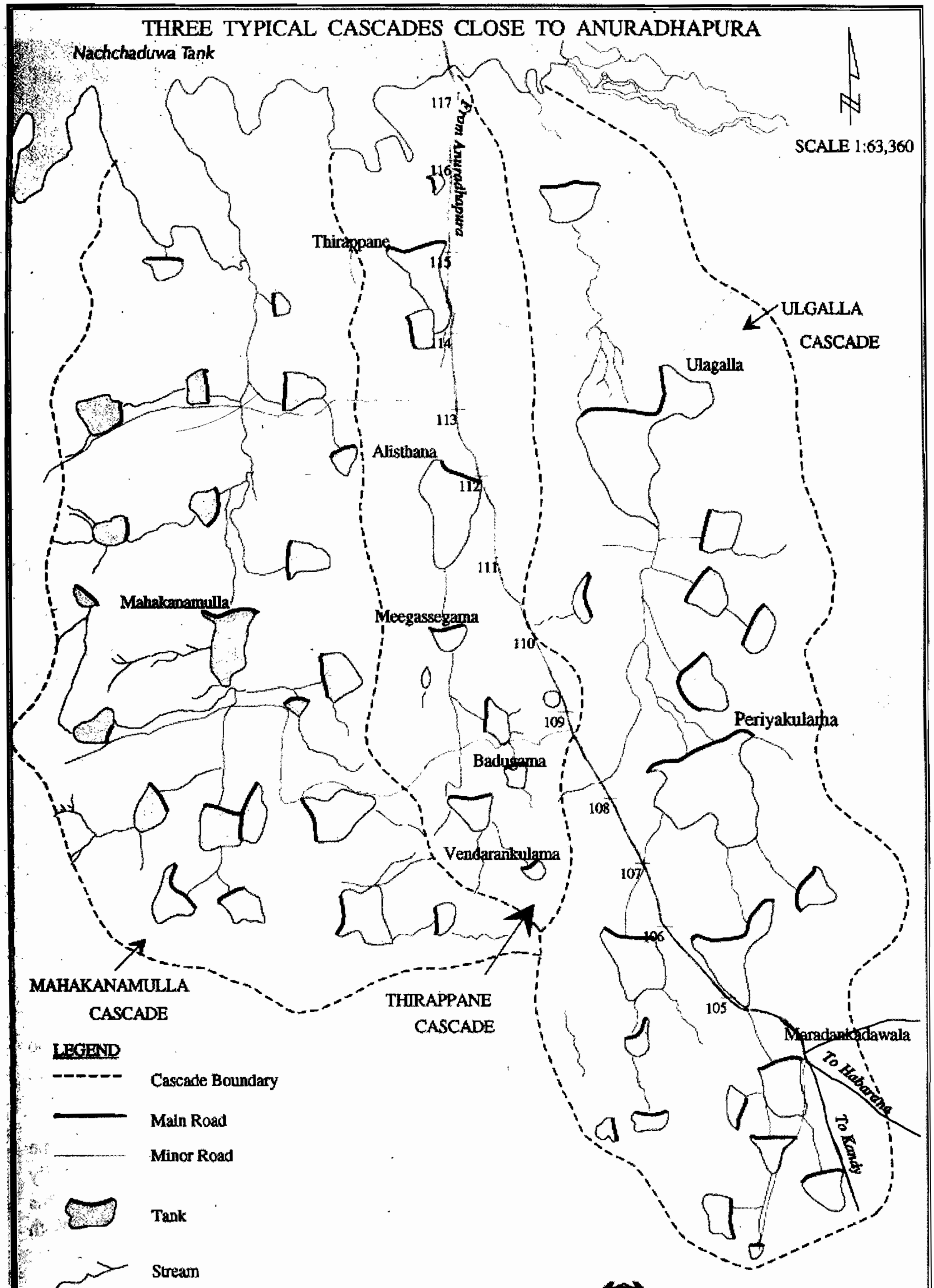


Figure 5

Prepared by Environment & Forest Conservation Division, Mahaweli Authority of Sri Lanka, Polgolla.

Chapter 4

Methodology and Approach

The nine river basins that make up the Rajarata region cover a part or whole of the following seventeen 1 inch to 1 mile topographic sheets (hereafter referred to as 1 inch topo sheets).

1. Puliyankulam 2. Kokkilai 3. Murunkan 4. Vavuniya 5. Padaviya 6. Kudremalai 7. Marichchukaddi 8. Medawachchiya 9. Horowupotana 10. Kalpitiya 11. Kala Oya 12. Anuradhapura 13. Kaudulla 14. Galgamuwa 15. Dambulla 16. Polonnaruwa 17. Nalanda - Elahera.

This could also be seen in the Master Map of scale 1:250,000 that accompanies this text. These nine river basins were each designated by a symbol bearing one or more capital letters as shown in table 2.

Table 2. **River basin names and symbol designation.**

River Basin Name	Symbol Designation
Kala Oya	K
Modaragam Ara	MO
Malwathu Oya	MAL
Parangi Ara	PAR
Ma Oya	MA
Mee Oya	ME
Yan Oya	Y
Koddikkaddi Ara	KO
Pankulam Ara	PAN

These designated symbol letters have been used in the subsequent numbering of the sub-watersheds and cascades within each of the river basins on the respective 1 inch topo sheets.

One Inch to 1 Mile Topographic Sheets

The **watershed boundaries** of each of the above river basins were demarcated on the 1 inch topo sheets and these boundaries have been shown in **thick green line** in each of the topo sheets that cover the whole watershed area.

The next sequential step was that of demarcating the individual cascade boundaries rather than the individual sub-watershed boundaries. The main reason for adopting this approach was to rationally group or cluster several cascades into hydrologically acceptable sub-watersheds units. This procedure also enabled an easy matching of the outer boundaries of the cascades with both the sub-watershed as well as the main watershed boundaries.

The boundaries of cascades that were located within the Medawachchiya, Horowupotana, Anuradhapura and Dambulla topo sheets were demarcated by stereo interpretation of aerial photographs of scale 1:22,000. This area covered approximately 80 percent of the total number of cascades of the whole of the Rajarata. The boundaries of the cascades that were located in the rest of the topo sheets were demarcated by a visual interpretation of the coloured 1 inch topo sheets. The **cascade boundaries** have been shown in **thin red line** in each of the 17 topo sheets.

The sub-watershed boundaries were next demarcated by grouping the cascades within well-defined second and third order watershed divides, together with a third or higher order drainage stream traversing the main drainage position of this sub-watershed. The **sub-watershed boundaries** have been shown in medium **purple line** on each of the 17 topo sheets.

The symbol numbering system that has been adopted for the main watershed, the sub-watershed and the individual cascade as shown in the 1 inch topo sheets is as follows.

The *main watershed* bears the letter symbol as shown in table 2. The *sub-watershed* is next numbered sequentially starting from the uppermost sub-watershed which is given numeral 1. Proceeding in an anti-clockwise manner the rest of the sub-watersheds are numbered in serial order. As could be seen in the master map, the uppermost sub-watershed of the Malwathu Oya bears the number MAL1, and is followed by the subsequent 14 sub-watersheds bearing numbers MAL2 to MAL 15. Similarly, the rest of the sub-watersheds that make up the nine main watersheds are numbered using the same procedure.

Thus the Kala Oya basin has 12 sub-watersheds designated K1 to K12; the Yan Oya basin has 7 sub-watershed designated Y1 to Y7; the Ma Oya basin has 5 sub-watersheds designated MA1 to MA5; the Modaragama Ara has 3 sub-watersheds designated MO1 to MO3; the Parangi Ara has 4 sub-watersheds designated PAR1 to PAR4 and the Pankulam Ara has 3 sub-watershed designated PAN1 to PAN3.

The individual cascades are next sequentially numbered in an anti-clockwise manner for each sub-watershed commencing from number 1 for the lowermost cascade situated on the left bank of the sub-watershed natural drainage stream. The first sub-watershed of the Malwathu Oya, namely MAL1 has a total of 15 cascades as could be seen in the 1 inch topo sheets of Dambulla and Anuradhapura. These bear the numbers 1/MAL1 to 15/MAL1. Thus each cascade bears the cascade number as well as the sub-watershed number. This numbering has been shown in red figures on the 1 inch topo sheet. In the Master Map of scale 1:250,000, the cascade boundaries are shown in red line, and only the cascade number without the symbol is shown in this instance.

Each cascade has also been given its place name according to the name of the largest tank occurring within the cascade. The names of the individual 457 cascades are shown in the annex. These are grouped according to the main watershed of each basin along with the component sub-watersheds.

While those areas that fall within System H of the Mahaweli have been excluded from this study, in respect of the Kala Oya basin, only those sub-watersheds and cascades that fall outside the presently developed System H area have been demarcated and shown in the maps.

Similarly, cascades have not been demarcated within the command areas of the major irrigation schemes such as Nachchaduwa, Hurulu Wewa, Mahakandarawa, Padaviya, Wahalkada and Mahavillachchiya. However, a special map has been prepared for the Hurulu Wewa command area which shows the cascades that would have been present prior to the development of the command area.

Since there are no tanks or cascades present in the downstream areas of the Modaragam Ara and the Malwathu Oya-Aruvi Aru, as seen both in the 1 inch topo sheets and the Master Map, these areas have been shown as blank areas.

The cascade boundaries of those tank clusters that show up as abandoned tanks on the 1 inch topo sheets such as the western segment of the Marichchukaddi and Kala Oya sheets, as well as the eastern segment of the Padaviya sheet, have been shown in broken line to distinguish them from those cascades that presently carry functioning tanks.

1:250,000 Scale Master Map

The map titled 'the Hydrography of the Rajarata' shows the following main features.

- watershed boundaries of main river basins – green line
- sub-watershed boundaries – purple line
- meso-catchment boundaries of small tank cascade systems – red line
- natural streams - blue
- irrigation reservoirs - blue

To help cross-reference with the 1 inch topo sheets, the boundary and name of each 1 inch topo sheets are shown in broken line.

The symbols depicting each sub-watershed are shown in black letters.

The cascade boundaries are shown in thin red line, and their numbering follows the same order as in the 1 inch topo sheets. Where the cascade is made up predominately of abandoned tanks, the cascade boundary is shown in broken red line.

Chapter 5

The Nomenclature, Distribution Pattern, and Hydrography of the Small Tank Cascade Systems

Nomenclature and Distribution Patterns

The method adopted in demarcating and numbering the main watersheds, sub-watersheds and individual cascades was outlined in the preceding chapter. Altogether 457 small tank cascades have been identified and demarcated over the 50 sub- watersheds that make up the 9 river basins of the Rajarata. The names and symbols of each sub-watershed and the number of cascades present within each sub-watershed are given in **table 3.**

Table 3. **Names of the respective watersheds, sub-watersheds, and the number of cascades within each sub-watershed.**

Symbol	Name of the Main and Sub-Watersheds	Number of Cascades	Area of Main Watershed in MIS^2
K	**KALA OYA**		1097.00
K1	Dambulu Oya	-	
K2	Hawanella Oya	06	
K3	Mirisgoni Oya	03	
K4	Kekirawa	03	
K5	Mid Kala Oya (Main stem)	07	
K6	Angamuwa (T)	-	
K7	Panikkan Kulam	09	
K8	Pan Ela	05	
K9	Lower Kala Oya (Main stem)	04	
K10	Giribawa	05	
K11	Siyambalangamuwa	20	
K12	Kalankuttiya Ela	06	
MO	**MODARAGAM ARA**		398.00
MO1	Talawa Oya	23	
MO2	Ittikulama Ela	12	
MO3	Lower Modaragam Ara	07	
MAL	**MALWATHU OYA**		1236.00
MAL1	Upper Malwathu Oya	15	
MAL2	Maminiya Oya	12	
MAL3	Nachchaduwa Tank	08	
MAL4	Upper Kanadara Oya	18	
MAL5	Rampathwila (Oya)	08	
MAL6	Kadahathu Oya	08	

Symbol	Name of the Main and Sub-Watersheds	Number of Cascades	Area of Main Watershed in MIS [2]
MAL7	Kanadara Oya	12	
MAL8	Upper Kal Ara	13	
MAL9	Ullukkulama	06	
MAL10	Lower Kal Ara	15	
MAL11	Narivili Aru	07	
MAL12	Weli Oya	19	
MAL13	Lower Malwathu Oya	23	
MAL14	Nuwara Wewa	04	
MAL15	Mid Malwathu Oya	11	
PAR	**PARANGI ARA**		
PAR1	Upper Parangi Ara	10	
PAR2	Thurumpamaddi Ara	07	
PAR3	Mid Parangi Ara	08	
PAR4	Periyakatte Ara	09	
MA	**MA OYA**		413.00
MA1	Mora Oya	17	
MA2	Mukunu Oya	11	
MA3	Lower Ma Oya	-	
MA4	Kitagala Oya	12	
ME	**MEE OYA**	01	64.00
Y	**YAN OYA**		607.00
Y1	Upper Yan Oya	14	
Y2	Hurulu Wewa (command area)	13	
Y3	Sellige Ara	09	
Y4	Mid Yan Oya	12	
Y5	Horowupotana	10	
Y6	Wahalkada	09	
Y7	Lower Yan Oya	07	
KO	**KODDIKKADDI ARA**	08	78.00
PAN	**PANKULAM ARA**		187.00
PAN1	Nelu Oya	04	
PAN2	Mora Oya	03	
PAN3	Lower Pankulama	04	
	Total	**457**	**4331.00**

A summary statement of the total number of sub-watersheds present within each main watershed together with the total number of cascades present within each main watershed is given in this table 4. For easy comprehension, the main watersheds are arranged in decreasing order of size in this table.

Table 4. **Summary statement of the distribution pattern.**

Main Watershed Basins	Number of Sub-Watersheds	Number of Cascades
MAL-Malwathu Oya	15	179
K-Kala Oya	12	68
Y-Yan Oya	7	74
MA-Ma Oya	4	40
MO-Modaragam Ara	3	42
PAR-Parangi Aru	4	34
PAN-Pankulam Ara	3	11
KO-Koddikkaddi Ara	1	08
ME-Mee Oya	1	01
Total	**50**	**457**

The names of each of these 457 small tank cascades together with the names of the individual sub-watersheds are presented in the annex. This annex provides a convenient cross reference to both the Master Map and the 1 inch topo sheets on which the respective boundaries have been demarcated. It can also be used as a ready reference for further studies on the cascade systems of this region.

As could be observed in the Master Map legend, the sub-watersheds are, for the most part, named after the dominant higher order drainage stream situated within the sub-watershed, and occasionally after the main irrigation reservoir located within the main stream. This helps to give a sense of place or location and identity to each of the 50 sub-watersheds. The names of each of these sub-watersheds are also shown in table 3 and in the annex.

The system adopted in giving a name to an individual small tank cascade follows the earlier convention of assigning the name of the biggest small tank located within the cascade, or at times to a well-known place name of a central small town or large village within the cascade. It should also be noted that there are certain place names of cascades such as Palugaswewa, Kumbukwewa, Meegaswewa, Timbiriwewa, Hammillewa, Aluthwewa, Konwewa that are common to and repeated over several sub-watersheds. However, since each cascade is also assigned its sub-watershed number both in the 1 inch topo sheets and in the annex, any confusion can be avoided.

As could be observed in the Master Map, a considerable degree of variation occurs in the small tank cascade densities across the Rajarata. For example, the distribution pattern and densities of small tank cascades in the Medawachchiya and Anuradhapura topo sheets as shown in the Master Map, shows that a higher density of small tank cascades occurs in the upper watershed aspects of the Kanadara Oya, Kadahathu Oya, Rampathwila Oya, Upper Kandara Oya (south), Maminiya Oya, and upper Malwathu Oya. This conforms to the normal process of landscape evolution where a higher drainage density occurs in the upper aspects of the watershed resulting in a higher cascade density occurring there.

To illustrate the degree of variation of the small tank cascade density across a single main watershed, the number of small tank cascade systems present within each sub-watershed and the small tank cascade density per 100 square miles is shown in **tables 5** and **6** in respect of the Malwathu Oya and Yan Oya main watersheds. The small tank cascade density per 100 square miles could range in value from a low of 7 to a high of 25. The main feature however is the significant decrease in small tank cascade density as one proceeds from the higher to the lower aspects of the main watershed.

Overall, for the whole of the Rajarata, in both the Master Map and the 1 inch topo sheets, a *high density* of small tank cascades occurs in the upper watershed regions of the Malwathu Oya and its main tributaries, namely the Kanadara Oya, Kadahathu Oya, Ranpathwila Oya, Upper Kanadara Oya and Maminiya Oya. Similarly, a high density of small tank cascades is also observed in the upper watershed regions of the Yan Oya as well as the Mora Oya, the latter being a main tributary of the Ma Oya, and in the Siyambalangamuwa Oya which is a tributary of the Kala Oya.

A *moderate density* of small tank cascades occurs in the upper aspects of the Modaragam Ara, Parangi Aru, Mukunu Oya which is a tributary of the Ma Oya and the Pankulam Ara. A similar moderate density is observed in the mid-aspects of the main Malwathu Oya, Ma Oya and Yan Oya.

A *lower density* of small tank cascades occurs in all the lowermost sub-watersheds of the Kala Oya, Modaragama Ara, Malwathu Oya, Ma Oya, Yan Oya and Pankulam Ara.

The most significant observation that could be made in the Master Map and the 1 inch topo sheets is the virtual absence of both medium size tanks and small tank cascades in the region beyond the Mahavillachchiya tank and also beyond the point where the Kanadara Oya joins the main Malwathu Oya. The reasons for the absence of tanks beyond these locations have been discussed in Chapter 2.

There is a lower density of small tank cascades on the right bank of the Yan Oya than on its left bank as in the case of the Horowupotana, Wahalkada and lower Yan Oya sub-watersheds. The influence of the landform type which governs this difference in tank density has also been briefly discussed in Chapter 2.

Table 5. **Malwathu Oya-MAL.**

Name of Sub-Watershed	Symbol	Number of Cascades within the Sub-Watersheds	STC Density per 100 Square Miles
Upper Malwathu Oya	MAL 1	15	15
Maminiya Oya	MAL 2	12	21
Nachchaduwa Tank	MAL 3	08	11
Upper Kanadara Oya	MAL 4	18	25
Rampathwila Oya	MAL 5	08	14
Kadahathu Oya	MAL 6	08	20
Kandara Oya	MAL 7	12	13
Upper Kal Ara	MAL 8	13	15
Ulukkulama	MAL 9	06	23
Lower Kal Ara	MAL 10	15	20
Narivili Aru	MAL 11	07	12
Weli Oya	MAL 12	19	17
Lower Malwathu Oya	MAL 13	23	8
Nuwara Wewa	MAL 14	04	13
Mid Malwathu Oya	MAL 15	11	16
			16 (mean value)

Table 6. **Yan Oya-Y.**

Name of Sub-Watershed	Symbol	Number of Cascades within the Sub-Watersheds	STC Density per 100 Square Miles
Upper Yan Oya	Y1	14	18
Hurulu Wewa (command area)	Y2	13	13
Sellige Ara	Y3	09	14
Mid Yan Oya	Y4	12	14
Horowupotana	Y5	10	13
Wahalkada	Y6	09	8
Lower Yan Oya	Y7	07	7
			13 (mean value)

Hydrography of the Rajarata

The overall disposition of the fourth order, third order, and second order streams that make up the natural drainage systems of the Rajarata could be observed in the Master map. The main *fourth order streams* comprise the main stem or course of the larger rivers, namely Malwathu Oya, Kala Oya, Yan Oya and Ma Oya. The main *third order streams* comprise the upper Modaragam Ara, the Parangi Ara, the Pankulam Ara as well as the major tributaries of the Malwathu Oya such as the Maminiya Oya, Kanadara Oya (south), Kandara Oya (north), Weli Oya, Kal Ara, Rampathvila Oya, Kadahathu Oya and Kanadara Oya (north); and the Kitagala Oya which is a tributary of the Ma Oya. The main *second order streams* comprise the smaller Mee Oya, Koddikkaddi Ara and Pankulam Ara.

It could also be observed in the Master Map that all cascades are located within either a first order or a second order stream, with the smaller cascades usually located within a first order ephemeral stream and the larger cascades within a second order stream. Only up to around 90 percent of all small tanks of the Rajarata are located within the 457 small tank cascades, while the remaining 10 percent of the small tanks are located outside these cascades.

The smaller individual tanks that occur along the side valleys of a cascade are usually located within the first order inland valleys that occur within the meso-catchment. The larger individual tanks are usually located along the main axis of the cascade (figure 4) which corresponds to a second order inland valley and which is also equivalent to a first order ephemeral stream. As could be seen in the 1 inch topo sheets, the overall size of these tanks increases as one proceeds down the second order inland valley.

While each small tank has its own catchment area, the drainage water from all such small tanks located within the cascade flows out at a common reference point at the lower end of the first order ephemeral stream and joins the second order stream at this point. In this sense, each small tank cascade is hydrologically independent and has no influence on any of the adjacent cascades.

A cluster of cascades would form the sub-watershed of a river, while a cluster of sub-watersheds would form the river basin, the basis of clustering being the hydrology of the water flow as could be seen in the Master Map. The pathway of the water flow is such that the drainage water from each cascade flows into a second order stream, which in turn flows into the next higher third order stream. These then drain into the fourth order streams or rivers such as the Malwathu Oya, Ma Oya and Yan Oya that finally drain into the sea.

There is no dry season flow in the first and second order streams from May to October, and again from mid-February to early April. In the case of the third order streams, depending on the amount of antecedent maha rainfall, there will be a very slight dry season flow from mid-February to early April, but there is no dry season flow usually after mid-June. In the case of the fourth order streams there is sufficient discharge from the irrigated lands during the February-April period that would ensure a dry season flow. Similarly, depending on the storage in the larger reservoirs and the extent of irrigation practised during the yala season, some degree of dry season flow is experienced up to late July. In the Yan Oya and Ma Oya fourth order streams, there is no dry season flow from June to October in a year of normal seasonal rainfall.

The larger irrigation reservoirs such as the Kala Wewa (6.400 acre water spread area), Padaviya (5,800 acres), Nachchaduwa (4,400 acres), and Hurulu Wewa (4,000 acres) are all situated on the main stem of fourth order streams, and are therefore subject to breaching in the event of a major flood as that occurred in December 1957. The Mahakandarawa tank (3,400 acres) and the Mahavillachchiya tank (2,400 acres) are located on the main stem of third order streams. In contrast, the Nuwara Wewa (3,000 acres) is located at the confluence of four cascades, and it has a total catchment area of 33.0 square miles in addition to its augmentation from the adjacent Malwathu Oya diversion canal.

In the Anuradhapura district alone, there are a further 45 medium size irrigation reservoirs whose command area is between 100 and 350 hectares. The total number of working small tanks with a command area of less than 80 hectares in this district is estimated at approximately 1,870, and the number of abandoned tanks at approximately 1,170. A recent estimate by Perera (1997: pp.23–26) gives a figure of 5,447 tanks of all sizes for the Rajarata area made up of the nine river basins included in this text.

The discharge as a percentage of precipitation for seven of the river basins as reported in the National Atlas of the Survey Department 1988 is as follows:

Name of River Basin	Discharge as % of Precipitation
Kala Oya	13.0
Modaragam Ara	12.5
Malwathu Oya	12.0
Parangi Ara	21.0
Ma Oya	20.0
Yan Oya	19.0
Pankulam Ara	28.0

The safely exploitable groundwater within a cascade during the dry season is mainly confined to the areas immediately adjacent to the main axis of the cascade and its subsidiary axes. This has been clearly established by an effective methodology developed by Senaratne (1996), which can be used to estimate the potential areas of occurrence of groundwater within a cascade as well as the optimum spacing and density of agrowells permitted within a cascade. There has been a very rapid expansion in the construction of agrowells in the Anuradhapura district over the last decade. In some cascades the critical limit in the permitted density of agrowells has already been exceeded. It is therefore necessary to guide and control the further development of agrowell construction in the Rajarata region as a whole.

Chapter 6

Application and Utilization of Maps and Text

Although this explanatory text and the set of maps have been produced for the benefit of the Mahaweli Authority of Sri Lanka (MASL), this information could be considered equally useful to the general reader, regional and district planners, irrigation professionals and other agencies operating in the North Central Province.

For the MASL, the main interest and use of this set of maps and text would be in the future development of all those areas beyond the present system H. In the proposed future development of these areas, it would be wise to retain the present setting and integrity of the different cascade systems and build into them rather than disrupting them as was done in the past as in System H. Many benefits could be derived from such an approach, chief among them being a minimum use of irrigation supply over a maximum extent of land, and minimal social and environmental disruption to the present setting and role of the small tank cascade systems in their overall landscape hydrology.

For the district agencies such as the Departments of Agrarian Services and Agriculture, Sakthivadivel et al. (1996) outline the methodology for the selection of tanks for rehabilitation, based on the hydrological endowment of the whole cascade within its own meso-catchment. The set of 1 inch topo sheets with the cascade boundaries demarcated on them would provide the required basic information for the whole of the Rajarata in place of the earlier studies that were restricted to the Anuradhapura district only.

In the rational planning of the development of the water resources of the Rajarata, the sub-watershed and cascade demarcation provide the basic hydrological units within which both the micro- and meso-planning could complement the macro-planning and irrigation layout.

The hydrological endowment of a cascade could be reliably evaluated by the IIMI guidelines set out in the 1994 Guidance Package for Water Development of Small Tank Cascade Systems. The agricultural agencies could use this information on the hydrological endowment of a cascade in order to rationally plan the cropping schedules for the representative cultivation seasons.

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Details of Watersheds

Main Watershed	Sub Watershed
Kala Oya (K)	K1 to K12
Modaragam Ara (MO)	MO1 to MO3
Malwathu Oya (MAL)	MAL1 to MAL15
Parangi Ara (PAR)	PAR1 to PAR4
Ma Oya (MA)	MA1 to MA4
Mee Oya (ME)	ME1
Yan Oya (Y)	Y1 to Y7
Koddikkaddi Ara (KO)	KO1
Pankulam Ara (PAN)	PAN1 to PAN3

K – KALA OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
K.1	**DAMBULU OYA**	-	-
K.2	**HAWANELLA OYA**	1/K2 2/K2 3/K2 4/K2 5/K2 6/K2	Miwewa Andiyagala Gambirigaswewa Udangama Maha Indigollewa Ranawa
K.3	**MIRISGONI OYA**	1/K3 2/K3 3/K3	Bellan Oya Galahiriyawa Wewa Randeniya Wewa
K.4	**KEKIRAWA**	1/K4 2/K4 3/K4	Nikiniyawa Telabiyagama Kurakkankulama
K.5	**MID KALA OYA (Main Stem)**	1/K5 2/K5 3/K5 4/K5 5/K5 6/K5 7/K5	Kimbulugala Hammillewa Kumbuk wewa Pelle Kagama Kunchikulama Nelliyagama Manewa
K.6	**ANGAMUWA (T)**		
K.7	**PANNIKAN KULAMA ELA**	1/K7 2/K7 3/K7 4/K7 5/K7 6/K7 7/K7 8/K7 9/K7	Nochchiyagama Lindawewa Timbiriwewa Talgaswewa Maragahawewa Walanteluwewa Kattambuwagamawewa Mahatanbanewa wewa Katupathwewa
K.8	**PAN ELA**	1/K8 2/K8 3/K8 4/K8 5/K8	Kirimatiwala Kuda Andaragollewa Timbiriwewa Elapathwewa Horunbindapu wewa

K.9	**LOWER KALA-OYA (Main Stem)**	1/K9 2/K9 3/K9 4/K9	Puliyankulama Veherabendiwewa Hammillagollewa Uapathwewa
K.10	**GIRIBAWA**	1/K10 2/K10 3/K10 4/K10 5/K10	Siyambalawa Gurulupitigama Medawewa Warawewa Giribawa
K.11	**SIYAMBALANGAMUWA (T)**	1/K11 2/K11 3/K11 4/K11 5/K11 6/K11 7/K11 8/K11 9/K11 10/K11 11/K11 12/K11 13/K11 14/K11 15/K11 16/K11 17/K11 18/K11 19/K11 20/K11	Tammannawa Medagama Pulanchiya Maha Galkadawala Liyanagama Radanebodawala wewa Poratukadawala Henukwewa Medagama Nikadenigama Gonnagama Potanegama Talandapitiya Talawa Meegaswewa Habarawatta Nilakuttiya Katudunne Bulnewa Wedenigama
K.12	**KALANKUTTIYA ELA**	1/K12 2/K12 3/K12 4/K12 5/K12 6/K12	Hiralugama Walpalugama Kumbukwewa Negampaha Negama Kiula wewa

MO-MODARAGAM ARA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
MO.1	**TALAWA OYA**	1/MO1	Mahamillegollewa
		2/MO1	Mahapuliyankulama wewa
		3/MO1	Nambadedigilya wewa
		4/MO1	Ranorewa
		5/MO1	Lokakettiyagama
		6/MO1	Maradenigama
		7/MO1	Bogahawewa
		8/MO1	Relpanawewa
		9/MO1	Talawa
		10/MO1	Indigaspotana
		11/MO1	Maha Bulankulama
		12/MO1	Ulukkulama
		13/MO1	Timbiriyagama
		14/MO1	Pahala Tibbotuwegama
		15/MO1	Ilangahawewa
		16/MO1	Yalogama
		17/MO1	Halmillakulama
		18/MO1	Pusiyankulama
		19/MO1	Tammennawa
		20/MO1	Maningamuwa
		21/MO1	Andaradigiliya
		22/MO1	Maha Nikawewa
		23/MO1	Newakkulama
MO.2	**ITTIKULAMA ELA**	1/MO2	Diwulwewa
		2/MO2	Katupitidiwulwewa
		3/MO2	Pettelliya wewa
		4/MO2	Weeragaha wewa
		5/MO2	Pahala Keriyagaha wewa
		6/MO2	Kabellapeenu wewa
		7/MO2	Kondigiliya
		8/MO2	Kudawewa
		9/MO2	Kongasdigiliya
		10/MO2	Kuda Ittikulama
		11/MO2	Dunumadalawa
		12/MO2	Suriyadamana wewa
MO.3	**LOWER MODARAGAM ARA**	1/MO3	Erige wewa
		2/MO3	Moragolle Ara
		3/MO3	Dabane wewa
		4/MO3	Katua wewa
		5/MO3	Mallimaduwa
		6/MO3	Bogaha wewa
		7/MO3	Sanda Mal Eliya

MAL – MALWATHU OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
MAL.1	**UPPER MALWATHU OYA**	1/MAL1	Kele Puliyankulama
		2/MAL1	Kandubodagama
		3/MAL1	Kadiragama
		4/MAL1	Toruwewa
		5/MAL1	Maminiyawa
		6/MAL1	Nelliyagama
		7/MAL1	Kirimetiyawa
		8/MAL1	Bellankadawala
		9/MAL1	Galkadawala
		10/MAL1	Pelugaswewa
		11/MAL1	Galapitigala
		12/MAL1	Muriyankadawala
		13/MAL1	Ambatale
		14/MAL1	Manampediyagama
		15/MAL1	Kuda Thulana
MAL.2	**MAMINIYA OYA**	1/MAL2	Kumbukwewa
		2/MAL2	Tammannawa
		3/MAL2	Kawarakkulama
		4/MAL2	Amunukole
		5/MAL2	Kumbukwalahinna
		6/MAL2	Nawakkulama
		7/MAL2	Ihalawewa
		8/MAL2	Dambagollewa
		9/MAL2	Siwalakulama
		10/MAL2	Galwaduwagama
		11/MAL2	Puliyankulama
		12/MAL2	Sandanakuttigama
MAL.3	**NACHCHADUWA TANK**	1/MAL3	Hammillakulama
		2/MAL3	Mahakanamulla
		3/MAL3	Thireppane
		4/MAL3	Ulagalla
		5/MAL3	Wannankulame
		6/MAL3	Muriyankadawala
		7/MAL3	Getalagama
		8/MAL3	Galkulama

MAL – MALWATHU OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	NAME	SYMBOL	NAME
MAL.4	UPPER KANADARA OYA	1/MAL4	Bulankulama
		2/MAL4	Dunumadalawa
		3/MAL4	Maha Kirindegama
		4/MAL4	Katupotha
		5/MAL4	Mankulama
		6/MAL4	Maha Rambewa
		7/MAL4	Kuda Rambewa
		8/MAL4	Nabadawewa
		9/MAL4	Indigollewa
		10/MAL4	Knowewa
		11/MAL4	Periyakulama
		12/MAL4	Himbutugollewa
		13/MAL4	Ichchankulama
		14/MAL4	Katukeliyawa
		15/MAL4	Kasamaduwa
		16/MAL4	Niwitigama
		17/MAL4	Galmaduwa
		18/MAL4	Weruppankulama
MAL.5	RAMPATHWILA OYA	1/MAL5	Etawetunuwewa
		2/MAL5	Seeppukulama
		3/MAL5	Gangurewa
		4/MAL5	Ellewewa
		5/MAL5	Kokmaduwa
		6/MAL5	Kukulewa
		7/MAL5	Ratawewa
		8/MAL5	Bandara Ikirigollewa
MAL.6	KADAHATHU OYA	1/MAL6	Gonewa
		2/MAL6	Talakolawewa
		3/MAL6	Moragahawala
		4/MAL6	Kapiriggama
		5/MAL6	Kendewa
		6/MAL6	Talgehewa
		7/MAL6	Walketuwewa
		8/MAL6	Dunninnegama
MAL.7	KANADARA OYA	1/MAL7	Katukeliyawa
		2/MAL7	Lindawewa
		3/MAL7	Diwulgaswewa
		4/MAL7	Karainbankulama
		5/MAL7	Relpanawa
		6/MAL7	Kirimetiyawa
		7/MAL7	Pihimbiyagollewa
		8/MAL7	Galwiragollewa
		9/MAL7	Kirigollewa
		10/MAL7	Wadiwewa
		11/MAL7	Palukandawewa
		12/MAL7	Medawachchiya

MAL – MALWATHU OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	NAME	SYMBOL	NAME
MAL.8	UPPER KAL ARA	1/MAL8	Nawakkulama
		2/MAL8	Nugagahawadiya
		3/MAL8	Timbiriwewa
		4/MAL8	Parana Hammillewa
		5/MAL8	Hali Pahudiwala
		6/MAL8	Tammennakanda
		7/MAL8	Alagalla
		8/MAL8	Nochchikulama
		9/MAL8	Iratperiyakulam
		10/MAL8	Kunundankulam
		11/MAL8	Ulukkulama
		12/MAL8	Rasentiranakulam
		13/MAL8	Suduventapulavu
MAL.9	PAVATKULAMA (T)	1/MAL9	Lindawewa
		2/MAL9	Etawetunawewa
		3/MAL9	Lolugaskanda
		4/MAL9	Marakkala Hammillewa
		5/MAL9	Kidawarankulama
		6/MAL9	Pulutumankulama
MAL.10	LOWER KAL ARA	1/MAL10	Kiritokulam
		2/MAL10	Varakusenai Kulam
		3/MAL10	Kurinchakkulam
		4/MAL10	Vilattikulam
		5/MAL10	Nedunkaraichchenai
		6/MAL10	Mayakudakulam
		7/MAL10	Koolankulam
		8/MAL10	Mathvuvaithakulam
		9/MAL10	Pumaduwa
		10/MAL10	Helambakulam
		11/MAL10	Kalayanuruwa
		12/MAL10	Maniarkulam
		13/MAL10	Ampalkulam
		14/MAL10	Periyapadduveli Kulam
		15/MAL10	Nakan Kulam
MAL.11	NARIVILI ARA	1/MAL11	Murutamadu
		2/MAL11	Mankulam
		3/MAL11	Periya Ulukkulama
		4/MAL11	Adappankulama
		5/MAL11	Mutaliyarkulam
		6/MAL11	Larampaimadu
		7/MAL11	Cheddikulam

MAL – MALWATHU OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	NAME	SYMBOL	NAME
MAL.12	WELI OYA	1/MAL12	Nikawewa
		2/MAL12	Kahagollewa
		3/MAL12	Kotiyawa
		4/MAL12	Harakweldamana
		5/MAL12	Kudurugasdamana
		6/MAL12	Dunnabindunuwewa
		7/MAL12	Dikgala
		8/MAL12	Kongollewa
		9/MAL12	Hammillewa
		10/MAL12	Nikawewa
		11/MAL12	Nambadagaswewa
		12/MAL12	Kumbukgollewa
		13/MAL12	Siyambalagaswewa
		14/MAL12	Maha Kumbukwewa
		15/MAL12	Tulaweliya
		16/MAL12	Kalawelpotana
		17/MAL12	Kudagama
		18/MAL12	Karambe
		19/MAL12	Peiya Chippukulam
MAL.13	LOWER MALWATHU OYA (Main Stem)	1/MAL13	Uvayadikulam
		2/MAL13	Kimpulwewa
		3/MAL13	Weliwewa
		4/MAL13	Maha Ehetu wewa
		5/MAL13	Andarawewa
		6/MAL13	Katugampolagama
		7/MAL13	Galpottegama
		8/MAL13	Galkadawala
		9/MAL13	Vijayarama
		10/MAL13	Palugaswewa
		11/MAL13	Saliyapura
		12/MAL13	Kopakulama
		13/MAL13	Pandiyankadawala
		14/MAL13	Elapathgama
		15/MAL13	Bellankadawala
		16/MAL13	Aluthgama
		17/MAL13	Relapanawa
		18/MAL13	Helambagaswewa
		19/MAL13	Anaiviluntan
		20/MAL13	Kappachchi
		21/MAL13	Andiyapuliyankulam
		22/MAL13	Periyakaddu
		23/MAL13	Paraiyanalankulam

MAL.14	**NUWARA WEWA (T)**	1/MAL14 2/MAL14 3/MAL14 4/MAL14	Kawarakkulama Kuda Kalattewa Maha Kalattewa Kurundankulama
MAL.15	**MID MALWATHU OYA**	1/MAL15 2/MAL15 3/MAL15 4/MAL15 5/MAL15 6/MAL15 7/MAL15 8/MAL15 9/MAL15 10/MAL15 11/MAL15	Bandara Bulankulama Potanegama Haggomuwa Ratmale Aluthwewa Kitulgahawewa Katugampolagama Tutuwilawewa Polambayagama Kongaswewa Ihalawewa

PAR – PARANGI ARA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
PAR.1	**UPPER PARANGI ARA**	1/PAR1	Tavesiyakulam
		2/PAR1	Kaddaiyarkulam
		3/PAR1	Periyakulam
		4/PAR1	Putukkulam
		5/PAR1	Vavuniya
		6/PAR1	Etambagaskada
		7/PAR1	Mamaduwa
		8/PAR1	Chinnakulam
		9/PAR1	Velankulam
		10/PAR1	Murutamadu
PAR.2	**THURUMPAMADDI ARA**	1/PAR2	Vennankulam
		2/PAR2	Welliyamkulam
		3/PAR2	Pandiyankallu
		4/PAR2	Omantai
		5/PAR2	Nallikulam
		6/PAR2	Podunkulam
		7/PAR2	Palaimoddai
PAR.3	**MID PARANGI ARA**	1/PAR3	Valliyappalai
		2/PAR3	Variudaiyariluppai Kulam
		3/PAR3	Ura Kulam
		4/PAR3	Navvi
		5/PAR3	Puverasan Kulam
		6/PAR3	Karuneppan Kulam
		7/PAR3	Mundumurippu
		8/PAR3	Kompuvaittakulam
PAR.4	**PERIYAKATTE ARA**	1/PAR4	Periyavalyankaddukulam
		2/PAR4	Palavu Kulam
		3/PAR4	Chekkadi Kulam
		4/PAR4	Kakkayankulam
		5/PAR4	Kollamarutamadu
		6/PAR4	Periyakaddu
		7/PAR4	Kidachchuri
		8/PAR4	Mullaikkulam
		9/PAR4	Karaiya-alampaikkulam

MA-MA OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	NAME	SYMBOL	NAME
MA.1	**MORA OYA**	1/MA1	Herath Hammillewe
		2/MA1	Olugaskada
		3/MA1	Tittagonewa
		4/MA1	Italwiddawewa
		5/MA1	Usgollewa
		6/MA1	Kebithigollewa
		7/MA1	Kiwulkada
		8/MA1	Tammannawa
		9/MA1	Rathmalgahawewa
		10/MA1	Kirigollewa
		11/MA1	Walahawiddawewa
		12/MA1	Ulpothgama
		13/MA1	Siyambalewa
		14/MA1	Kiriketuwewa
		15/MA1	Elapathwewa
		16/MA1	Bandara Ulpotha
		17/MA1	Kurullanne Ulpotha
MA.2	**MUKUNU OYA**	1/MA2	Nikawewa
		2/MA2	Vihara Hammillewa
		3/MA2	Indigollewa
		4/MA2	Etambagaskada
		5/MA2	Dutuwewa
		6/MA2	Relapanawa
		7/MA2	Kunchuttuwa
		8/MA2	Kongollewa
		9/MA2	Talganawewa
		10/MA2	Singhaya Ulpotha
		11/MA2	Nika wewa
MA.3	**LOWER MA OYA**	-	-
MA.4	**KITAGALA OYA**	1/MA4	Kadduppuvarasankulam
		2/MA4	Ariyamadu
		3/MA4	Unchalkaddi
		4/MA4	Maradankulan
		5/MA4	Vedivaittakallu
		6/MA4	Uttukkulam
		7/MA4	Chamali Ra
		8/MA4	Kokkaichan Kulam
		9/MA4	Bogaha wewa
		10/MA4	Galpitawewa
		11/MA4	Mahakollewa
		12/MA4	Siyambalagaswewa

ME – MEE OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
		1/ME	Nawagaswewa

Y – YAN OYA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	NAME	SYMBOL	NAME
Y.1	UPPER YAN OYA	1/Y1	Dambagaha Ulpotha
		2/Y1	Maha Diwulwewa
		3/Y1	Weragala
		4/Y1	Kuda Rambewa
		5/Y1	Diganapathaha
		6/Y1	Sigiriya
		7/Y1	Piduragala
		8/Y1	Gedigaswelana
		9/Y1	Unagollewa
		10/Y1	Habarana
		11/Y1	Maha Meegaswewa
		12/Y1	Medawala
		13/Y1	Maha Rambewa
		14/Y1	Marikkarawagama
Y.2	HURULU WEWA (Com.Area)		
		1/Y2	Maha Kirimetiyawa
		2/Y2	Punchi Hammillewa
		3/Y2	Veheragala
		4/Y2	Kumbukwewa
		5/Y2	Puliyankandawala
		6/Y2	Galenbindunuwewa
		7/Y2	Palukanda wewa
		8/Y2	Meegaswewa
		9/Y2	Muwapitiya
		10/Y2	Karuwalagas wewa
		11/Y2	Padikkaramaduwa
		12/Y2	Diwulwewa
		13/Y2	Dambagolla
Y.3	SELLIGE ARA	1/Y3	Puliyankadawala
		2/Y3	Nabadawewa
		3/Y3	Keddutuwewa
		4/Y3	Ihalawewa
		5/Y3	Konwewa
		6/Y3	Dematawewa
		7/Y3	Parayankulama
		8/Y3	Diyatittawewa
		9/Y3	Parangiyawadiya

Y.4	**MID YAN OYA**	1/Y4 2/Y4 3/Y4 4/Y4 5/Y4 6/Y4 7/Y4 8/Y4 9/Y4 10/Y4 11/Y4 12/Y4	Elawissagoda Morakewa Galkandegama Hammillewa Italwetunuwewa Konwewa Hettuwewa Mahapotana Pandarellewa Timbiriwewa Ellepotana Nelugollekada
Y.5	**HOROWUPOTANA**	1/Y5 2/Y5 3/Y5 4/Y5 5/Y5 6/Y5 7/Y5 8/Y5 9/Y5 10/Y5	Relapanawa Maradankadawala Horowupotana Olugaskada Kayangollewa Bendawidanagewewa Timbiriwewa Ratmale Gona wewa Meeulpothahinna
Y.6	**WAHALKADA (T)**	1/Y6 2/Y6 3/Y6 4/Y6 5/Y6 6/Y6 7/Y6 8/Y6 9/Y6	Migaskada Kapugollewa Wagollakada Palugaswewa Dutuwewa Ettabendi wewa Penikotiyawa Gomarankadawala Pettewa
Y.7	**LOWER YAN OYA**	1/Y7 2/Y7 3/Y7 4/Y7 5/Y7 6/Y7 7/Y7	Ottankulam Kompiyantaddamodi Medawachchi wewa Bellankadawala Mahahorwu wewa Mugatiyapenne wewa Kumbuk wewa

KO – KODDIKKADDI ARA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
KO	**KODDIKKADDI ARA**	1/KO	Maha Alankulama
		2/KO	Nillappanikkan Kulam
		3/KO	Mora wewa
		4/KO	Kiwulakade
		5/KO	Pulikandiya
		6/KO	Chamalankulam
		7/KO	Kosavan Ara
		8/KO	Tillamadu Karachchi

PAN – PANKULAM ARA WATERSHED

SUB-WATERSHEDS		CASCADES	
SYMBOL	**NAME**	**SYMBOL**	**NAME**
PAN.1	**NELU OYA**	1/PAN1 2/PAN1 3/PAN1 4/PAN1	Nikawewa Uagollewa Mahawewa Kumbukwewa
PAN.2	**MORA OYA**	1/PAN2 2/PAN2 3/PAN2	Morawewa (South) Ulhela (North) Galmetiyawa (North)
PAN.3	**LOWER PANKULAMA ARA**	1/PAN3 2/PAN3 3/PAN3 4/PAN3	Kuruniyan Kulam Vilpana Kulam Kambakkoddai Meanda Kulam

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