

Article

Ancient Water Management and Governance in the Dry Zone of Sri Lanka Until Abandonment, and the Influence of Colonial Politics during Reclamation

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Abstract: The dry-zone water-harvesting and management system in Sri Lanka is one of the oldest historically recorded systems in the world. A substantial number of ancient sources mention the management and governance structure of this system suggesting it was initiated in the 4th century BCE (Before Common Era) and abandoned in the middle of the 13th century CE (Common Era). In the 19th century CE, it was reused under the British colonial government. This research aims to identify the ancient water management and governance structure in the dry zone of Sri Lanka through a systematic analysis of ancient sources. Furthermore, colonial politics and interventions during reclamation have been critically analyzed. Information was captured from 222 text passages containing 560 different records. 201 of these text passages were captured from lithic inscriptions and 21 text passages originate from the chronicles. The spatial and temporal distribution of the records and the qualitative information they contain reflect the evolution of the water management and governance systems in Sri Lanka. Vast multitudes of small tanks were developed and managed by the local communities. Due to the sustainable management structure set up within society, the small tank systems have remained intact for more than two millennia.

Keywords: text sources; tank cascade system; reservoir, Dry Zone Sri Lanka

1. Introduction

The ancient *Rajarata* kingdom flourished in the present-day North Central Province of Sri Lanka from the 6th century BCE to the 13th century CE, and mainly consisted of current districts of Anuradhapura and Polonnaruwa (Figure 1). The dry zone is characterized by mean annual precipitation of 1750 mm and a distinct dry period during the summer months [1]. Therefore, inhabitation of the dry zone of Sri Lanka is completely dependent on irrigation agriculture. From ancient times, people of the island constructed irrigation works ranging in complexity from simple dams to an integrated watershed management system [2].

The dry-zone water-harvesting and management system of the *Rajarata* kingdom is one of the oldest historically recorded systems in the world [3]. It consists of a connected series of manmade tanks, locally called *wewa*, which were used to store, convey, and use water for paddy cultivation [4]. Small, medium, and large tanks are connected by channels and spillways, and allow water to be conveyed along the cascade and to irrigate interconnected agricultural fields [4,5]. This water-harvesting and management system guarantees the availability of water resources throughout the year for agriculture production and domestic use, especially during the dry seasons. According to the ancient chronicles, this tank-based irrigation system was initiated in the 4th/3rd century BCE and had its maximum extent in the 12th century CE [3]. Murphey points out that nowhere else in the pre-

modern world was there such a dense concentration of irrigation facilities at such a high technical level [6]. Due to the South Indian *Chola* invasions and the unstable political conditions that followed, the *Rajarata* irrigation landscape was abandoned in the middle of the 13th century CE and the kingdom was shifted to the Kurunagala district in the North Western Province [7–10]. However, the dry-zone irrigation landscape was reused in the 19th century CE, under the British colonial administration [11].

Today, nearly 10,000 tanks originating from the ancient water-harvesting system still function in the dry zone of Sri Lanka [12]. For nearly two millennia, tank-based irrigation in the dry zone played a significant role in the landscape management and social organization by means of the multiple uses of irrigation water for agriculture and domestic use [13]. The “Green Revolution” transformed the rural economies in most of the Asian, Latin American and Sub-Saharan African countries during 1960–1990 [14,15]. The High Yielding Varieties, chemical fertilizers and other agrochemicals were introduced to the dry-zone agriculture in the 1950s and 1960s [16] and resulted with a rapid changes in the technological and socio-cultural norms of irrigated agriculture.

Comparable indigenous water management systems have been identified and examined in several South Asian countries, especially in the peninsular of India. According to Gunnell and others [17] in peninsular India, small reservoirs or tanks, predominantly supplied by surface runoff as opposed to river canals have for centuries been dominated an entire agrarian civilization. Further they illustrate village communities have been taking advantage of the potential for surface and subsurface runoff harvesting by developing the tank system [17]. Similar to the tank cascades in Sri Lanka, South Indian tanks frequently form chains down the axes of shallow inland valleys, within natural drainage boundaries. Many scholars highlighted the importance of studying the historical perspectives of these systems for an adoptive and sustainable future prospect [18–20].

According to Rogers, “... water governance refers to the range of political, social, economic and administrative systems that are in place to allocate, develop and manage water resources and the delivery of water services for a society ...” [21]. It is of the utmost importance to analyze the development of the water governance system in a historically evolved irrigation landscape to understand the sustainability of these long-term functional systems. There was an integral relationship between the religion and every aspects of the ancient society including irrigated landscape and water governance [3]. Dating from the 3rd century BCE onwards, a series of written records with a Buddhist religious origin, mainly comprising lithic inscriptions and chronicles are available for the reconstruction of the ancient water governance structure in Sri Lanka. A gap in the written records exists from the abandonment of the irrigation landscape in the 13th century CE to the reuse period in the 19th century CE. However, several colonial reports and writings provide valuable information for the period of reclamation.

This paper aims to identify the ancient water management and governance structure and its socio-economic implications in the dry zone of Sri Lanka through a systematic analysis of ancient sources, from its historical beginnings to its abandonment in the 13th century CE. Special effort is made to analyze the role of Buddhist temporalities on the governance of water and irrigated landscape. Continuation of the historical records on the dry-zone irrigation landscape were ceased in the mid-13th century CE due to the transformation of kingdom into the intermediate and wet zone followed by the abandonment of the ruler sponsored large irrigation networks in *Rajarata* kingdom. An attempt is made to illustrate the status of the irrigation landscape and its governance structure during this literally Dark Age of irrigation between the 13th century and 19th century CE. Colonial politics and interventions during the reclamation of the irrigation landscape were critically analyzed and compared with ancient water governance structures to identify their impacts on the water-harvesting and management system.

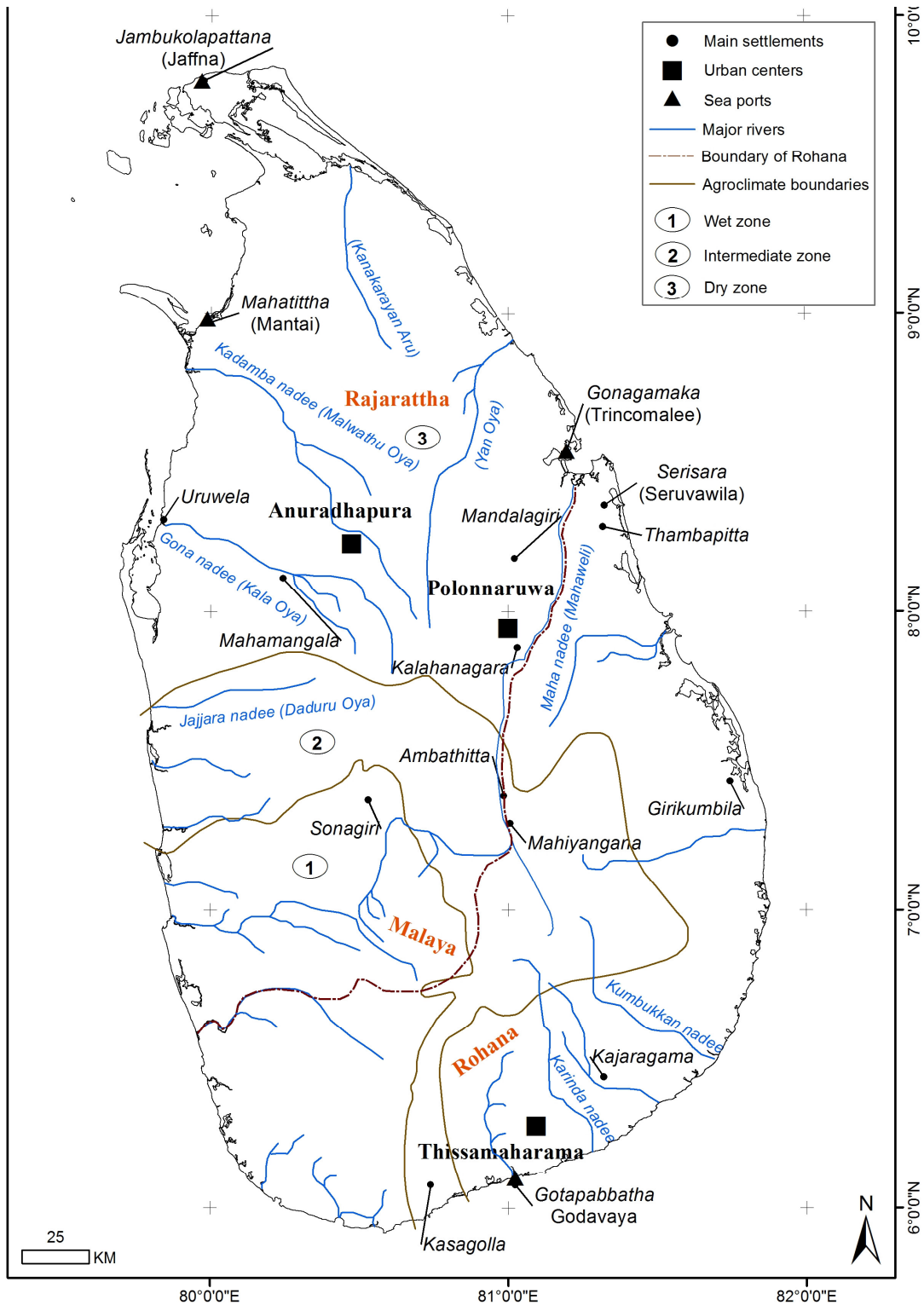


Figure 1. Administrative centers of Sri Lanka during Middle Historic times (c.300–1250 CE) and present-day climatic zones (rivers are based on survey department 1:250,000 topo sheets, climatic zones are based on the National Atlas of Sri Lanka [22], historical place names and administrative units are derived from Liyanagamage and Gunawardhana [23].)

1.1. Previous Research

Ivers, Forbes and a few others were the pioneers among colonial travelers, explorers and researchers who reported on the ruined irrigation landscape in the dry zone of Sri Lanka in the 19th century [24,25]. These reports mainly focused on the partly collapsed and partly functioning irrigation elements. During the 20th century, systematic studies of the irrigation system were carried out by researchers such as Parker, Kennedy and Brohier who attempted to link the major irrigation schemes with the irrigation activities described in the ancient sources [26–28]. In 1975, Brohier outlined the story of irrigation in Sri Lanka from its beginnings to modern times with special reference to colonial interventions [11]. Gunawardana was the first researcher to interpret the ancient water governance structure of Sri Lanka based on materials from ancient written sources [3]. His special interest was in the role of Buddhist temporalities in dry-zone landscape management, and he hypothesized a multi-centered society with power devolving on the gentry and the monastic institutions [3]. In 1961, Leach published a study of a traditional village irrigation community in Pul Eliya, north-central Sri Lanka with special reference to traditional land tenure and kinship [29]. He also undertook a critical analysis of Karl Wittfogel's concepts of "hydraulic society" and "Oriental despotism" based on information from the ancient water-harvesting system of Sri Lanka, for which he identified similarities to European feudalism [30]. Leach described the ancient Sri Lankan water management system as "hydraulic oriental" feudalism.

Most recently, Coningham attempted to study ancient water governance structures in the *Rajarata* kingdom based on archaeological and historical materials [31,32]. He described the water management system of the kingdom of Anuradhapura as a theocratic landscape where monastic centers played a dual role of religious and secular administration, based on grants of irrigation works to monastic entities and the absence of towns and lower-order administrative centers in the hinterland.

In addition, several scholars such as Madduma Bandara, Ithakura and Abernethy, and Panabokke and Tennakoon, investigated the physical characteristics, environmental aspects, and techno-engineering characteristics of these systems [4,33–35]. Tank sediments as archives for environmental reconstruction were investigated by Schütt and Bebermeier [36,37]. Withanachchi investigated the water management system from a historical perspective with special reference to ancient anicuts and dams [38,39]. However, there has to date been no complete and systematic assessment of the ancient sources to identify the water management and governance structure. Furthermore, no attempt has been made to critically analyze the effects of colonial politics on local water governance during the reclamation of the irrigation landscape.

1.2. The Irrigation Landscape from Its Abandonment to the Beginning of the British Regime

Little is known about the dry-zone irrigation landscape after its abandonment in the mid-13th century CE until the onset of the British colonial times in the 19th century CE, since there are few written sources. The *Culavamsa* (please refer to Section 2) reveals that in the late 13th century CE King Vijayabahu IV (reign: 1267–1270 CE) made an attempt to restore the religious places in Anuradhapura and Polonnaruwa, but the relevant references are missing in the major chronicles [40]. The *Culavamsa* also reports that King Vijayabahu IV requested the *Vanni* people to stay in the abandoned city to protect the religious monuments, an order that can be interpreted as indicating continuing small-scale settlements. *Vanniyas* are the petty chieftains who controlled the rural area after the collapse of Polonnaruwa in the 13th century CE [41]. According to the archaeological evidence, 11 medieval settlements (1200–1500 CE) with three ceramic scatters existed in Anuradhapura and its hinterland [32]. A geoarchaeological survey conducted in the hinterland of Anuradhapura also indicates that some people remained in the area and continued small-scale irrigation agriculture and water management even though the major reservoirs had started to silt up [42].

There is no evidence aiding understanding of the management and governance of irrigation infrastructure during this Dark Age of irrigation in Sri Lanka. However, during the kingdom of Kandy (15–19th century CE), a compulsory labor system called *Rajakariya* or King's Labor was used to maintain state services. Murry assumes this compulsory labor system was the communal machinery used by the villagers to keep the small village tanks maintained by village communities

even after the large irrigation infrastructure was abandoned in the 13th century CE [6]. During the Dutch rule of Sri Lanka (1640–1796 CE), agriculture received some attention but the focus of interest was the coastal plains since Dutch more focused on commercial cultivation such as cinnamon [43]. Reports from this period are confined to the reservoir structures in the coastal zone such as the Giant's tank in the Mannar district (report from 1739) and the Kantale tank in the Trincomalee district (report from 1791) [11]. Knox, who explored the Sri Lankan dry zone in the 17th century CE, treated the whole area as an uninhabitable wilderness [44]. When writing the Manual of the North Central Province in the 19th century CE, Ivers mentioned that nearly all villages were held under the rule of native laws and customs when the British arrived [25].

1.3. Reclamation of the Irrigation Landscape under British Rule

The coastal regions of Sri Lanka came under British rule in 1796 and in 1815 the entire country, including Kandyan Province, was acquired through a convention [45]. Colonial rulers were highly inspired by trade and commerce from the beginning. In consequence, they promoted large-scale coffee, tea and rubber plantations in the wet zone area, while customary paddy cultivation in the dry zone was neglected [46]. Few attempts were made to enhance paddy cultivation during the initial stages of British rule. Maitland (1760–1824) was one of the first governors who improved the irrigation of the agricultural landscape by providing money to the cultivators and owners of paddy land to repair the tanks [11].

After the “Uva Rebellion” in 1817, the colonial government decided to abolish the King's Labor or compulsory labor system (*Rajakariya*) following the recommendations of the Colebrook-Cameron commission report from 1832; this resulted in the gradual destruction of small tanks which had been maintained by village communities [47,48].

Between 1832 and 1875 little was done to enhance the irrigation landscape. The Governor Henry Ward with his ordinance No. 9 (1856), entitled “An ordinance to facilitate the revival and enforcement of ancient customs regarding irrigation and cultivation of paddy lands”, initiated the restoration of the village tanks by the villagers [11,46,48]. Furthermore, this ordinance facilitated the reform of the village councils to improve the restoration of irrigation works [48]. In 1872, Governor William Gregory made a substantial contribution by providing sluices for the village tanks wherever the restoration of earth-works was successfully completed by the local villagers, affecting several hundred restored tanks in the dry zone [11]. Restoration projects concerning larger irrigation schemes such as the Yodaela canal, Kalawewa tank, Kantale tank, Giant's tank and Minneriya-Elahara scheme were initiated in the last decades of the 19th century [11,46].

The Golden Era of the restoration of the dry-zone irrigation landscape was ushered in by the new constitution based on the Donoughmore commission report in 1931 [11,49,50]. With the new constitution, government administration was shifted into the hands of local people and D.S.Senanayake was appointed as the Sri Lankan Minister for Agriculture and Land [11]. Consequently, restoration of the dry-zone irrigation landscape was accelerated by several government-sponsored colonized schemes such as Minneriya (10,000 acres of paddy), Kalawewa (17,000 acres of paddy), Minipe (3800 acres of paddy) and Parakrama Samudra (5940 acres of paddy) [11].

1.4. Colonial Institutional Framework and Management Structure for the Irrigation Landscape

Under the British colonial regime, the *Nuwarakalawiya* (Anuradhapura) was governed by a Government Agent (GA) from 1833 onwards [45]. In the initial stages, the main responsibility of the Agent was to collect revenues, especially grain taxes [46]. After enacting the ordinance of 1856, the government's responsibility for irrigation development was transferred to the GA as the administrative head of the province, and the GA was expected to undertake irrigation development with the support of the proprietors of arable land through village councils [48]. In 1867 the “1856 ordinance” was revised with the more flexible and community-oriented “*Paddy cultivation ordinance*” [46,48].

Before 1874 the restoration of small tanks was conducted mainly by the local community using the prevailing customary procedures [46]. Concurrently, different mechanisms were established for the restoration of larger irrigation schemes such as the Kalawewa tank and Yodaela canal since they required more engineering skills. After 1886, the Department of Public Works and its provincial divisions conducted the restoration work. Again, in 1887, an ordinance was approved to create a Central Irrigation Board and Provincial Irrigation Boards where the GA acted as the president to promote restoration and irrigation activities in the dry zone [28,46]. By the end of the 19th century, major irrigation works in the dry zone were under the administration of the centralized Irrigation Department established in 1900 [48].

In the early days of British rule in Sri Lanka, village level administration of the small tanks was the responsibility of a hereditary officer (*Gamarala*), who was usually also the headman. In 1870, the British attempted to allocate recognized authority to this position by introducing a headmen system called *Vel Vidane* under the Village Committee system. The village tank and the functionality of irrigation and cultivation were maintained under the leadership of the *Vel Vidane* [46].

During their rule, the British made several changes to the traditional land tenure system in the irrigated landscape. Under the *Temple Land Commission* in 1856 and the *Service Tenure Commission* in 1870, land which was not cultivated as *Service Tenure Villages* (*Rajakariya* land) was declared to belong to the Crown [51,52]. Furthermore, the British government acquired all forestlands within village boundaries which were used for slash-and-burn cultivation (*chena*) in customary practice. In contrast, according to traditional practice, entire villages including the tank, field and highland forest areas were the property of the *Service Tenure Villages* (*Viharagam*, *Devalagam*, *Nindagam*) [46].

1.5. Research Questions

The ancient dry-zone water-harvesting system of the *Rajarata* kingdom which flourished for more than 1500 years was abandoned in the middle of the 13th century and reclaimed under the British colonial regime in the 19th century. There is a gap of nearly five centuries between the abandonment and the reclamation of the local water-harvesting system. Therefore, it is of utmost importance to investigate the missing link between the ancient and colonial water governance structures which were the prelude to the present-day management of the water resources. This article aims to investigate the past water management and governance systems of dry-zone Sri Lanka based on the following key research questions.

- What are the characteristics of ancient water management and governance in the *Rajarata* kingdom?
- What was the role of Buddhist monastic institutions in water governance?
- How were British politics involved in the reclamation of the water-harvesting and management systems?
- Was there a continuation of the ancient water governance system under the British regime?

2. Materials and Methods

Systematic stylistic analysis of ancient written sources and content criticism were the main approaches used for the study. The written sources for Sri Lankan history mainly comprise chronicles and lithic inscriptions [7]. The first chronicle, *Dipavamsa*, contains historical narratives from the legendary beginning of the kingdoms of the island in the 6th and 5th centuries BCE to the reign of King Mahasen in 362 CE. The *Pali* chronicle *Dipavamsa* was written by unknown authors in the middle of the 4th century CE and translated into English by Oldenberg in 1879 [53]. The *Mahavamsa* is the main chronicle analyzed and was translated into German by Geiger in 1908 [54]. This *Pali* chronicle is composed of the *Mahavamsa* (Great Chronicle) and the *Culavamsa* (Little Chronicle) and consists of four different parts [55]:

- The *Mahavamsa* compiled by a Buddhist monk called Mahanama (5th or 6th century CE) comprises chapter 1 to chapter 37, verse 50 and covers the period 544 BCE–362 CE.

- The *Culavamsa*, part 1, compiled by a Buddhist monk called Dhammakitti (12th century CE) comprises chapter 37, verse 51 to chapter 79, verse 84 and reports on the period 362 CE–1186 CE.
- The *Culavamsa*, part II, compiled by an unknown author comprises chapter 79, verse 85 to chapter 90, verse 102 and contains information about the period 1186–1333 CE.
- The *Culavamsa*, part III, was compiled by a Buddhist monk called Tibbotuvave Sumangala in the 18th century CE and comprises chapter 90, verse 105 to chapter 100, verse 292. It reports on the period 1333–1781 CE.

A lithic inscription tradition was established on the island from the 3rd century BCE onwards [41,56] (Figure 2). The earliest cave inscriptions were denoted to record various dedications to the monks and the names of donators in a contemporary manner [56]. In later periods, many rock and slab inscriptions were made to record predominantly common acts such as donations to the monasteries. Furthermore, some inscriptions contained details on bureaucracy and regulations for the local community [57]. English translations of the inscriptions originating from the 3rd century BCE to the 17th century CE were extensively studied [56,58–74]. In accordance with the general procedure, ancient lithic inscriptions in Sri Lanka were divided into four different categories based on the paleography [57]:

- Early Brahmi (3rd century BCE–1st century CE)
- Later Brahmi (2nd century CE–4th century CE)
- Transitional Brahmi (5th century CE–7th century CE)
- Early Singhalese (8th century CE onwards)

As mentioned before, Rogers highlighted water governance as range of political, social, economic and administrative systems that are in place to allocate, develop and manage water resources and the delivery of water services for a society [21]. All the ancient sources were carefully analyzed for information regarding the ancient water management and governance systems; the relevant text passages were entered in a database. Accordingly, database records were classified into different themes related to political, social, and administrative perspectives of the water-harvesting and management systems. All records in the database were categorized under the following themes:

- Grants of irrigation
- Irrigation ownership
- Irrigation professions
- Official announcements
- Irrigation income
- Other components

Using the geocoded inscription locations data were geocoded and integrated into a Geographic Information System (ArcMap 10.4.1). Descriptive statistics were applied to identify the temporal and spatial distribution of the records.

Information on water management and the relevant governance structures from the time of abandonment in the 13th century CE to reclamation during the British colonial period in the 19th century CE was captured from secondary literature including colonial writings from explorers, travelers and researches, colonial reports, and compilations of colonial writings such as books and research papers.

3. Results

Information on water governance structures from ancient sources was captured from 222 text passages containing 560 different records. 201 of these text passages were captured from the lithic inscriptions and 21 text passages originate from the ancient chronicles. Table 1 documents the distribution of the analyzed records related to different sources and categories. The highest number of records, 281 (50%), refer to grants of irrigation while 106 records (19%) refer to irrigation incomes. Another 51 records (9%) contain references to official announcements related to irrigation

management. Records of irrigation professions (n = 44; 8%) and ownership of irrigation (n = 29; 5%) are of minor importance, records of other components (n = 9; 9%) appear negligible.



Figure 2. Ruwanwelisaya slab inscription by King Nissankamalla (reign: 1187–1196) mentioning water tax and taxes on *chena* cultivation. (Photograph by Wasana Sampath in August 2018).

Table 1. Number of records of irrigation and percentages from different sources.

Sources	Irrigation Grants		Irrigation Ownership		Irrigation Professions		Official Announcements		Irrigation Incomes		Other Components		Sum	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<i>Mahavamsa</i>	4	1	1	3	0	0	0	0	1	1	2	4	8	1
<i>Culavamsa</i>	47	17	0	0	0	0	1	2	3	3	0	0	51	9
Lithic inscriptions	230	82	28	97	44	100	50	98	102	96	47	96	501	90
Sum	281	100	29	100	44	100	51	100	106	100	49	100	560	100

The temporal distribution of the records ranges from the 4th century BCE to the 12th century CE (Figure 3). For the 4th century BCE only one record related to water management and governance could be derived from the chronicles; no records could be captured for the 3rd century BCE. From the 2nd century BCE onwards an increasing number of records could be discovered, most likely related to the popularization of lithic inscriptions written in Brahmi script. For the 2nd century CE the highest number of total records (n = 188) was discovered; correspondingly, also for the 2nd century CE the number of records of grants of irrigation (n = 119), irrigation income (n = 43) and ownership of irrigation (n = 8) peak. Irrigation professions were mentioned from the 2nd century BCE onwards and peak in the 10th century CE (n = 26). Official announcements concerning irrigation governance appeared after the 9th century CE and reach a high in the 12th century CE (n = 29) while they appear negligible in the 4th, 7th, 8th and 11th centuries CE (n = 5).

The majority of 201 text passages from inscriptions were chronologically divided into four major genres using their scripts as mentioned in the original English translations (Figure 4). Accordingly, the highest number of lithic inscriptions (n = 70) referencing water governance were written in Late Brahmi script (2nd to 4th century CE); another 66 records were assigned to Early Sinhalese script (8th century CE onwards), while Early Brahmi (3rd century BCE to 1st century CE) and Transitional Brahmi (5th to 7th century CE) inscriptions account for another 63 and two records, respectively.

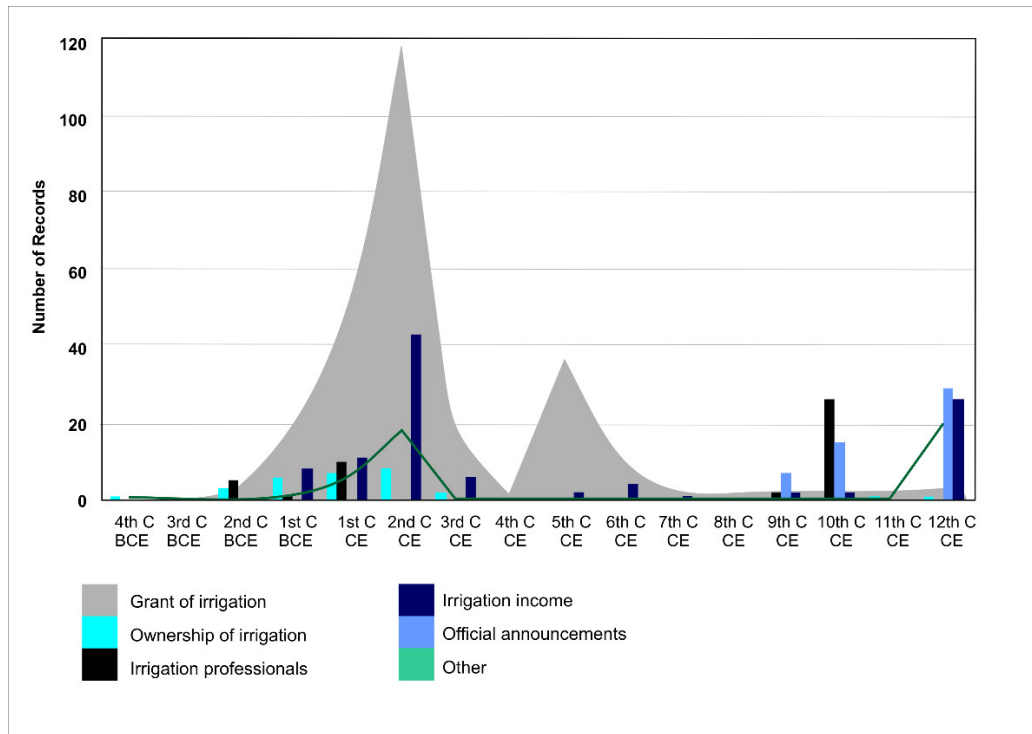


Figure 3. Temporal distribution of analyzed records in different categories of ancient water governance structures.

A total of 194 inscriptions out of 201 registered inscriptions were geocoded using the places of origin mentioned in the inscription volumes (Figure 2). Turning to the spatial distribution of the inscriptions (Figures 4 and 5a), the majority, 53 records (27%), originate from the Aruvi Aru-Malwathu Oya river basin. Another 36 inscriptions (19%) are located in the Mahaweli river basin, while 21 inscriptions originate from the Kala Oya river basin ($n = 21$; 11%), 15 (8%) from the Mi Oya river basin and 12 (6%) from the Yan Oya river basin; less than 5% of the inscriptions originate from other river basins (Figures 4 and 5a). Likewise, 42% of the inscriptions ($n = 81$) are in the present-day district of Anuradhapura and 18% are in the Polonnaruwa district ($n = 35$).

A range of information on ancient water governance in Sri Lanka was obtained from the text passages and is compiled exemplarily for each category:

1. **Grants of irrigation:** “The *Nacadaka* canal in *Ambagama* [is given] to the Sangha”. (IC-1, Nos. 379–380)
2. **Irrigation ownership:** “The pond of the chief Phussadeva, the revenue officer of the king”. (IC-1, No. 703)
3. **Irrigation professions:** “The cave of the chief Uvahajanaka, proprietor of the tank *Kadapi*”. (IC-1, No. 1151)
4. **Official announcements:** “(These are) the immunities in the ninth (regnal) year of His Majesty Srisamboya in respect of the fish that bless the waters of this pond and the flora around it. This is the edictal stone prohibiting anyone committing anything illegal around this pond”. (IC-5, Part-1, 14.9)
5. **Irrigation income:** “(...) The Uparaja Tissa (has granted) as the property of the Sangha one share of the (three) main shares of the tank of *Rajakola*”. (IC-2, Part-1, 51)

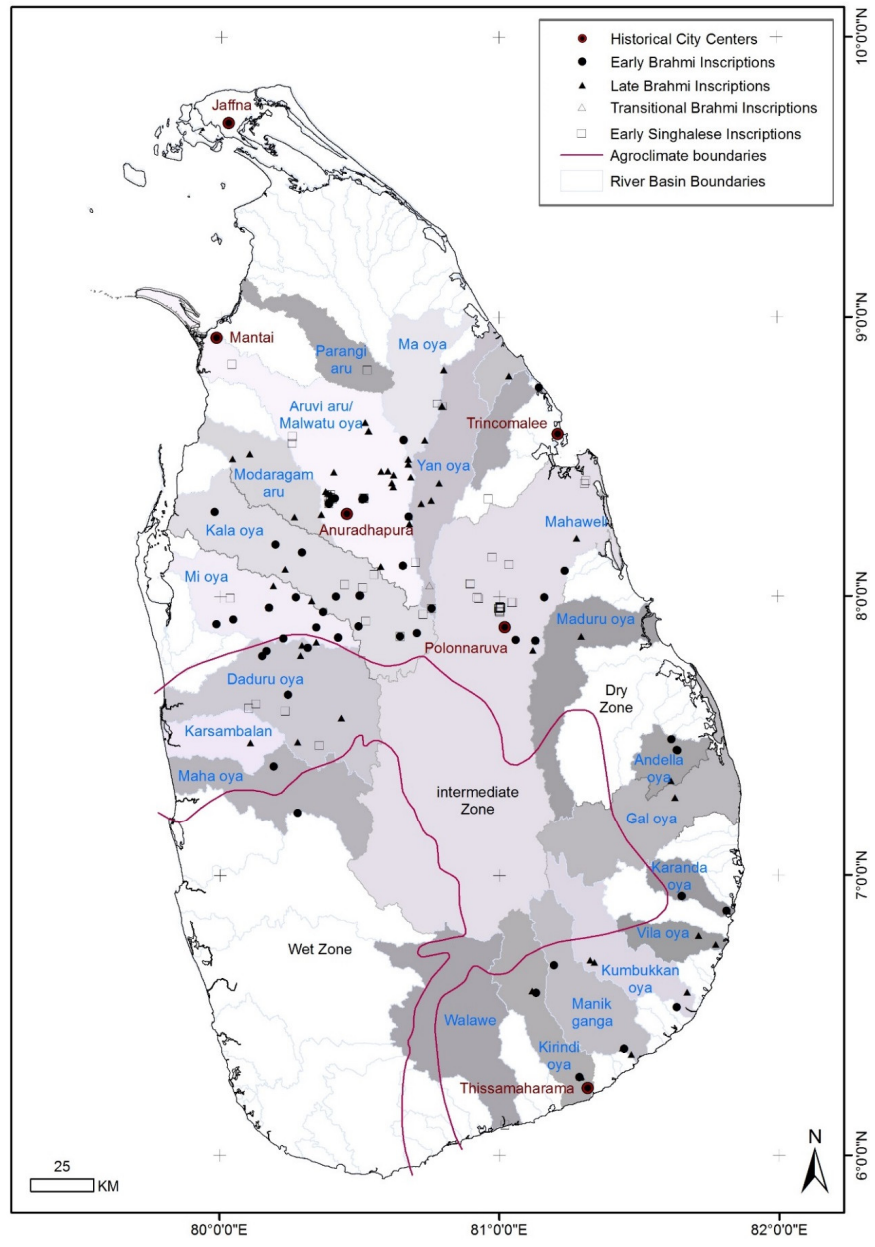


Figure 4. Spatial distribution of lithic inscriptions in Sri Lanka containing information on ancient water governance structures correlated with the river basins. (Relative locations of the inscriptions were assigned by correlating the place names mentioned in the official English translations of the inscriptions with 1:50,000 topographic data compiled by the Sri Lanka Survey Department. Agro climate boundaries are based on the National Atlas of Sri Lanka [22]).

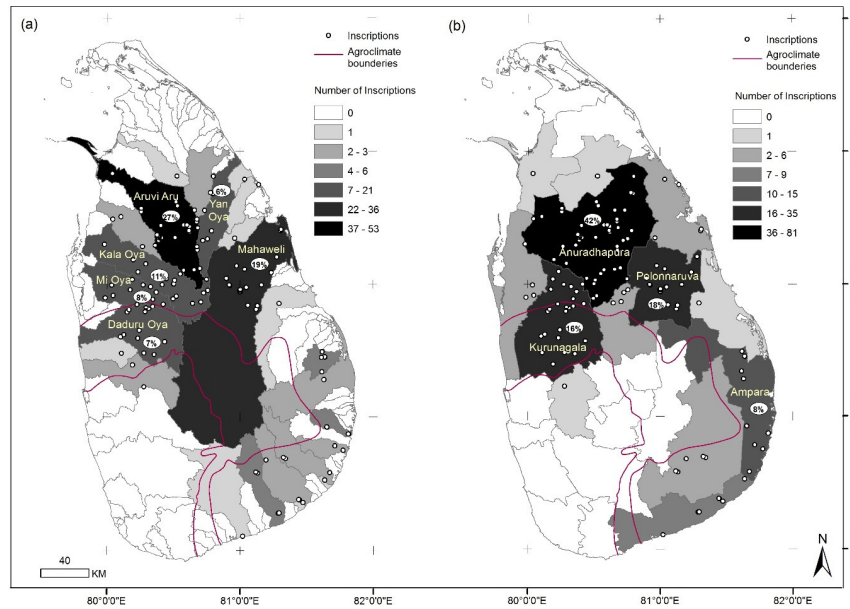


Figure 5. Spatial distribution of lithic inscriptions in Sri Lanka based on river basins and present-day districts. (a) Distribution of inscriptions based on river basins. Percentages are mentioned for river basins with >10 inscriptions; (b) Distribution of inscriptions based on present-day district boundaries. Percentages are mentioned for river basins with ≥ 10 inscriptions.

3.1. Grants of Irrigation

From the 2nd century BCE onwards, grants of irrigation works are a prominent subject in most ancient sources; 50% of the records captured in the database ($n = 281$) refer to this category; 124 of these 281 records originate from inscriptions (Figure 6a). Most grants were made for a particular monastery (33%) and for monks dwelling in a particular monastery (24%) (Figure 6b-i). 15% of the records of grants were made to monks without a particular name and 14% to unnamed monasteries. Records of grants to a particular element of a monastery encompass 11% of the records of grants of irrigation. Secular grants and grants with no mention of the grantee amount to 3% and 4% of records (Figure 6b-i).

Most grants (46%) came from kings and elite groups (Figure 6b-ii). In addition, the local community provided a considerable number of grants (26%). 15% of the grants were mentioned without naming granters and another 13% were granted by government officials (Figure 6b-ii). Grants of irrigation in ancient times were mainly based on religious purposes (Figure 6b-iii). In only a few instances were secular grants mentioned, such as when King Datusena (reign: 459–477 CE) granted half of the share of the *Kalavapi* (Kala wewa tank; *Kalavapimhi bhagaddham*) to his brother Kumarasena (*Culavamsa* XXXVIII/53). Accordingly, 28% of the records refer to grants for the benefits of monks and 28% to grants for carpets/antelope skins in the monasteries (Figure 6b-iii). 16% of the records relate to grants for the expense of oil and offerings in monasteries and another 19% of the records of grants of irrigation relate to other purposes (Figure 6b-iii). 9% of the records of grants of irrigation relate to maintenance purposes.

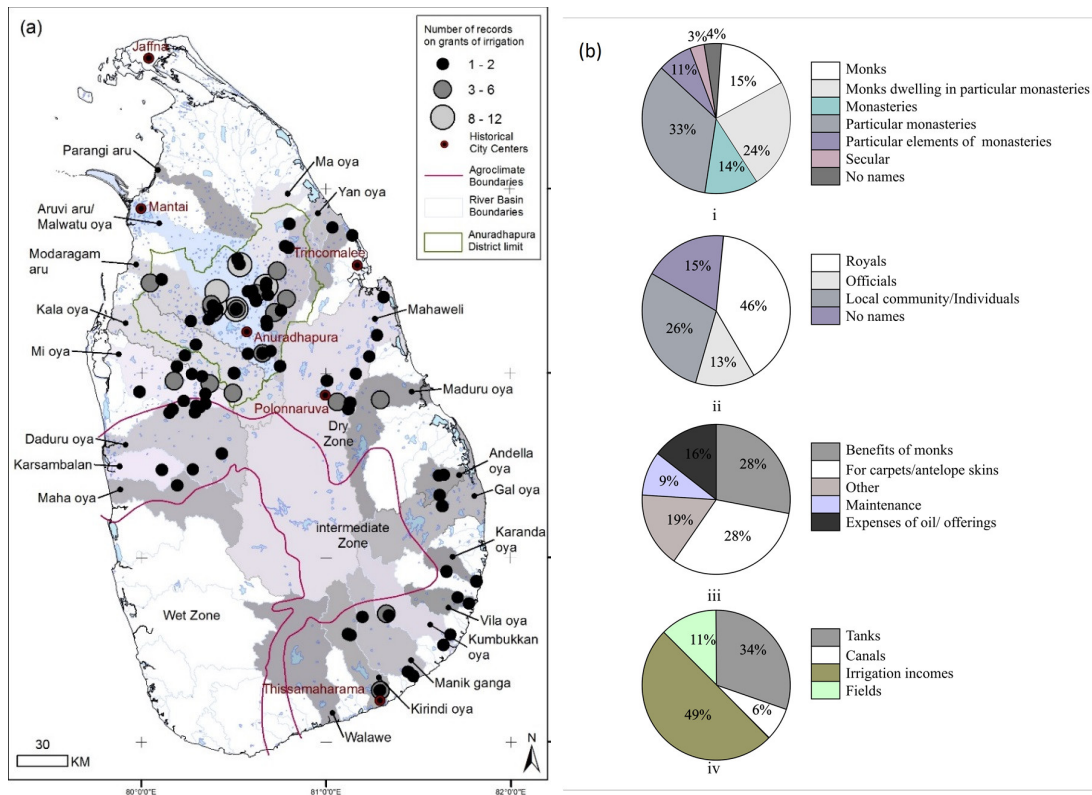


Figure 6. Grants of irrigation: (a) Distribution of records on grants of irrigation based on river basins; (b) i. percentages of type of grantees, ii. percentages of types of granters, iii. percentages of purpose of grants iv. percentages of elements of irrigation granted.

Ancient sources mention grants of irrigation in different forms (Table 2). Most records (49%) refer to incomes and shares (Figure 6b-iv), 34% refer to grants or tanks, 11% to grants for irrigated fields and 6% to grants for canals (Figure 6b-iv). Table 2 documents the grants of irrigation categories in the wider sense, with relevant examples from the inscriptions and chronicles.

Table 2. Different categories of grants of irrigation to the Buddhist monastic entities recorded in ancient sources.

Category of Grant	Text Passage	Source
Grant of tanks	<i>Success! The reservoir of Dubalagama (is the property) of the community of bhikkhus. The reservoir of Pidavika (is the property) of the community of bhikkhus. The senior wife of King Kutakanna, the Queen Anula, gave to the community of bhikkhus in the monastery ofPilipavata.</i>	IC,II, Part 1/3
Grant of waterhole	<i>The waterhole and the cave of Parumaka Data, son of Parumaka Utara son of Parumaka Pulaya, are given to the sangha.</i>	IC,I, No. 712
Grant of cistern	<i>The son of the chief Mala is the chief Namara; of the chief Naga, son of the chief Namara—of this (personage)—the cistern is dedicated to the Sangha of the four quarters, present and absent.</i>	IC,I, No. 318
Grant of parts of tanks	<i>Success! One part of ten parts of the Hayagaraya tank has been donated to the community of bhikkhus in the Kalaka-vahanaka monastery.</i>	IC,II, Part 2, 160 A

Re-grant of tanks	<i>Success! The son of King Vasabha (was) King Tissa. King Gamani Abhaya, son of King Tissa re-granted the Upala-donika tank, first granted by King Sabha, to the community of bhikkhus, for the purpose of carpets of antelope skins to the community of bhikkhus of the Ekadvara monastery.</i>	IC,II, Part 1, 62
Grants of fields in the tanks	<i>Success! (The gift) of the Minister Cadula Naka, to the Caitya, of two karisas of fields in the tank of Rajadatika Citala and the tank of Nitalaovi tika.</i>	IC,II, Part 2, 191 A
Grants of pasture lands of the tanks	<i>Hail! The overlord's income from the pasture land of the tank of Dinna has been dedicated to this cave.</i>	IC,I, No. 1150
Grants of canals	<i>To allow repairs at all times on the Ratanapasada he granted it the Getthumba canal.</i>	Culavamsa XLIX/41
Grants of water shares	<i>(...) The great King Tissa granted one part out of three parts of the water share from this to the monastery of Kubilavi-Tisa-pavata.</i>	IC,II, Part 1/14.2
Grants of water revenues	<i>Success! King Lanjaka-Tissa, having built a vihara for the Elder Godhagatta Tissa, gave to this vihara, the two categories of revenue of the tanks Vakaravi, Viharavi, Panitakavi, of the lake named Nikula, and of the channel of Kalahanagara.</i>	IC,II, Part 1/15

3.2. Ownership of Irrigation

Chronicles and lithic inscriptions refer to the ownership of irrigation on numerous occasions. Altogether 29 records (5%) refer to different kinds of ownerships of irrigation. Most irrigation elements recorded in ancient sources refer to individual ownerships (48%, n = 14), while royals and elite groups are mentioned in 28% (n = 8) of records of ownership. Another 17% (n = 5) refer to the local chiefs (Parumaka) and 7% (n = 2) mention family ownership. Table 3 illustrates the different irrigation elements and their ownership as mentioned in ancient sources.

Table 3. Ownership of irrigation mentioned in ancient sources.

Irrigation Element	Ownership	Source
Purified natural pond	King	MV 10/77, 78
Pond	Chief (Parumaka)	IC,1, No. 703,
Waterhole	Chief (Parumaka)	EZ. VII. p. 57
Cistern	Chief (Parumaka)	IC,1, No. 318
Tank	Chief (Parumaka)	IC,1, No. 1051
Tank	Chief (Parumaka)	IC,1, No. 1052
Reservoir of Dubalagama	Senior wife of the king	IC,2, Part 1/3
Tank of Kabaduka	King Lajaka	IC,2, Part 1/13
Maragama tank	King	IC,2, Part 1/14.1
(Tank of) Abala-ketavi	King	IC,2, Part 1/14.2
Revenue of Balayata-gamakavi tank	King	IC,2, Part 1/20
Tank of Ayibaravika	Householder Butayas' family	IC,2, Part 2, 127
Tank Ayibaravika	King	IC,2, Part 1/37
Tank Hamanavi	Female lay-devotee Phussa	IC,2, Part 2, 171 C
Tank	Female lay-devotee Matta	IC,2, Part 2, 171 D
Tank of Mata	Bahakava	IC,2, Part 2, 157
Tank named Mahapada	Kad and Tissa	IC,2, Part 2, 183
Tank and the field	Naka, son of Ba(ma)na	IC,2, Part 2, 180
Tank	Minister Nakayai	IC,2, Part 1, 84
Tank (named) Dakkhina-Tissa-vapi	The great King Tissa	IC,2, Part 2, 85
Tank Mataka	Father of King Kanittha Tissa	IC,2, Part 2, 86
Pajini Honagiriya tank and Padi tank	Honagiriya monastery	IC,2, Part 2, 141 C
Water revenue of tanks of Katelavasaka and Ahuraviki	Vahabha, son of Sena	IC,2, Part 2, 159
Principal (lit. great) revenues (or share) of the tank	Minister Homiya Nakala	IC,2, Part 1, 73

Water revenue of <i>Ketavalaka</i> tank	Treasurer <i>Bataka</i>	IC,2, Part 1, 45
<i>Mahavavi</i> and the <i>Abagamaka-vavi</i> tanks	(The Minister) <i>Badaba</i>	IC,2, Part 1, 49 II
Share of the fish in the channels of <i>Cigaravaliya</i> tank	Family of <i>Mahakanha Tissa</i>	IC,2, Part 2, 103
Tank (named) <i>Varuka</i>	King <i>Suvanna-Vahaka</i>	IC,2, Part 2, 115
Paddy field irrigated by canal	Brother-in-law of <i>Devarad</i> of <i>Bulatgama</i>	IC Vol VI 17.5

3.3. Irrigation Professions

Different professions related to irrigation agriculture are mentioned in lithic inscriptions from the 2nd century BCE onwards (n = 44). However, no records of irrigation professions were captured from the 1st century CE to the 8th century CE; in the 10th century CE the total again increased (n = 26). Table 4 illustrates the different irrigation professions mentioned in inscriptions from the 2nd century BCE onwards. However, the inscriptions mention these professions in relation to grants of irrigation or different purposes, in consequence there is no detailed information on the responsibilities and obligations of these professions.

Table 4. Ownership of irrigation mentioned in ancient sources.

Centuries	Profession	Sources
2nd C BCE	Chief <i>Naguli</i> (flow operator)	IC,I, No. 260, IC,I, No. 869
2nd C BCE	Officer in charge of canals	IC,I, No. 791
2nd C BCE	Irrigation officer	IC,I, No. 846
2nd C BCE	Proprietor of the ferry (<i>Parumaka Thota-Bojhaka</i>)	IC,I, No. 860
1st C BCE, 1st C CE	Proprietor of the tank (<i>parumaka vapihamika</i>)	IC,I, Nos. 1129, 1130, 1132, 1151, 1153, 1200, 1217, 1218
1st C CE	Lord of <i>Kadahalaka-vavi</i>	IC,I, No. 1122
1st C CE	Proprietor of the pasture land	IC,I, No. 1149
9th C CE	Agricultural officer who looks after the water courses	IC,V, Part 1/10.5
9th, 10th C CE	Agriculture officers	IC,V, Part 3/4, 11, 27, 70, 78, 89, 120, IC,V, Part 1/57.6, 94.4, 97.1, IC,V, Part 2/7.7, 8.8, 41.4,
10th C CE	Junior agriculture officers	IC,V, Part 1/112.22
10th C CE	Officials attached to the Department of Agriculture	IC,V, Part 1/57.6
10th C CE	Agriculture Committee of five members	IC,V, Part 1/92.2, 106.16, IC,V, Part 3/15
10th C CE	Cultivation officers	IC,V, Part 1/57.6
10th C CE	Grain collecting officer	IC,V, Part 3/89
10th C CE	Directors of agriculture	IC,V, Part 3/78
10th C CE	Commander of the reservoir guards	IC,V, Part 2/22.22
10th C CE	Commission of <i>Tala-arak Kitaln</i> (warden of reservoirs)	IC,V, Part 3/20
10th C CE	Bodyguard cum conservator of reservoirs	IC,V, Part 3/21
10th C CE	Officials of the <i>Alasara</i> (officer in charge of dams and canals)	IC,V, Part 3/27
10th C CE	<i>vel-vassan</i> (field inhabitants) and <i>vel-kamiyan</i> (field workers)	EZ.II, pp. 49 ff.,
10th C CE	Twelve great reservoirs	IC, V, Part 1/61.10, 68.17, 100.10 IC,V, Part 2/18.18, EZ. V. pp. 350 ff., EZ. IV, pp. 186 ff.

The professions mentioned in the Early Brahmin inscriptions from the 2nd century BCE to the 1st century CE mainly refer to various livelihoods based on irrigation agriculture, such as flow operators and proprietors of tanks and canals. After the 9th century CE a more bureaucratic and structured official order becomes visible. In addition, the records repeatedly mentioned members of a committee called “*twelve great reservoirs*” and agricultural committees.

3.4. Official Announcements on Irrigation

Various official announcements on irrigation were introduced by the sources, mainly by inscriptions, after the 9th century CE. Altogether 51 records (9%) were captured in this category. Official announcements were issued for different purposes (Table 5, Figure 7). Most official announcements mention regulations related to the revenue system. For instance, the Dambulla rock inscription of King Nissamkamall (reign: 1187–1196) gives directions on tax collection:

“(...) he ordained that the revenue should be collected at the rate of one amuna and three palas (in grain) and six manda-run (in cash) for an amuna (sowing extent of land) of the highest productivity, one amuna two palas and four manda-ran for an amuna (sowing extent of land) of middling productivity, and one amuna and one pala and three manda-ran for an amuna of least productive fields, and kati-ada tax should not be collected from the slash-and-burn cultivation for all times, as ‘those’ who follow that form of cultivation earn their livelihood distressfully (...)” [63].

A few other inscriptions of the same king point to the abolishment of water taxes and the taxes for *chena* cultivation. In the 12th century CE, 12 other inscriptions refer to regulations implemented to protect the natural landscape and wildlife. The Polonnaruwa stone sheet inscription of King Nissamkamalla mentioned: *“(...) He abolished for all times taxes on chena cultivation and gave protection to living beings living in forest and in great reservoirs (...)” [63].* Three inscriptions including the Basawakkulama pillar inscription, which was inscribed in the 10th century CE, elaborate the regulations taken to prevent illegal fishing in the tanks [60].

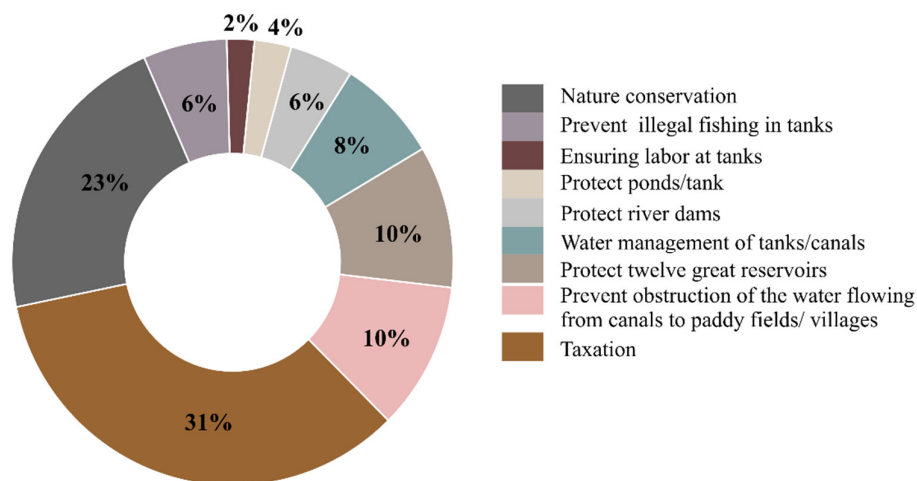


Figure 7. Different categories of official announcements on irrigation recorded in ancient sources.

Various inscriptions in the database refer to strict regulations established for the management and protection of irrigation components. For instance, five records in the database refer to rules to prevent obstructions to the water flowing from canals to paddy fields/villages, another five records refer to the protection of 12 larger reservoirs. Dorabavila inscriptions from the 10th century CE note the following:

“(...) Carts, oxen, domesticated elephants and buffaloes shall not be appropriated for (free) service at the dams or in the beds of the reservoirs; even if the Twelve Great Reservoirs are breached, domesticated elephants and buffaloes shall not be appropriated for (free) service; (...)” [60].

There are four records that refer to regulations on water management of tanks and canals. They were mainly erected to prevent the obstruction of water flows from streams and canals to villages and paddy fields. There are no fines or punishments mentioned for such acts and the rules were mainly based on religious beliefs. As an example, the Abayagiriya pillar inscription of the 10th century CE says:

“(...) the water flowing here from the Kolob canal shall not be hindered; may those who transgress the regulations laid down here and commit unlawful acts become crows and dogs” [60].

A few other inscriptions refer to some official announcements related to the protection of ponds, tanks, and river dams while only one inscription refers to the allocation of labor to tank maintenance.

Table 5. Categories of official announcements on irrigation mentioned in ancient sources.

Centuries	Purpose of the Official Announcement	No. of Record	Sources
9th C CE	Prevent illegal fishing in tanks	3	IC,V, Part 1/14.9, 15.10, CV. 51/130
9th C CE	Ensuring labor at tanks	1	EZ. VI. pp. 12 ff.
9th, 10th C CE	Protect ponds/tanks	2	IC,V, Part 1/11.6, EZ. I, pp. 113 ff.,
9th, 10th C CE	Protect river dams	3	IC,V, Part 1/39.6, 112.22, IC,V, Part 3/6
10th C CE	Water management of tanks/canals	4	EZ. VI. pp. 12 ff., EZ.I, pp. 98 ff., IC,V, Part 2/69.8
10th C CE	Protect 12 great reservoirs	5	IC, V, Part 1/61.10, 68.17, 100.10, EZ. V. pp. 350 ff., IC, V, Part 2/18.18, EZ. IV, pp. 186 ff.
10th C CE	Prevent obstruction of the water flowing from canals to paddy fields/villages	5	IC,V, Part 1/70.19, 71.20, 72.21, 94.4, EZ. II, pp. 49 ff.
12th C CE	Related to revenue system	16	IC Vol VI 27.4, 32.9, 33.10, 34.11, 39.16, 41.18, 42.19, 44.21, 45.22, 48.25, 52.29, 52.29, 56.33, 57.34, 69.46, 71.48
12th C CE	Natural landscape management	12	IC Vol VI 33.10, 34.11, 39.16, 41.18, 42.19, 44.21, 52.29, 52.29, 56.33, 69.46, 70.47, 71.48

3.5. Irrigation Income

Irrigation income was mentioned in 106 records starting from the 1st century BCE. The highest number of records on irrigation income were found to date from the 2nd century CE (n = 43). Each of the following centuries has fewer than ten records on irrigation income. However, 26 records are again found for the 12th century CE. The chronicles mentioned the water revenues as *udabhaga*. For instance, King Vasaba in the 2nd century CE allotted *udabhaga* or a share in the water of the canal *Alisara* to the *Mucela vihara* monastery [59]. Inscriptions often refer to the revenues as *dakapati*, *bojakapati*, *bojiha-baka* and *matera maji baka*. Analysis of the database records reveals irrigation incomes were allotted in different ways in the sources (Table 6). Most records mentioned water tax or revenues from tanks (n = 28) and the second highest number of records referred to the share of fish caught in

the canals (n = 10). The analyzed records show that revenues or shares for fishing are only visible where related to the canals.

Table 6. Categories of irrigation incomes mentioned in ancient sources.

Irrigation Income	Number of Records
Proprietor's share (<i>bojiha-baka</i>) of tanks	4
Main share of tanks	4
Principal (lit. great) revenues from tanks	1
Overlord's income from tanks	4
Overlord's revenue from tanks	4
Overlord's share of tanks	1
Income from tanks	3
Water tax/revenues from tanks	28
Water share of the tanks	5
Water quota	2
The revenue of the lands irrigated by tanks	2
Water share of canals	1
Dues from the dams of canals	1
Share of the fish (caught) in the channels	10
Revenue from the tract of fields of tanks/canals	2
Water ration for the <i>yala</i> season	1

In most cases the database records on revenues mention the irrigation grants and the related incomes as relevant to Buddhist monastic entities. As a result, only the names of the various revenues and incomes were mentioned without detailed information on structure and organization. However, a few instances give certain indications of the organization of revenues. A 2nd century CE inscription situated in Tammannakanda, Anuradhapura district mentions the revenue of a district called *Utarapana*:

"Success! Of the tank Pajalaka in the district of Upala-ava and of Palaaviya (in the same district) and of the Manikaragamaka tank in the revenue district of Utarapara—of these three tanks—the proprietor's share the great King Naga gave to the community of bhikkhus in the Pacina-Naga pabbata monastery, having had the taxes thereon remitted" [58].

The Nattukanda rock inscription (2nd century CE) also refers to the same revenue district *Utharapana* [59]. Another inscription found in Mahagalkulama mentions a revenue district called *Devagama* [59]. A 1st century CE rock inscription located in Kaduruvava indicates a revenue agency called *Gavidaganaka* [58]. However, only the names are mentioned, and no further details are available on the functioning of the agencies and districts.

In the 12th century CE, during the reign of King Nissamkamalla (reign: 1187–1196), several inscriptions were established to show the ordinances and regulations on taxation. For instance, a Vanduruppa slab inscription in Ambalantota district, Southern Province provides details on the amount of tax collected:

"(...) he enacted an ordinance to the effect that in collecting revenues the tax on an amuna (sowing extent) of the field of the highest productivity (utte amuna) should not exceed one amuna and three palas and six akas as manda-ran, for an amuna (sowing extent) of middling quality (mande amuna) should not exceed one amuna and two palas and four akas as manda-ran, an amuna (sowing extent) of least productive land should not exceed one amuna one pala and three akas as manda-ran; as the chena cultivation was a painful mode of livelihood, he enacted the perpetual remission of its tax; and also he remitted the water-tax levied in respect of giant reservoirs and granted protection to all beings" [63].

3.6. Other Components

Diverse information on water governance and irrigation management is also provided by 49 records assigned to the category “other”. Most records in this category elaborate on purchases of irrigation works and their incomes (n = 11). Various records show that in ancient Sri Lanka people could sell or buy the ownership of tanks. This is also documented in the Sithulpav inscription (2nd century CE):

“Success! The great King Tissa, younger brother of the great King Bhatika Tissa, and son of the great King Naga, having paid (the price of) eight hundred and thirty-three kahapanas (local money), caused the tank (named) Dakkhina-Tissa-vapi to be purchased as his own property in perpetuity of (the monastery of) Cittalapabbata, and granted it for the benefit of the umbrella and railing on the summit of the Caitya” [59].

In many cases, the inscriptions refer to the purchases of different revenues and shares of irrigation similar to the purchase of tanks. There are no records that refer to purchases of canals. However, a few inscriptions mention the purchase of the shares of fish caught in canals. The Mahagalkulama inscription (2nd century CE), currently located in the Anuradhapura museum, says:

“(…) these three persons—having paid a hundred thousand, and another seven hundred, and another sixty-three-(having paid) the above stated (number of) kahapanas—acquired in its entirety the share of the fish in the channels of the tank of Padahata-raka situated in the revenue district of Devagama, the Minister Devaba of Mahavilabanaka paid to the banker Mata Kalaya the sum of five thousand kahapanas and, having purchased in its entirety, the share (due to the overlord) of the fish (caught) in the channels of the tank of Hakanakara in the district of Upalava” [59].

Another seven records give particular information on the traditional way of making the grants of irrigation to grantees. The event was called the “ceremony of golden vase”. By pouring water from the golden vase into the hand (of the donee) the king symbolized the official validity of the grant [58,59]. Next to this common procedure, a particular grant to a monastery could be announced and legitimized by the beating of the drum of proclamation by the messengers within the area [58,59].

Several other inscriptions in the category “other” refer to construction labor for irrigation works. They show that the labor was paid for—even by the kings. An Early Brahmi inscription (1st century CE) located in the Ganekanda monastery in Kurunagala district says: *“Having caused the dam to be constructed and thus made the village content, the king gave nine hundred thousand for the labor of hands and feet” [56].* The Viharegala rock inscription of King Suba stated that he bought the Upaladonika tank for 500 kahapanas (local money) and that he had the silt removed by spending another 500 kahapanas [58].

A Nattukkanda inscription (2nd century CE), situated in the Anuradhapura district, reveals information on the mortgage of tanks provided by a monastery to a village council:

“Success! Kumaraya and Siva-Nakaya sons of the Amati Badahariya, dedicated and donated to the community of bhikkhus in the Honagiriya monastery, Pajini Honagiriya tank and Padi tank, the property of the monastery of Honagiriya in the Revenue Agency of Utarapara which had been mortgaged to the assembly of Atarajiva, and are redeemed” [59].

A few other records in this category refer to water festivals and cultivation seasons [58,59]. In the 12th century CE, during the reign of King Nissamkamalla, several inscriptions refer to the abolishment of water taxes and taxes on *chena* cultivation [63].

4. Discussion

There is a continuous line of sources mainly originating from ancient chronicles and lithic inscriptions for more than 2000 years, covering the Ancient Period of Sri Lanka. The analysis of these text sources necessitates a comprehensive investigation of the trustworthiness of the retrieved information [75]. Systematic stylistic assessment of the ancient sources requires content criticism to place the sources in the precise context of the background information [76].

Classical texts written by the scholar monks generally contained narratives based on historical facts and myths; the origin of these narratives is linked to North India and to stories of invasions coming from South India [77]. According to Senevirathne, these texts were codified in order to legitimize particular faiths, lineages and ritual centers within a pan-Island context [77]. Consequently, classical texts are strongly biased to the Buddhist religion and focus on the major political and ritual centers and their royal sponsors [8].

The chroniclers mainly provided information on religious and major political occurrences. The *Mahavamsa* (also: Great Chronicle) was written as a poem, resulting in many embellishments and exaggerations [55]. However, the translator of the chronicle, Wilhelm Geiger, clearly concluded that the authors never attempted to intentionally record a falsehood, despite their religious bias [55].

The value of the information given in the sources depends partly on the proximity to the events they described. The ancient chronicle tradition of Sri Lanka was established from the 4th century CE onwards. Occasionally, chronicles referred to historical events which happened immediately prior to the writing of the chronicles. Conversely, the chroniclers referred to classical Buddhist literature and early commentaries written in Early Sinhalese on the *Pali* Canon named *Atthakatha Mahavamsa*. Therefore, all these chronicles are based on an interconnected historical tradition which has to be considered in its entirety [7].

Sri Lanka has a lithic inscription tradition established from the 3rd century BCE onwards. Lithic inscriptions primarily referred to common acts such as grants of monasteries, lands, and incomes. Mostly they can be linked to Buddhist monasteries, but sometimes bureaucratic official announcements and regulations issued for the common people are also documented in the inscriptions [57]. Lithic inscriptions predominantly provide documents contemporary to the described events and untouched by the hands of editors and copyists [4,44]. The current study is mainly based on inscriptions—90% of the retrieved records (n = 501) are from the inscriptions, assuring credible information.

Various research papers show the potential of ancient sources for the derivation of historical events and circumstances. In 2001 Perera investigated the institutions of ancient Ceylon from inscriptions [78]. Liyanarachchi conducted research on accounting in ancient Sri Lanka based on lithic inscriptions [79]. Adithiya analyzed aspects of ancient architecture and town planning using the chronicle *Mahavamsa* [80]. In consequence, it can be assumed that the text passages and records from the ancient sources represent a valuable archive for the derivation of information on ancient water governance in Sri Lanka.

4.1. Spatio-Temporal Distribution of Text Sources

Several factors affect the spatio-temporal distribution of the text sources. In archaeological and historical disciplines, the identification of territories is always challenging [81]. An exact delineation [81] of the historical hinterlands of the Anuradhapura and Polonnaruwa kingdoms is not achievable. Therefore, the river basin divides and the present-day administrative district boundaries were used as a basis for the spatial analysis of the records, predominantly focusing on the places of origin of the lithic inscriptions.

The spatial pattern of the lithic inscriptions clearly illustrates that the highest number of inscriptions referring to water governance can be assigned to the present-day Anuradhapura district (North Central Province) and the Aruvi Aru as well as the Malwathuoya river basins, which were the major river catchments linked to the ancient capital Anuradhapura (Figure 3a,b). Correspondingly, the second highest number of inscriptions can be allocated to the present-day Polonnaruwa district (North Central Province) and the Mahaweli Ganga river catchment, which is directly linked to the ancient capital Polonnaruwa (Figure 3a,b). This spatial pattern is partially correlated with the present-day distribution of tanks (Table 7). Consequently, the Northwestern Province demonstrates the highest density of present-day tanks with a density of 0.8 tanks·km⁻², followed by the North Central Province with 0.4 tanks·km⁻². In contrast, the high density of inscriptions in the North Central Province impressively documents that the two major ancient kingdoms in *Rajarata* existed in this province, namely Anuradhapura and Polonnaruwa. Research

interests in epigraphy and classical archaeology have focused on these two ancient cities and kingdoms for more than a century, starting from the Colonial Era, while coevally the peripheral regions were neglected and received no systematic investigation until very recently [77]. These different allocations of research interests must be considered when assessing the spatial pattern of the inscriptions.

In the Northern Province the large number of small tanks is documented in a high tank density of 0.2 tanks·km⁻²; in contrast, only two inscriptions are recorded for this area. The Sri Lankan civil war (1983–2009) [82] is a major factor influencing the poor number of systematic archaeological investigations in the area, resulting in a low total of recorded inscriptions. Moreover, the limestone bedrock in the Jaffna and Mannar districts is highly sensitive to weathering processes and the state of conservation of the lithic inscriptions is therefore poorer than in the plutonic rocks in the other parts of the dry zone [22].

Table 7. Distribution of small tanks in different provinces (modern Sri Lanka) [83] and number of inscriptions referring to water governance.

Region	Small Tanks (Number)	Tanks per km ² (Number)	Functioning Tanks (%)	Abandoned Tanks (%)	Inscriptions Referring to Water Governance (Number)
North Central Province (Anuradhapura and Polonnaruwa district), size 10,472 km ²	4017	0.4	52	48	116
North Western Province (Kurunagala, Puttalam districts), size: 7888 km ²	6463	0.8	65	35	35
Northern Province (Jaffna, Kilinochchi, Mullativu, Vavuniya, Mannar district) size: 8884 km ²	1424	0.2	43	57	2
Southern Province (Galle, Matara, Hambantota district) size: 5444 km ²	1410	0.3	46	54	9

The first appearance of information on water governance in the ancient sources dates to the 4th century BCE. However, even with a coarse temporal resolution the continuity of records is uncertain for many centuries. A gradual increment of records is visible from the 2nd century BCE and achieved its maximum extent in the 2nd century CE. The popularization of lithic inscriptions to demarcate a series of religious grants began with the introduction of Buddhism to the Island [56] and is a remarkable factor influencing this gradual increase. Furthermore, this period corresponds with the transformation of the Anuradhapura settlement into the kingdom's capital [32,84], enriched by monumental architecture and the religious centers which formed a crescent around the ancient Anuradhapura Citadel [85]. During the 1st century CE, the Anuradhapura Citadel was supposedly among the ten largest cities of the Indian sub-continent [86], expanding to an area of 100 ha [87]. The highest number of records on water governance in the 2nd century CE is an indicator of the growing interest in documenting different factors related to land and water management systems. In addition, religious developments, and the increasing number of religious grants to the monastic entities must be considered as a factor contributing to the increase in documentation intensity. Various authors date the initial development stage of the massive irrigation infrastructure in the *Rajarata* kingdom in the dry zone to the same period as the development of the kingdom and the concurrent development of Buddhism [42].

Continuing consideration of the temporal distribution of records on water management, there was an abrupt drop after the 3rd century CE with only four records discovered for the 4th century

CE. However, this century is remarkable in Anuradhapura due to improved commercial activities and monumental architectural developments [7,85,88]. Furthermore, the availability of published materials is a major factor explaining this scarcity of records since two important publications (Inscriptions of Ceylon volumes 3 and 4), intended to comprise translations of inscriptions from the 4th to the 7th century CE are still in preparation by the Department of Archaeology, Sri Lanka (friendly oral communication with Mr. Namal Kodithuwakku, Director—Epigraphy and Numismatics, Department of Archaeology, Colombo, August 2017).

Again, after the 9th century CE the number of records on water governance increased and peaked once more in the 12th century CE during the kingdom of Polonnaruwa. This could be interpreted by reference to several different factors. The last phase of the Anuradhapura kingdom (8th–11th century CE) is characterized as a period of political instability due to several invasions from South India [9,89]. It is hypothesized here that the 22 records on official announcements originating from the 9th and 10th centuries CE document precautions to counter destruction and collapse with a highly bureaucratic centralized water governance structure. However, the systematic compilation of inscriptions for the previous period (4th–7th century CE) is in preparation for publication and this evidence is thus interpreted as *terminus ante quem*.

Most inscriptions on water governance originating from the 12th century CE can be linked to King Nissamkamalla (reign: 1187–1196 CE). According to Paranavitana, King Nissamkamalla was not a favorite character among the chroniclers and they neglected to record his activities [63]. King Nissamkamalla responded to this neglect with a large number of lengthy epigraphs established in the capital of Polonnaruwa and other areas [63]; this is directly reflected in the high number of records observed for the 12th century CE.

4.2. Ancient Water Governance System in the Rajarata Kingdom

The prehistorian Clark already highlighted the importance of water management and governance in human history in 1944 [90]. According to Clark, water has continuously reflected the image of society from prehistoric times to the present. This statement is also valid for the water management system in the Sri Lankan dry zone. According to the grand theories on water and society, augmented by authors such as Wittfogel and anthropologist Steward [91,92], state societies in Asia depended on the creation of large-scale irrigation works which required organized, forced labor and centralized bureaucratic management. However, most recent cross-cultural studies on water and society have revealed more complex and diverse associations and methods of indigenous water management and governance [93,94].

The water management system in the dry zone of Sri Lanka must be regarded as a unique example, which developed in harmony with the participation of both rulers and local people. The number of inscriptions referring to private ownership is direct evidence for this hypothesis. In the current database, 48% of the records on the ownership of irrigation refer to private ownership and only 28% refer to the rulers. Early and Late Brahmi inscriptions often mention tanks together with their ownership such as *Parumaka* (chief), *Vapihamika* or *Vavihamika* (proprietors of the tanks) (Table 4).

During the kingdom of Kandy (1469–1815 CE) and the initial phase of British colonial rule, management of most services including irrigation was based on the compulsory labor system called “*Rajakariya*” (corresponding to King’s Labor) [25,46]. However, in the initial stages, labor was not always free, as documented by the inscriptions: there is strong epigraphic evidence mentioning hired labor for construction and the management of irrigation works. In one instance, a powerful ruler Gajabahu I (reign: 113–1135 CE) spent 5000 monetary units for labor to create the *Vadamanakavapi* and *Kandahavapi* tanks [64]. Another inscription from the 1st century CE originating from the Ganekanda monastery in the Kurunagala district mentioned that the king spent 900,000 monetary units for the labor of hands and feet to construct a dam [56], indicating the use of hired labor rather than of government forced labor free of charge. The trading of ownerships of irrigation works and their incomes is frequently mentioned in the inscriptions. The ownership of tanks and shares of irrigation were often exchanged via trading. However, no records were retrieved on the trading of canals

although shares of income from the canals, such as for the fish caught, were traded. This indicates that the canals were treated separately to allow the free flow of water without obstacles, since they interconnect the tanks.

As revealed by the ownerships of elements of irrigation, the trading of ownerships and hired labor, water management and governance in the *Rajarata* kingdom was initiated and developed as a community-based local system before it developed into a centralized, bureaucratic system managed by the rulers. In 1959 Leach highlighted that the large tanks and their management may have been the works of bureaucracy, but the small village tank systems certainly were not [30]. Furthermore, he argues that the whole system showed similar characteristics to European feudalism [30]. Leach claimed the ancient Sri Lankan water management system was “hydraulic oriental” feudalism. In contrast, Gunawardane describes a dual patronage between rulers and the local community [3].

The number of inscriptions referring to the administration of water, especially the indicators of different professions, link up with the water management system. The professions mentioned in the Early Brahmi inscriptions from the 2nd century BCE to the 1st century CE approximately refer to livelihoods based on irrigation agriculture such as flow operators and proprietors of the tanks. Official announcements of strict laws and regulations are unknown from this period. In contrast, bureaucratic official orders and firm regulations on water governance are repeatedly found from the beginning of the 9th century CE. The temporal distribution of professions and official orders is a clear indication that water governance in the dry zone of Sri Lanka was not initially based on bureaucratic statehood as suggested by Wittfogel [92], instead it was a community-driven local system. Furthermore, even during the bureaucratic stage, no strict fines or punishments were mentioned in the official announcements. Governance was partly based on religious and spiritual beliefs, as demonstrated by the many inscriptions saying, “*Those who transgress the regulations laid down here and commit unlawful acts become cows and dogs*”.

The records compiled clearly show that a revenue system was well established from the initial period documented by records, i.e., from the 1st century BCE. Since most of the records on revenues relate to certain religious grants, it is hard to reconstruct the exact revenue structure. The most prominent character of the revenues is that, as with the irrigation elements, revenues were privately owned, and ownership could change by trading. Several inscriptions mention the administrative framework of the revenues such as revenue districts, agencies, and officers, but reconstructing functions and responsibilities is challenging since only the names are given in the inscriptions. For the 4th–10th century CE only a few references on revenues could be extracted from the sources. The insufficiency of published materials on the 4th–7th century CE could be one reason for this scarcity of information. For the 12th century CE the high number of records available on revenues ($n = 26$) is related to the abolishment of water tax and *chena* cultivation tax. Nonetheless, this increment of records is directly linked with the personal interests of King Nissamkamalla (reign: 1187–1196) and his large number of inscriptions.

According to the analyzed records, Buddhist temporalities played a key role in water management and governance in the *Rajarata* kingdom. Most records (50%) referred to numerous grants of irrigation and their incomes to Buddhist monastic entities. Gunawardana assumes there was a dual purpose behind these grants of irrigation to the temple authorities [3]. He suggests that these grants and subsequent developments turned the Buddhist monasteries into largely self-sufficient economic units so that they eventually became administrative and political centers [3]. Furthermore, Gunawardana assumes that the society was multi-centered with power devolving on the gentry and the monastic institution [3]. Comparably, Coningham suggests Anuradhapura was a theocratic landscape where monastic centers played a dual role in religious and secular administration, based on the grants of irrigation and in the absence of towns and lower-order administrative centers in the hinterland [31]. However, as revealed by the database records, it is hypothesized here that in the initial development stage of the water management and governance systems (1st century BCE to 3rd century CE) the temple authorities were only one layer of irrigation owners among other groups. In light of the spatial distribution and the purpose of the grants, it is hard to conclude that temple authorities were administrative centers (Figure 8). The spatial

distribution of the records on grants of irrigation evidently shows that the grants were mainly focused on Anuradhapura and its hinterland as the ancient capital and ritual center and did not display an area-wide pattern correlating with the present-day distribution of tanks (Figure 6a). According to an inscription located in the Nattukkanda archaeological reserve in the Anuradhapura district, two tanks owned by the monastery were mortgaged to a village council called *Atrajiva*, indicating the different layers of owners of irrigation in the 3rd century CE. Furthermore, the purpose of most of these grants was mentioned as religious (Figure 6b-iii). However, it is challenging to uncover the role of the monasteries during the following centuries due to the scarcity of records as the official publications on the inscriptions for the period of 4th–7th centuries are in preparation (friendly oral communication with Mr. Namal Kodithuwakku, Director–Epigraphy and Numismatics, Department of Archaeology, Colombo, August 2017).

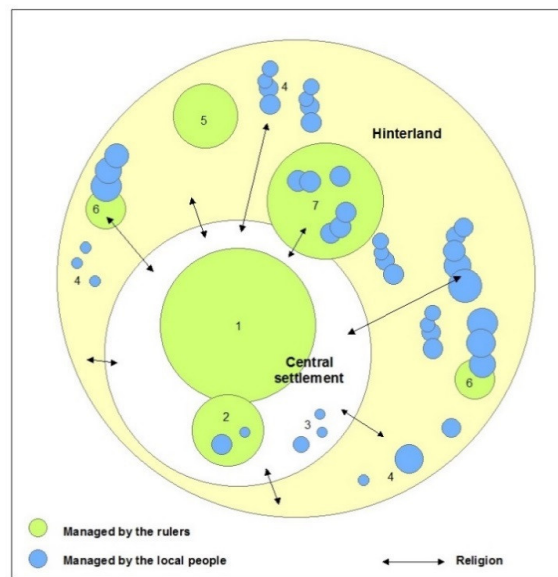


Figure 8. Ancient water management and governance in Anuradhapura. (1) Totally managed irrigation works by the central bureaucracy such as citadel and the major ring of irrigation (2) Local involvement within the central bureaucracy in irrigation management; agricultural landscape at the periphery of the main settlement. (3,4) Locally governed small tank systems within the main settlement and the hinterland. (5) Centrally managed major irrigation works in the hinterland. (6) Combined management by rulers and local people. (7) Locally managed small tank systems within the large-scale irrigation schemes covering wider regions; ex—the Kalawewa Jaya Ganga scheme covering a wider area and linking large tanks, canals and small tank cascades in the main settlement and hinterland.

4.3. Water Governance under British Colonial Influences

The spatio-temporal distribution of the records shows that the dry-zone water management and governance system evolved as a community-based local system and transformed into a centralized bureaucratic system over the centuries. After the 13th century CE, continuation of the historical records was interrupted by the abandonment of the dry-zone civilization [7,89], which was not reintroduced until the British Colonial Era [11]. Since the colonial rulers were initially predominantly interested in trade and commerce, they promoted coffee and tea plantations in the wet zone highland areas while customary paddy cultivation in the dry zone was neglected [46]. Later, due to several economic and political reasons, they attempted to recolonize the dry zone. According to Senevirathne, the primary need was to establish a rapid route network for the transportation of South Indian workers to the coffee plantations in the highlands via the North Central Province [77].

Since the historical records on water management completely cease after the 13th century CE little information is available on the functioning of the water management and governance systems from this time until the 19th century. In his manual on the North Central Province Ivers mentions that in 1899 nearly all villages were held under the rules of native laws and customs at the time the British arrived [25]. However, according to many writers, a system called *Rajakariya* or King's Labor, a communal compulsory labor system, was used to maintain the village irrigation works after the larger irrigation works were abandoned in the 13th century CE [6,46]. It is assumed that the governance system gradually shifted from a community-driven local system comprising different layers of ownership into a compulsory labor system due to continuous grants of irrigation to temple authorities. However, it is hard to prove this hypothesis because of the fragile temporal resolution of records in some centuries and the vacuum after the 13th century.

It is evident that in the initial stages of the British colonial period there was no concern about the traditional practices of water management and governance. For instance, after the "Uva Rebellion" in 1817, the colonial government decided to abolish the *Rajakariya* system, followed by the recommendation of the Colebrook-Cameron commission report in 1832 that resulted in the gradual destruction of the preserved small tanks which were under the management of village communities [47,48]. Furthermore, British reforms of traditional land tenure systems also affected Buddhist monastic involvement in the landscape and the water management and governance structures. For instance, under the *Temple Land Commission* (1856) and *Service Tenure Commission* (1870) land which was not cultivated as Service Tenure Villages (*Rajakariya* lands) was declared to be the property of the Crown. In the customary practice, entire villages including the tank, paddy and forest areas were the property of the Service Tenure Villages (*Viharagam, Devalagam, Nindagam*) [46] and this allowed the holistic management of the landscape under monastic ownership. This is made evident by several inscriptions referring to grants of tanks including pasture lands and the immediate surroundings of the tanks. In addition, the British government acquired all forestlands within the village boundaries that were used for *chena* cultivation in customary practice. Many inscriptions mentioned that *chena* cultivation was an accepted livelihood during historical times and that King Nissamkamalla abolished the taxes for *chena* cultivation in the 12th century CE.

At the beginning of British rule in Sri Lanka, village level administration of the small tanks was undertaken through a hereditary officer called *Gamarala*, a petty headman. Even though no direct evidence is available it is assumed that this position might have developed out of the title named "proprietor of the tanks" as mentioned in early inscriptions. In 1870 the British colonial powers attempted to give recognized authority to this position by introducing a headmen system called *Vel Vidane* under the Village Committee system. Maintenance of the village tanks and the proper functioning of the irrigation and cultivation areas was undertaken under the leadership of the *Vel Vidane* [46]. By the end of the 19th century, major irrigation works in the dry zone were maintained by the centralized Irrigation Department established in 1900 [48].

5. Conclusions

The spatial and temporal distribution of the historical records on water management and governance together with their qualitative information reflect the evolution of the water management and governance systems in the dry zone of Sri Lanka. Over the centuries, large-scale irrigation works were important to expand and develop dry-zone hydraulic civilization throughout the northern lowland plains and to enhance the livelihoods of the people by ensuring water availability throughout the year. In addition, the implementation of the water management and governance systems resulted even in ancient times in a strengthened economic situation due to a stable food supply. A centralized bureaucratic administration was set up for the management of these large-scale systems in the later part of the Middle Historic Period (3rd–13th century CE). As a result, when the central government disintegrated the main irrigation systems were largely abandoned.

In contrast, from the beginning of the Sri Lankan hydraulic civilization the vast multitude of small village tanks were developed and managed by local communities with less sophisticated skills. Due to the sustainable management structure setup within society, the small tank systems existed

intact for more than two millennia, even with the dry zone being abandoned during medieval times. Different layers of management strategies were implemented, blending centralized larger irrigation schemes with locally controlled small irrigation systems. Buddhist temporalities were used to link the hinterland with the main settlements, not in a secular administrative fashion but in a more spiritual and intangible relationship. Likewise, the ancient capital Anuradhapura and its hinterland display a unique example of a water management and governance system developed in harmony with a dual patronage between rulers and local people. This conclusion is partly contrary to Karl Wittfogel's hypothesis that state societies in Asia depended on the creation of large-scale irrigation works which required organized, forced labor and centralized bureaucratic management [92].

After nearly five centuries of abandonment, the water management and governance systems in the *Rajarata* kingdom were reused under the British colonial regime. However, the initial intention was based on political and economic reasons rather than to reactivate the traditional management mechanisms. British colonial rulers slightly changed the few main elements of the traditional system such as the compulsory labor system called *Rajakariya* and the Buddhist temporalities based on service land tenure. However, in the later stages British colonial rulers tried to adopt the community-based sustainable nature of the traditional governance structure as documented by the introduction of the *Vel Vidane* system for the small tank cascades. The dry-zone indigenous agricultural system of Sri Lanka was initiated in the heydays of ancient kingdoms and undergone several transformations for nearly two millennia. It is utmost important to critically analyzed the structural and socio-economics implications of the system to sustainable use of the water resource in future.

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