MONSOON ASSEMBLAGES

ELEMENTS OF THE URBAN HYDROLOGY OF SOUTH CHENNAI
Literature Review

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This review looks at the literature regarding the hydrology and the built up environment of South Chennai as well as the different types of knowledge shaped around them. It examines academic papers, books and book chapters originating in a wide variety of disciplines (eg. architecture, social sciences, geography, hydrology) as well as non-academic texts (eg. newspaper articles, official administrative body websites, NGO reports) and maps (eg. from official agencies, academic papers). It particularly attempts to understand how the different monsoonal cycles have been playing a role in shaping the hydrology and the built up environment as well as the different types of knowledge used to interpret them and act upon them, or else how these cycles failed to be effectively captured in the knowledge production.

Addressing these themes required to examine a very diverse literature, at times tackling very specific aspects of the issues at hand. A consistent attempt has been made to coherently extract those bits of information and build an overall picture of the area while laying out the context and identifying relevant issues for the Monsoon Assemblages research project. In spite of this, this review does not claim to be a complete investigation on the elements of the hydrology of South Chennai: the objective has been rather that of identifying which gaps, pertinent to the Monsoon Assemblages line of enquiry, will have to be filled as well as scoping the field for the overall research.

This literature review considers a study area in South Chennai roughly comprised between the overall bending shape of the Adyar River, limiting it to the North and the West, and the Bay of Bengal to the East. Its southern limit is proposed to be the Kovalam backwaters, a place marking the separation between two different marshy water systems: the Great Salt Lake to the South and the Pallikaranai Marsh to the North. This limits the field to an area stretching about 35 km south of central Chennai and encompassing the bulk of the urban dynamics connected to the development of the IT corridor and taking place around the Pallikaranai Marsh, which plays the key hydrological role. The only exception is the part of the review analysing the literature about the Chembarambakkam lake which, although situated outside of the defined field, still plays a central role in the water provision to the area and ultimately influences its dynamics.

In general terms the study area this literature review considers is mostly composed of a category of spaces referred to, by different researchers (eg. Arabindoo 2009; Dahiya 2003; Gajendran 2016), as "peri-urban": a definition attempting to capture their rapidly shifting physical, economic and social characteristics. This adds a layer of complexity to the interplay between city, water and knowledge and contributes to identifying relevant emerging themes in the current development of the city.

In order to break down such complexity, after a description of the main characteristics of the local hydrology and of the problems encountered in grasping its manifold aspects, the review identifies and looks at six families of interconnected elements: 1. the Buckingham Canal, the Okkium Maduvu and the low lying areas along them; 2. the *erys*; 3. the temple tanks; 4. the Chembarambakkam lake; 5. the Adyar river; 6. the Veerangal Odai and other storm water drains. The review is organised in a section for each of them which expounds their role in the hydrology, how each of them has had an influence on the development of the built up environment and how knowledge has been constructed around them.

The local hydrology

Many of the of the most comprehensive texts examined in this section have an origin in the raising interest in climate related urban disasters, in particular floods. The alleviation and prevention of the damages caused by these events play a big role in the texts and connect them to the overarching themes of "risk" and "vulnerability". The information available in these papers and reports has been confronted with official maps from relevant institutions dealing with watershed management, such as the Agricultural Engineering Department of Tamil Nadu (AED) or the Ministry of Agriculture of the Government of India and its Soil and Land Use Survey of India (SLUSI) in order to build a more complete picture of what is known about these areas. As a result, the delimitations of watersheds as drawn in the Macro-Watershed Atlas of India (Ministry of Agriculture, no date) have been found to be consistent with the scientific hydrological literature (eg. Bharadwaj et al., 2014; Vanaja & Mudgal, 2013) and have been used as the main term of reference.

Accuracy of geographical information is not always to be taken for granted. For instance, the delimitations of the water basins of the Chennai area produced by the Water Resource Organisation of the Public Works Department of the Government of Tamil Nadu (PWD, no date) show watershed borders different to those of the SLUSI atlas which appear to be less scientifically accurate and have been taken here as a less reliable term of reference. It is interesting to notice, that the difference between them is very substantial since the two maps show a big difference between the shape of the "Adyar watershed" (SLUSI Atlas map) –*excluding* almost all of South Chennai– and that of the "Adyar sub-basin" (PWD map) –*encompassing* the Pallikaranai Marsh and a big part South Chennai. The second map is shown in the report on the 2015 floods (Narasimhan et al, 2016) and is officially produced and used by the PWD, one of the main government agencies dealing with flood-related issues. This raises questions and requires further investigation on the origin and type of knowledge used in order to deal with urban planning and disaster management on the part of Tamil Nadu State agencies and the city of Chennai.

Anyway, due to the low-lying character of the landscape, it is likely that the division between the Adyar watershed and the rest of South Chennai does not necessarily impair run-off flowing across their borders in case of floods. The low gradient of the land might explain also why both previously mentioned maps do not necessarily overlap with those of the city's Drainage Catchment Areas map (Narasimhan et al, 2016 after CMDA), suggesting that man-made drainage infrastructure may at times ignore the way in which the water would naturally flow downstream.

Relative flatness plays indeed a major role in the spatial character of the city: Chennai lies at an average elevation of 6.7 mean from the mean sea level (Lavanya, 2012), and is characterised by the presence of alluvial soil and the local emergence of different rock formations - mainly charnockite, a granite-like stone (Packialakshmi et al, 2010). This notably marks the southern bank of the Adyar river and separates it from the next watershed, named Kovalam in the maps of the Agricultural Engineering Department of Tamil Nadu (AED, no date).

The Kovalam watershed, just like most of the rest of the territory of the city, is characterised by small inclinations and is divided into three different sub-watersheds or mini-watersheds (Mambakkam, Sengadu and Kazhanipakkam) (AED, no date). Out of these three, the Mambakkam sub-watershed encompasses the bulk of the Pallikaranai Marsh and of the ongoing peri-urban dynamics of change in land uses shaping contemporary South Chennai (Packialakshmi et al. 2010).

The Mambakkam sub-watershed and the other ones are in turn divided in multiple micro-sheds (Ministry of Agriculture, no date), lacking a typical tree shaped structure of river based watersheds. The abundance of subdivisions with no immediately apparent main drain is consistent a landscape characterised by a small gradient forming vast interconnected low lying areas, at slightly different heights. This configuration, seems to purport the idea that the general behaviour of this watershed would be naturally characterised by filling of low-lying areas with run-off water and the consequent waterlogging, evaporation, infiltration into the ground and slow flow into the sea. These characteristics are explained by the description of the stretch of coast between the Adyar and Palar as a palaeo-lagoon or palaeo-tidal-flats system, characterised by an ongoing and long term process of gradual formation of sand bars and filling of coastal brackish and freshwater bodies with sediments (Srinivasalu et al., 2007). The yearly changes in beach coastal sedimentation, which influence the functioning of this type of systems, have been associated with seasonal monsoonal cycle manifestations (Chauhan 1995).

In historical times, human intervention has altered the development of this spontaneous process and the Mambakkam subwatershed low-lying areas have now a constant presence of salt-water and a direct connection to the sea through the Adyar estuary and the Kovalam Creek. This seems to have happened in connection with the construction of the Buckingham Canal in colonial times, the more recent works concerning the Okkium Maduvu water body (which will be discussed in a specific section), as well as the efforts to keep the Kovalam Creek outlet to the sea open, opposing the tendencies of coastal sedimentation (Patnaik & Srihari, 2004).

Human modification of the landscape, in order to harvest rain water and control run-off, is a defining characteristic of the area and of the wider region, at state level and beyond. As a result, the local hydrology is composed of recurring elements which are often the result of a series of intricate actions imposing man-made structures on natural features; particularly in the case of the *ery* system (which will be discussed in a specific section). The defining aspects of these processes are more clearly traceable in non-urbanised contexts and for this reason, much information about the original functioning and behaviour of some of the elements of the hydrology can be understood looking at literature relating to rural settings (eg. Mukundan, 2005; Mosse 1997). On the other hand, the way in which these elements have changed and have been taking new roles when incorporated into urban settings is a relatively new process in South Chennai, and has been analysed looking at current academic production (eg. on changes in land uses) and at newspaper articles reporting on social processes and physical changes involving elements of the hydrology.

Each of the elements, or families of elements, are presented and discussed one by one in the remainder of the review, unpacking relevant aspects relating to the three categories of hydrology, built up environment and knowledge production.

The Buckingham Canal and the Okkium Maduvu

The way in which the Kovalam watershed hydrology, and the Mambakkam sub-watershed hydrology within it, act according to mere local conditions of topography and geology in ways that precede human presence and intervention, has been modified over time by the superimposition of several man-made structures. From the perspective of the overall study area, one of the main features which brought radical hydrological modifications has been the construction of the canal known today by the name of Buckingham. The canal, whose construction started in 1806, was meant as a navigation waterway to move goods along the coast, and particularly salt. Its construction was marked by a complex engineering and economic history: the canal was built in different moments along different sections and called different names as a result of a long and fragmented process of construction (Russell, 1898). In general terms, the canal has been laid out parallel to the coast stretching about 800 km, using natural depressions and connecting existing outlets to the sea and estuaries through the low-lying areas and wetlands characterising this part of the coast (Janakarajan et al, 2007).

In the study area, its design integrated many “local streams, backwaters, artificial and natural river channels” and measured an average width of 25 metres (Seenivasan, 2016). Furthermore, it envisaged a rather complex set of devices meant to control the level of the waters feeding it, coming from the Adyar estuary and the Kovalam Creek, as well as side bunds meant to separate it from the run-off water of the Kovalam watershed and from the flood-prone, low-lying areas it stretched across. By the end of the 19th century (Russell, 1898), within the study area, the canal had two systems of locks that controlled the inflow and outflow of water at the outlets to the sea, whose traces are still visible today (Narasimhan et al, 2016). Other mechanisms of water control were also present: three “flush escapes” and one “drop inlet” (Russell, 1898). Although there is no reference to these devices in more recent literature, they were likely to be used in order to let excess water flow out of the canal when needed, or to partially drain the canal for desilting and maintenance. Nevertheless, newspaper articles refer to the desilting of the canal as being carried out today using mechanical dredges (The Hindu Chennai editorial staff, 2011), hinting at the fact that those devices are not in use or have also fallen into disrepair, along with the locks.

All these engineering features originally made the canal a salt water one (Appasamy & Lundqvist, 1993; Murali, 1994) due to the pervious connection with the Adyar estuary and the Kovalam Creek, and to the control devices separating it from the hydrology of the Kovalam watershed. But despite these separations, once introduced, the waters of the Buckingham Canal started playing an increasingly relevant role in the hydrological system. For instance, the Buckingham Canal was dug between 10 to 12 metres below the average ground level, at a depth where the ground can bear potable water, while approximately below that level the water becomes brackish (Ganesan, 2008). The positioning of the canal parallel to the coast and at that depth, surely interacted with the ground water hydrology of the coastal low-lying areas.

But the canal had also other effects on the vaster hydrology. In the northern part of the Mambakkam sub-watershed, for instance, run-off is collected in the Pallikaranai Marsh and, through the water body known as the Okkium Maduvu, would flow into the low-lying areas where the Buckingham Canal was built. These are described as naturally prone to flooding, namely in the area of Semmencherri (Jothilakshmy & Malar, 2010), and historical maps (Survey Office of Madras, 1905) do not show clear or permanent outlets connecting them directly to the ocean, hinting at the variable nature of these low-lying areas and confirming the shifting character of the landscape of this trait of coast, in line with the nature of a palaeo-lagoon or a palaeo-tidal flats system. The construction of canal bunds cutting across them, led necessarily to an alteration of their crucial role in the hydrology and altered their capacity to accommodate run-off. The consequences of these alterations became increasingly evident as the canal fell in disrepair, its water control devices and bunds became non-functional or were altered, and the waterway became an integral element of the Kovalam watershed hydrology.

Particularly, as the Buckingham Canal stopped being used for navigation in 1954 (Gupta & Nair, 2011), it increasingly started playing a major role as a drainage infrastructure (Seenivasan, 2016), a role that extended to that of a “flood buffer” (Roumeau et al., 2015) and was observed in connection with a series of floods that hit the city in the years 1943, 1976, 1985, 1996, 1998, 2005, 2010 (Gupta & Nair, 2011), and more recently in 2015 (Narasimhan et al., 2016). This new role led to new challenges, such as, for instance, the presence of larger amounts of silt in its bed (Krishnakumari et al., 2016), , not foreseen inn tis original design. High level of pollution, which make the Buckingham Canal along with the Cooum river the “widely recognised” most polluted waterways in the city (Gupta & Nair, 2011), along with observations of anaerobic waters and of the presence of sewage, featured in the 2015 Flood Assessment Report (Narasimhan et al., 2016), indicate that the Buckingham Canal is currently used not just as a drain, but as part of the sewerage system, too (Steinbruch & Hörmann, 2015).

Although no official maps of the drainage system appear to be available, city officials have declared that a major producer of water discharge such as the Perungudi Sewage Treatment Plant discharges into the Buckingham Canal (Roumeau et al., 2015) confirming the crucial role of this waterway in the current city drainage system. This information, though, should be questioned, as other sources report the non-functionality of the treatment plant and report that it might be discharging directly into the Pallikaranai Marsh rather than in the Buckingham Canal (Patnaik & Srihari, 2004). Steinbruch & Hörmann (2015) attach further importance to the construction of that sewage treatment plant in 2006: they attribute to it a crucial role in discharging a continuous flow of water into the Pallikaranai Marsh converting its northern part into a perennial shallow water body feeding the already perennial water body Okkium Maduvu. The introduction of this inflow of water, in connection with the digging of a permanent connection between the Okkium Maduvu and the Buckingham Canal (which will be discussed later) have, according to these authors, switched the “surface flow” from a South-North to a North-South direction in an area roughly overlapping with the Mambakkam sub-watershed (Steinbruch & Hörmann, 2015).

Further modifications were brought to the canal when vast stretches of its path were earmarked for the development of the Chennai MRTS system, an urban elevated railway system conceived in the 1970s (Madras Area Transportation Study Unit 1973) and implemented starting from 1990s (Seenivasan, 2016). In the northern part of the study area the MRTS line is superimposed to the canal, with huge concrete pillars built in its bed: a choice made due to the public ownership of the canal, which circumvented the acquisition of private lands for the implementation of the project. As a result, in the affected areas the Buckingham Canal have been reduced in width from an original average 25 metres, to 10 metres, particularly where MRTS train stations have been built (Stephen, 2016). Not only, then, the Buckingham Canal was not meant to serve as a water drain or eventually as a sewer, but subsequent planning decisions connected with the MRTS project brought into play “legal encroachments” which hindered its role as a flood buffer, too (Jameson & Baud, 2015).

In spite of the active interest on the part of academics, activists and city official in the canal, its actual current role in the hydrology does not seem to be fully understood, both because of a lack of data and proper monitoring (Narasimhan et al., 2016) and because of the fragmentary fashion in which the canal is looked at, analysed and included into decision-making processes by the judiciary, different state agencies and local administrative bodies. The Madras High Court pronunciation in the case Exnora vs The Government of Tamil Nadu (2006), for instance, represents a crucial moment in which the demand on the part of an NGO for a more comprehensive understanding of the hydrology and the ecology of the area in order to inform effective and coherent planning, was overruled by circumstantial considerations on the larger public interest of the MRTS project, as well as by a narrow interpretation of the legal definition of “natural” water bodies, instead of considering the complex relationship between the city, the hydrology an the role of man-made infrastructure (Seenivasan, 2016).

But the most important modification of the Buckingham Canal which had large scale consequences on the hydrology at large, involving the Pallikaranai Marsh and especially the permanent water body known as Okkium Maduvu, is rather recent and even though it has previously been mentioned in relation with the construction of the Perungudi Sewage Treatment Plant (Steinbruch & Hörmann, 2015) needs further clarifications.

The Okkium Maduvu is the only permanent water body which is not an *ery* (see related section) within the study area and is already marked in the Survey Map of 1905 (Survey Office of Madras, 1905). Its curved and dendritic shape is consistent with that of a creek discharging excess water from the marsh and allowing tidal flows in it, a role supported by the description of its cyclical –*respiratory*– functioning made by Coelho and Raman, who describe it with the metaphor of an “aorta” or “pulmonary vein” (Coelho & Raman, 2013).

The interest in the Okkium Maduvu started making an appearance in the early 2000s, when a series of massive interventions were initiated on it. The Tamil Nadu Slum Clearance Board, in accordance with the Corporation of Chennai, decided to transform a vast stretch of it, along with a substantial chunk of wetlands along its course, into what was meant to become one of the biggest slum resettlement colonies in India: Kannagi Nagar. The entire operation happened by reclaiming the wetlands with landfills, altering the shape of the Okkium Maduvu main course and deepening it, and finally directly connecting it with the Buckingham Canal by breaching its bunds. All these measures were meant to possibly guarantee the safety of Kannagi Nagar in case of floods, compensating for the loss of wetlands it was built upon, while providing a more efficient drainage to the wider area (Housing and Land Rights Network, 2014). Coelho & Raman (2013) report that the very Okkium Maduvu had completely been transformed in such way, and permanently connected to the Buckingham Canal by the early 2000s.

Shortly after, and in connection with those interventions on the Okkium Maduvu, the 13.5 km long trait of the Buckingham Canal comprised between the Okkium Maduvu itself and the Kovalam Creek got widened. The widening was the result of engineering works financed under the Jawaharlal Nehru Urban Renewal Mission (JNNURM) and carried out around 2014 (Lakshmi, 2016) which enlarged the section of the canal to up to 100m in order to encompass the wetlands present on its two sides and turn them into parts of the canal. The enlargement was conducted by breaching regularly the bunds of the Buckingham Canal and deepening the wetlands along it. Although some of these breaches might have come into existence due to a lack of maintenance, this project conducted under JNNURM was the first intervention showing an active will to do away with the separation of the canal from the rest of the hydrology, and turn the connections between the Pallikaranai Marsh, the Okkium Maduvu, the coastal low-lying areas and the Buckingham canal into a single waterway as pervious and permanent as possible. All these works were carried out with the purpose of mitigating flood risk The Hindu Chennai editorial staff, 2010), in connection with the works at Kannagi Nagar and were meant to be further progressed by digging out a permanent connection between the Okkium Maduvu and the ocean, which was never realised. The improved efficiency in preventing or mitigating floods of the current configuration remains to be assessed.

The appearance of landfills emerge has one of the major elements both shaping the built up environment and modifying the hydrology. Three major landfills (the two main phases of the Kannagi Nagar resettlement colony and the so-called Secretariat Colony), have been described in detail in Coelho & Raman (2013), but many more are likely to be present even if not covered in the literature.

It is also important to notice the role attributed to the Buckingham as a storm water drain in semi-official documents, hinting at its role in the development of the physical form of the city: in a paper presented in a seminar organised by the Corporation of Chennai, the Buckingham Canal is said to drain 29% of the city's storm water (in Seenivasan, 2016). If this must be interpreted, as it is likely, that actual storm water piped connections have been laid out linking the road side drains to the canal, it is likely that the presence of the canal has significantly driven the spatial patterns of development of the city, providing a ready-made infrastructure.

At least two themes regarding how knowledge has been produced and used in order to capture the complex monsoonal hydrology in the study area and act on it. The first theme is the difference between the construction of the Buckingham Canal on one hand -taking advantage of the palaeo-lagoon configuration of the area and controlling its interferences with the watershed behaviour; and the enlargement of the Buckingham Canal on the other hand -an active attempt to modify the functioning of the hydrology in order to carry out land reclamation for purposes of public interest (eg. implementing an efficient drainage system). The second theme is the fragmentation of knowledge into piecemeal, sectorial approaches applied in planning decision-making and implementation processes, corresponding to a fragmentary and partial knowledge held by the institutions acting on the Buckingham Canal and the Okkium Maduvu themselves. This emerged in the process of construction of the Kannagi Nagar slum resettlement colony, initiated around the year 2000 by the Tamil Nadu Slum Clearance Board, not in accordance with the urban plan or to a city-wide hydrological map and financed by a set of diverse, circumstantial, non-coordinated programmes, such as the JNNURM and the Emergency Tsunami Reconstruction Project (ETRP) (Housing and Land Rights Network, 2014). These served emergency purposes and supported the clearance of the Buckingham Canal, rather than long term objectives and visions.

In this framework, the knowledge produced by NGOs, activists, academics, plays a vital role in order to overcome the fragmentation and understand how old and new major modifications to the local hydrology have been stacked onto each other, resulting in whole new configurations that bear major consequences. This type of knowledge is produced in several ways: in researches reconstructing the tortuous development of big urban transformations (Coeho & Raman, 2013), or city-wide development trends (Gajendran, 2016); in studies analysing the spatial and social results of localised changes in the social and physical fabric of the city (eg. Arabindoo, 2011), but also in fieldwork studies collecting primary data with the urban poor (Jothilakshmy & Malar, 2010; Housing and Land Rights Network, 2014; Gajendran, 2015). Particularly these populations, reasonably more exposed to flood risk or to the daily interactions between water and the city in their most visible manifestations, seem to be valuable informants in order to understand the how different monsoonal cycles shape the built up environment and clash with it, under the current modes of development.

The erys

Long before urbanisation revolutionised the landscape, the age old adaptation to monsoonal cycles led human populations in the area to manipulate it in order to harvest the seasonally and cyclically available rain water and use it for different purposes - with the bulk of it being employed for irrigation. This process has resulted in a carefully, collectively designed landscape of rain water and river run-off harvesting reservoirs, whose management has numerous deep cultural, symbolic and social implications (Mosse, 1997; Ludden, 1979): the *erys*.

Erys (alternatively spelled *yeris, eris* or *aeris*, or also called tanks or lakes in English) are artificial waterbodies, built taking advantage of natural depressions. They work with the natural gradient of the land, with one side open and shallow in order to collect run-off and the other one relatively deep and surrounded by a bund. The bund is normally pierced by sluices which distribute water to other *erys* and irrigate the landscape through a network of gravity-fed irrigation channels (Jameson & Baud, 2016). When they collect and distribute water from a diversion in a river (called *anicut*) *erys* are called system *erys*. When, despite being interconnected among themselves, they rely on rain water catchment areas to be filled, they are classified as non-system *erys*, which are a less common occurrence (Mukundan, 2000).

Erys have historically played a major role in irrigation and have, up to quite recently, supplied 1/3 of the water needed for agriculture “in areas with relatively low-rainfall, such as most parts of Karnataka, Andhra and Tamil Nadu” making them a defining characteristic of the whole region, (Mukundan, 2000) and originating several place names (Sudhakar 2016). They have been organised based on precise empirical knowledge of the land, as the devices needed to control them are articulated across vast stretches of territory. Most notably those are: sluices, placed at different levels to irrigate fields lying at different heights; weirs, meant to control overflows; percolation ponds, meant to manage excess water, support irrigation, collect silt; and the already mentioned irrigation canals (Mukundan, 2000). Many of these elements are still partially visible today in the urban landscape.

Due to their need to be fed by run-off water and distribute it to cultivable land, *erys* were laid out where the effort of building and maintaining one would pay off. For this reason, within the study area, they are found at a reasonable distance from the shoreline, so as to allow the presence of a sizeable command area. Lacking the Mambakkam sub-watershed the presence of a river, the *erys* in the study area are of the non-system type, making the very local geological conditions (the already mentioned presence of charnockite rock and alluvial soils) and more recently the degree of urbanisation, crucial in understanding their hydrological functioning and current conditions. As these *erys* got progressively incorporated into urbanised areas, they increasingly saw changes in the social context their management was based on, and in the land uses of their *ayacuts*, but also in their shape and size (eg. Saravanam & Vennila, 2015).

The decrease in the use of the *erys* for agricultural purposes, though, is not necessarily a direct consequence of urbanisation, and has been debated in rural contexts (Vaidyanathan, 1992) as possibly being linked to subsequent shocks and changes in social and economic conditions as well as in administrative set-ups over a very long period of time (Mosse, 1999); or as been attributed to their lower economic profitability compared to other forms of irrigation, namely wells (Sakurai & Palanisami, 2001). The decrease in the irrigation uses of *erys* is of course naturally led to that of non-irrigation uses of *erys* (eg. the collection of silt to use as fertiliser), worsening their state of maintenance and performance in collecting and retaining water. These non-irrigation uses according to Palaniswami et al. (2011) are in principle still capable of generating enough revenue as to pay for the expenses of operating and managing them, something that might have interesting implications in urban settings, too.

Erys' past uses, even if to a vast extent organised the morphology of the territory, have dramatically decreased in the study area and these water bodies are today in the process of acquiring new roles in Chennai's hydrology. This comes with shifts in the knowledge built around them. *Erys* are today, in fact, often made the object of activist actions and academic studies which aim at finding new hydrological and social roles for them, consonant with their urban setting. These enquiries vary considerably in scope: they investigate the *erys*' possible contribution to an effective flood management strategy and advocate for their integration in the city storm water drainage system (Jameson & Baud, 2016); they analyse the interaction between *ayacuts'* hydrology and new land uses or encroachments and build experimental case studies around the introduction of local supply-chains of potable groundwater (Saravanam & Vennila, 2015); they look at their decrease in size as a concause of worsening flood hazard (Suriya & Mudgal, 2012); or they highlight the specific break with the past and the abrupt loss of local knowledge connected with their management brought in by urbanisation in the territory in and around Chennai (Arabindoo, 2011).

Some of the urban *erys* appear recurrently in the in the local news, in connection with their perceived lack of maintenance, excess of silt, pollution, presence of encroachments etc. (eg. for the Velachery lake, Oppili & Lakshmi, 2013). In very few cases, where urbanisation is less pervasive, it is possible to find reference of the channels connecting them and trace them. The Raj Bhavan channel connecting the *erys* of the Guindy park and the Velachery lake, for example, is referred to as one of those which have been managed with a view to prevent dumping of garbage and in virtue of its jurisdiction under the Water Resource Organisation of the Public Works Department (Lopez, 2014). This exemplifies how, when *ery* channels are indeed maintained, they are included in policies that do not necessarily consider them as part of a comprehensive system, across bureaucratic and management boundaries.

Erys, besides being elements in the local hydrology, rely or used to rely on complex institutional set-ups managing water a vital resource for the community, which required a complex understanding of climate, hydrological and topographical conditions and, in short, required the production of highly specialised knowledge held and produced locally (Ariza et al., 2007; Mosse, 1997, 1999; Ludden 1979; Vaidyanathan, 1992). Communities have constantly made estimates of the water available in the *ery* based on their best knowledge of monsoonal cycles. Such estimates were used to make sure that the most efficient use of available water would be ensured and that water could eventually last for a period of one year or more. “Folk knowledge” is referred to in Mukundan (2000) as able to predict rainfall quantities reasonably in advance depending on the observation of –unspecified– natural phenomena, preparing farmers for shortage in rainfalls. Traditional crop systems used in the *ayacuts* were finely tuned to monsoon cycles, too, and contrarily to farming system based on the Green Revolution paradigm, made careful use of the available water, making “optimal adjustments” to its availability (Mukundan, 2000).

This refinement of the knowledge system built around *erys*, though, has been significantly put in a critical perspective by Mosse (1997; 1999), who pointed at the influence of administrative bodies restructuring it in order to serve wider administrative and control purposes. Precise local knowledge of the irrigation and water availability patterns, as well of the conditions of and quality of the soil, although varied and dwindled over time due to a complex series of reasons, translated into rather precise classification of land uses matched by institutional set-ups at a local and supra-local level, which also went through processes of crisis and restructuring (Mosse 1997; 1999). Notably, the complex land use classification inherent to *ery* irrigation systems was eventually simplified under the British revenue system (Mosse, 1997), giving rise to the land use category of “wasteland” which ended up encompassing several previously existing more specific categories connected with pattern of irrigation, and flooding and to the monsoonal cycles (Basu, 2008; Singh, 2013; Vencatesan, 2006; Yanagisawa, 2008). This simplification is likely to have had profound impacts on contemporary patterns and modes of urbanisation on top of former *ayacuts*, as implied in some sources (eg. Saravanam & Vennila, 2015). These impacts are, for instance, connected to the often public ownership attributed to wastelands by the modern Indian legal system, and the scarce legal recognition attributed to customary rights which communities often enjoyed over them (Vencatesan, 2006).

The perception of the manifold functions of the *erys* and the knowledge production built around them are still today object of specific studies aimed at understanding *erys*’ role in contemporary rural communities in Tamil Nadu (Ariza et al., 2011; Kumarasamy, 2015), as these have been constantly reproducing, challenging and renegotiating social and institutional arrangements around these water bodies (Mosse, 1997). The decline of the *erys* is thus a complex phenomenon that is difficult to pin down, and raises interest, discussions and new forms of mobilisations and efforts to rethink their role in contemporary urban settings.

New types of activism are having an influence in the way *erys* are reappearing in the public discourse in Chennai, in ways that can be ascribed to the deployment of what Arabindoo has called hydro-politics (Arabindoo, 2011). In the case of the *erys*, hydro-politics manifest themselves in conflicts and actions around the use of these water bodies in the city. Groups of citizens, often of an upper-middle class extraction, lobby, protest and promote community actions, to push an agenda for the “environmental” recuperation of the *erys*, in connection with flood mitigation, ground water recharge and especially the provision of pleasant public and leisure spaces. These actions are meant to promote a stronger legal and administrative framework to control pollution, encroachment (illegal landfills or informal settlements) and often attract the attention of the local media (Srikanth, 2015; Kanthimathi, 2016). Nevertheless, these mobilisations seem to voice only partial aspirations and concerns in Chennai, failing to take into consideration the wider picture, both in terms of the social and economic context in which *erys* are placed (crucial for a real reinstatement of meaningful community management) and in terms of their new role in the urban hydrology. The situation is rendered even more complex by the often contradictory and fragmentary approaches of Tamil Nadu state agencies, which on one side are meant to oversee and promote the maintenance of many urban *erys*, and on the other have been promoting the construction of landfills that altered them and reduced their size, with no comprehensive plan balancing out the effects of the lost water collecting capacity (Packialakshmi et al., 2010).

The temple tanks

Temple tanks are generally square, artificial waterbodies found in the proximity of a temple and often clustered with it in a single spatial ensemble. They are surrounded by stone steps on all sides leading to the water, and vary between 2,000 to 30,000 sqm in surface (Ganesan, 2008). Even though it is not clear whether temple tanks always played a coherent role in the network of the irrigation system, early maps of colonial Madras (the former name of Chennai), show both temple tanks linked to secondary derivations of the irrigation system originating from *erys*, and temple tanks independent from that system (Ravenshaw, 1824). Both possibilities are consistent with the description of temple tank restorations made by Ganesan (2008) as facing problems both in terms of clearance of their catchment areas, and in terms of maintenance of the *channels* feeding them.

From the perspective of the hydrological system, these objects played multiple roles according to their configuration: either as rain-water harvesting devices for the immediately adjoining areas, or as elements contributing to managing excess irrigation water coming from the *erys,* with the various derivative functions of this main one, such as silt collection. These functions are in line with those described for percolation ponds (Mukundan 2000) and find confirmation in the role attributed to these water bodies in recharging surrounding water wells (Ganesan, 2008; Arabindoo, 2011; Ramesh, 2013; Vivek, 2016) and acting as flood control devices while crucially complementing the ecological system of the *erys* in rural Tamil Nadu (Ariza et al., 2007).

The temple tanks' connection with groundwater and water table levels is multiple: they interact with groundwater, not just by means of letting rain water percolate from the tanks into the ground, but also by providing an escape for excess groundwater soaking the soil, adaptively responding to different monsoonal conditions. At least one well is always present in the floor of each temple tank, a fact that seems to indicate that also the surfacing of groundwater, in determinate conditions, plays an important role in actually filling these water bodies, considering that piezometric levels in central Chennai after monsoonal rains can be 1 to 2 metres below ground level (Ganesan, 2008). For this reason, the desilting of temple tanks has been central in maintaining their efficiency in the past. On the other hand, Arabindoo (2011) proposes that the presence of wells, at least in some occasions, is the result of recent digging and new temple tank restoration initiatives, altering previous modes of interaction between these elements and groundwater. In either case -infiltration and percolation from the temple tank stepped walls or water surfacing from floor wells- desilting, cleaning and maintenance played a major role in the effective functioning and filling of temple tanks and the tasks relating to those activities were encompassed in the community life and religious rites taking place around temple tanks (Ganesan, 2008).

In general, temple tanks traditionally played a vital role in the activities of Tamil Nadu communities, and were connected to vital cultural aspects of everyday life and to the perception of time cycles, such as in the case of the town of Kancheepuram where seven tanks are, still today, associated with the seven days of the week (Ganesan, 2008). Although their role is today not as central as it used to be, they still play a significant role in the social and cultural life of communities. For instance, when religious festivals are organised, temple tanks are the settings of ceremonies, festivals, rituals, social gatherings etc. (Ganesan, 2008; Arabindoo, 2011).

While their role in the Hinduist religious worship would require a literature review of its own, several sources refer to temple tanks as being the object of the production of local knowledge, relevant for both the physical shaping of city as well as for the political development of its elites. For instance, Washbrook (1973) writing about the period between 1880 and 1930, mentions “temples committees” as one of the places where Madras elites, pushed out of the official administrative decision-making processes as the city grew, were able to find new spaces of political organisation - at times through shadowy practices of lobbying - and try and influence urban policies, there included those regarding water.

Today, temples, and especially temple tanks are still at the centre of political mobilisation. Middle class activists mobilise and lobby for their restoration, in similar ways as they do for the *erys*, both because they are seeking to find alternative means to secure local water supply through groundwater recharge, and to materialise their political aspirations by beautifying urban space: the hydro-politics invest temple tanks, too. Much of what has been said about *erys* is to a significant extent valid for temple tanks, too, and actually Arabindoo (2011) has focussed her account of the local aspects of hydro-politics precisely on the restoration of a temple tank, the perceived role that such an endeavour would have on water security for the local community, and its actual effects.

Restorations of temple tanks were driven both by concerns about their role in the hydrological equilibrium of groundwater levels and by concerns about their poor state of maintenance and they contributed to produce and reproduce a specific technical knowledge on the material culture embedded in temple tank construction and maintenance (Ganesan, 2008), and possibly to partially reinvent it.

Temple and temple tanks have a structuring role in defining the built up form, typology and concatenation of space in Tamil villages, having in most case a central position in the settlement (Ganesan, 2008) and a reportedly a central role in the organisation of Tamil cities (Singer, 1971). Due to the establishment of Chennai on a land which has a long history of human settlements, temples most likely played a role in shaping the growth of the Portuguese and British settlements. Indications of temple tanks and streets irradiating from them and structuring their surroundings are visible in maps from the and 19th centuries (eg. Ravenshaw, 1824). This overlap between the past traces of rural settlement influencing the shape of the city are consistent with the accounts that describe Chennai as a “rural metropolis” well into the 1970s (Vasanthakumaran et al., 2012). Work-in-progress academic literature (Srirangam & Forsyth, 2012) seems to support this idea, by proposing a taxonomy of the urban morphologies of temple clusters, looking at the relative positions of temple precincts, temple tanks and streets. These compositions of urban materials seem to have a direct influence not just on how neighbourhoods are spatially organised, but also on how social activities take place in the streets, and particularly on how commerce is present in certain places and not others. On the other hand, despite their role in structuring its form, urbanisation seems to have an adverse effect on the hydrological role of temple tanks and its blamed for the loss of temple tanks’ capacity in terms of catching and maintaining water (Ganesan, 2008).

Finally, the very architectural design of tanks reflects the uses of the water held in the tank, such as the recurrent presence of a landing every ten steps (Ganesan, 2008), which might have been used to more comfortably access the resource as well as providing strength to the overall structure. These uses might have played a central role in structuring social activities in the city as it was growing and shifting from rural uses to urban ones.

The Chembarambakkam lake

The Chembarambakkam lake does fall within the study area, but has been included among the elements studied in this literature review due to its role in in the piped water supply to vast parts of South Chennai, which end up being drained by the Kovalam watershed. Nevertheless, excess water discharge from this water body cannot be considered to have played a role in the 2015 floods in the study area (Narasimhan et al., 2016), despite the connection drawn by some of the media (eg. The Hindu editorial staff, 2016).

Chembarambakkam is one of the large *erys* which are found in the western part of Chennai urban area. This series of bigger *erys* is located in an area parallel to the coast between 12 and 30 km from the shoreline, and comprise Poondi, Puzhal, Cholavaram lakes among others. Most of them are have specific ecologic characteristic and are listed as Ecological Heritage Sites (Sudhakar, 2016). Their unusual dimensions could be explained with specific geological characteristics of the landscape where these water bodies sit. The Puzhal lake, for instance, sits on a localised formation of laterite and bauxite, part of a larger presence of lateritic formations in the eastern coast of Tamil Nadu (Achyuthan, 1996), from which it probably takes its English name of Red Hills lake. The Chembarambakkam lake, instead, occupies the eastern most area of an extensive formation of plutonic rocks (Suriya, 2014). It is possible that this specificity, besides the local topographic conditions, have had an influence in the viability of constructing a considerably bigger *ery* specifically in this area, which in the case of Chembarambakkam potentially irrigate an *ayacut* of 5,452 ha (Sivaraman, 2005).

Chennai, as un urban settlement, is not alone in its pairing with large *erys.* It is interesting to notice that other urban settlements in the northern coastal area of Tamil Nadu share a similar relationship with comparable bodies of water, likely securing water provision or large scale agricultural production: Puducherry is located downstream of the Osudu lake, while Chidambaram is located downstream of the Veeranam lake. And indeed, large *erys* in the case of Chennai have played a fundamental role in the urbanisation of city: Puzhal lake was included in the urban water supply system in 1870 (Janakarajan, 2009), while other water bodies followed suit over a longer period of time and play today a vital role in supplying water to the city (Krishnakumari et al. 2016). The Chembarambakkam lake was acquired by Metrowater (the Tamil Nadu agency for water supply and services in Chennai) for this purpose after urban land uses took over its *ayacut*, making its use for agricultural purposes inefficient. This process happened gradually and was completed by the year 2000 (Srinivasan, 2015) when it became officially incorporated into the water supply sources of the city (Coelho & Kumar Reddy, 2004).

In order to respond to the new demand of water for urban uses, Chembarambakkam had to undergo different alterations and had to have its whole functioning redesigned so as to artificially keep its water levels as constant as possible and guarantee a reliable supply of water. The Telugu Ganga infrastructural project, first approved in 1977 and completed around the mid-1990s (Sampathkumar, 2005) was meant to enhance supplies by diverting towards the city, and partially into the Chembarambakkam lake, parts of the water of the Krishna river in Andhra Pradesh. The project was conceived in order to include most of the abovementioned large *erys* West of central Chennai, with the purpose of both storing water and distributing it to the different areas of the city. It first reached Poondi lake, and from there distributed water to Puzhal lake, first, and to Chembarambakkam lake afterwards. In order to fulfil this new role as a city reservoir, the physical infrastructure of the Chembarambakkam was modified so as to increase its capacity: its full reservoir levels were brought up by two feet (Sampathkumar, 2005) by restructuring the bund of the lake so that it could contain up to 103.2 million cubic metres of water (Coelho & Kumar Reddy, 2004). This modification in the regime of water intake, drawn to Chennai from very far away, has led to fundamental changes in the previous functioning of the lake, for instance bringing modifications to the cycles of expansion and contraction of the volume of water previously exclusively tuned to local manifestations of the monsoonal cycles. In the course of these alterations, specific physical devices were added to the lake, such as a weir and canal meant to control its excess water and discharging into the Adyar, upstream of the airport, possibly modifying a pre-existing weir or other elements of the bund in the 1990s, in order to manage bigger quantity of waters (Lakshmi, 2015).

A consistent amount of the water coming from Chembarambakkam lake is distributed to households placed within the limits of the Kovalam watershed as shown in the official map of the city's water piped infrastructure and distribution (Metrowater, no date). Although no reliable and complete information is available on the paths this water takes once is flushed away or discharged from the households, different sources refer that, at least partially, it might end up in different waterbodies within the Kovalam watershed, such as the Buckingham Canal, the Pallikaranai marsh (Steinbruch & Hörmann, 2015) or the Velacherry ery, where sewage and water discharges have been observed (Manikandan, 2012).

The Chembarambakkam lake cannot be said to have had a direct influence on the shape of the built up environment within the study area, but certainly it was both influenced by and had an influence on some of the recent trends connected to the urban growth of Chennai. While urban land uses on the Chembarambakkam *ayacut* are mentioned as one of the reason for its acquisition by the state-owned water supply company Metrowater (Srinivasan, 2015), it is possible that the great urban development experienced in the northern areas of the Kovalam watershed received propulsion, starting in the early 1990s, in connection with the infrastructural works on the Chembarambakkam lake. These opened the prospect of a reliable piped water supply in the southern part of the city, which was eventually brought about with the construction of different water distribution stations, such as the Velachery one, commissioned in 1994 (Pratheeba, 2011).

Modifications of both the Chembarambakkam lake and the land uses on its *ayacut*, as well the shifting objectives behind its management explain how over time the types of knowledge used to harness, control and use its waters gradually shifted from those discussed for *erys*, to others concerned with constant water supply to the city and flood hazard mitigation. These shift is discussed by Arabindoo (2017) in relation to floods and can be traced back to as far as the 1970s, when decisions regarding the water at Chembarambakkam started to be taken according to different criteria from those which the tank was originally meant to obey to. Engineering knowledge conceived for the management of water supply reservoirs, meant to retain water as much as possible are now applied to an *ery*: a physical infrastructure built for cyclical retention and irrigation following monsoonal climatic conditions.

The Adyar river

The Adyar river has received a great deal of attention in the literature, in connection with the behaviour and evolution of land uses on its watershed (Ramesh, 2013; Janakarajan et al., 2007; Vanaja & Mudgal, 2013) and its relation with urbanisation processes (Suriya & Mudgal, 2012; Bharadwaj et al., 2014), and, as one of the main waterways in the city, it was also a central object of analysis in the assessment of 2015 floods (Narasimhan et al., 2016).

The Adyar river is one of the two main fresh waterways that run through central Chennai and, much like the similar Cooum river to the North, is alimented by the run-off of "tanks and small lakes" upstream (Murali, 1994). Its course is substantially defined by the presence of Charnockite rock formations on its South bank which, along with the small gradient, contribute to define its lower course. The Adyar has its source in a group of *erys* in the Kancheepuram district, and catches surplus from about 450 more along its path (Gupta & Nair, 2011; Narasimhan etal., 2016). Even though the Chembarambakkam lake would not naturally belong to the Adyar watershed according to official data (SLUSI, no date), the presence of a weir and of a canal for the control excess water make a substantial amount of its waters discharge into the Adyar river, so much so that the lake is now considered one of its main sources of water, and hydrological studies include it in its watershed (Bharadwaj et al., 2014). The Chembarambakkam lake is credited for making the presence of – slowly– flowing water in the Adyar river constant, a phenomenon that was already described in the mid-1990s (Murali, 1994) and its role in the floods of the Adyar watershed is universally recognised (Arabindoo 2017; Narasimhan et al., 2016)

The Adyar mostly passes through alluvial soil, presumably carrying in its current, especially during monsoonal rains, substantial amounts of sediment, a fact that seems to be supported by the references to the Adyar estuary as a mutable landscape, characterised by the formation of sand bars at the opening towards the sea. These sand bars are reported as a cause of concern (Suriya & Mudgal, 2012) and in need of constant breaching in order to keep waters freely flowing from the river into the ocean (eg Hemalathai 2011). The estuarine nature of the Adyar's outlet to the sea is confirmed by the changing shoreline noticeable in relatively recent historical maps, where the river mouth is marked one kilometre north of its current position (Johnston at al., 1894; Bartholomew & Bartholomew, 1893), still characterised by sand bars and islands forming in the proximity of its mouth. Further sources refer to the reintroduction of mangroves, as part of ecological restoration efforts of some of its meanders – namely the one around Quibble Island – which may infer the past presence of this type of ecosystem in its estuary (The Hindu editorial staff 2013).

The ways in which restoration or eco-restoration projects are carried out, and their implications in the political arena of Chennai, is the object of severe scrutiny on the part of researchers (eg. Coelho & Raman, 2010, 2013; Arabindoo, 2011). Beautification schemes, either past or upcoming are a commitment of state agencies through the constitution of an *ad hoc* body: the Chennai River Restoration Trust, established in 2010 by the Tamil Nadu Government. This body has a power to design and intervene on the rivers and waterways within a specific mandate, which does not necessarily entail a comprehensive understanding of the wider economic, social or even hydrological dynamics of the urban territory (Adaikalam, 2010), or coordination with other bodies. The Tamil Nadu Slum Clearance Board or the Tamil Nadu Housing Board, for instance, have been using drainage channels, wetlands and river banks as location for slum resettlements and low-income housing provision (eg. Housing and Land Rights Network, 2014). Similarly, the proposal for new arterial road infrastructure by the Tamil Nadu Road Development Corporation chose the Adyar river banks to propose a new major road infrastructure, in no coordination with other programmes or planning initiatives concerning the river (Coelho & Raman, 2010). The fragmentary approach with which planning is conceived and infrastructural projects are carried out hinders a comprehensive understanding of the river's behaviour and its role in the hydrology of the city.

As a result, urban poor and informal settlements, due to their physical presence on the very river banks, are often blamed for encroaching it and making floods effects more severe, while wider causes are neglected. Slums are then brutally targeted with evictions and demolitions (Coelho & Raman, 2010), while formal planning allows developments featuring landfills and high rise apartments blocks which have similar, if not more dubious, impacts on flood hazard (Coelho & Raman, 2013). The debate about how to mitigate and combat floods, and the emergency discourse built around them, seem to have altered the way the rivers are conceptualised and discussed, even in hydrological terms. These, tend often to be seen as "macro drainages" and to be perceived as entities to be managed in order to evacuate excess water in case of floods, rather than complex urban water systems (Jameson & Baud, 2016) whose behaviour is connected with monsoonal cycles. But the approach to using knowledge to act on urban rivers seems to be endlessly contradictory and sectorial. When water scarcity, for instance, has been the object of policies, check dams have been built on the Adyar in order to recharge the water table. While this move is supported by studies about its effectivity in the wider area of Chennai hydrological, considerations on its appropriateness are apparently limited to groundwater behaviour (Renganayaki & Elango, 2013), overseeing possible detrimental effects on urban floods or interactions with urban impermeable surfaces.

Fragmentary and incomplete approaches, are possibly the result of very compartmentalised, bureaucratic management of planning, on the part of the State of Tamil Nadu and its agencies. Agendas seems to look at the issues at stake from singular, narrow perspectives, rather than in a comprehensive way. This is accompanied by a lack of investment in reliable data collection, necessary to build a complete picture: the 2015 Chennai floods assessment report (Narasimhan et al., 2016), for instance, refers to the lack of reliable gauging stations along the Adyar, and therefore to the lack of reliable data sets regarding the evolution of the floods.

On top of this, the city has evolved on the river developing complex and interacting spatial and social patterns. The banks of the Adyar have been for a long time, well into the 60s, a prime location for high-end residential developments and representative buildings (Murali, 1994). Longstanding high land-values and the presence of high end real estate locations are probably to be put in connection with the tendency on the part of the colonial elite to occupy the area around the Adyar with gardens and mansions since the early 19th (Basu, 1993) and still today, representative, symbolic buildings and historical mansions, such as the Chettinad House, the Madras Club or the Adyar Villa, can be found on the banks of the Adyar, even though other types of development have appeared over time, making today a much more mixed urban environment.

The banks of the Adyar were also used for the purposes of trade. According to Murali (1994) parcels of government land were conceded in lease to merchants, who used the river as a waterway to transport them up until the mid-20th century. Concomitantly with vaster processes of urbanisation investing Chennai from the 50s onwards, vacant spaces along river banks and other water bodies and beaches became the locations where informal settlements would grow. References to their presence along the Buckingham canal, the Adyar river and multiple drainage canals are recurrent (Seenivasan, 2016; Lavanya 2012; Gupta & Nair, 2011). More specifically, the river banks are one of the places where this phenomenon has been more thoroughly observed and discussed in the press, due to its perceived responsibility in the encroachment of the river and in its role in worsening the effects of 2015 floods or hindering preparedness (eg. The Hindu Chennai editorial staff 2013b; Coelho, 2016; Philipi, 2015; Sashwath, 2015).

The Veerangal Odai and other storm water drains

Finally, this literature review tackles the smallest elements composing the local hydrology: storm water drains (Public Works Department, State of Tamil Nadu 2016). This definition, for the purpose of this enquiry and within the study area, refers to surface channels which function as drains in the northern part of the Kovalam watershed, and have an origin in previously existing either natural drains and streams or excess water channels deriving from the *ery* system. In the study area, in particular, there are two main ones, the Veerangal Odai and the Velachery drain, and they play a major role in draining water from the northern part of the Mambakkam sub-watershed (Narasimhan et al., 2016).

In particular, the Veerangal Odai presence in the literature and coverage in the press, is here discussed as representative of the complex issues that invested storm water drains in the process of urbanisation and caused local scale modifications with major implications for the overall hydrology of the study area. These issues regard its physical design, its management and its property status.

The Veerangal Odai appears in satellite imagery, as late as the early 2000s (Digital Globe, 2002), as a freely meandering waterway discharging water from the Adambakkam *ery* and surrounding areas into the Pallikaranai Marsh and is characterised by such a small gradient, that its nature is, in some traits, that of a low-lying wetland integral to the Pallikaranai Marsh wider system. By 2016, its course had been regimented and rectified and partially built over (Stephen, 2016), transforming it into two concrete storm water drains along an urban infrastructural corridor composed of a rail line and a major six lane thoroughfare. The southernmost section of the Inner Ring Road infrastructure –part of the main infrastructural strategies meant to meet the growth needs of the city in recent years (Sekar & Kanchanamala 2011)– paired with an extension of the MRTS, had been built on top of it starting from 2008 (The Hindu editorial staff 2008).

As a consequence, the Veerangal Odai was reduced in width from about 150 metres in 2000 to less than 10, today (Digital Globe, 2000; 2016). This reduction, which made the wetlands along its course disappear and forced it between concrete walls, dramatically altered its speed, capacity and interaction with the geological layers, and caused it have an important role in the 2015 floods in the study area, along with Velachery drain which was invested by similar, although lesser, processes (Narasimhan, et al., 2016).

The reasons behind the planning choices regarding the Veerangal Odai are similar to those mentioned for building the MRTS on top of long stretches of the Buckingham Canal: free space and the possibility of circumventing private land acquisition for infrastructural projects. In fact, waterbodies, their adjoining areas as well as areas subject to flooding, be they connected to *erys,* channels, or part of wetlands and marshlands, as anticipated before are mostly classified as wastelands or *poromboke* (out of the revenue system) in Tamil Nadu (Vencatesan, 2006). This means that they are often characterised by poorly recognised community customary rights of use, by an official status as public property or under public trust protection, and by land uses easily subject to change for reasons of general interest and subject to acquisition through Eminent Domain (Singh, 2013).

The coming together of these spatial and legal aspects made the Veerangal Odai a hydrological element ending up dictating the spatial development of the city: it got completely overwritten by infrastructural projects driven by *ad hoc* policies and planning decisions. Around it, complex issues were embodied in spatially very clear manifestations making it an exemplary case, of processes present already elsewhere, and similar for instance to those described for the Buckingham Canal and the Adyar River in previous sections

Along with alterations which changed its hydrological functioning at the scale of the city, other localised processes invested the uses of this drain, as well as the ways in which it is looked at and conceived. The Veerangal Odai is listed as a macro storm water drain in official designations (CMDA, 2010) serving an adjoining, increasingly impermeable, residential areas, as reported in the press (The Hindu editorial staff 2002). Allegations of its illegal use for discharging grey and waste waters are referred in connection with the activism of local groups protesting pollution, poor state of maintenance or misuse of public funds meant to maintain or improve the drain (The Hindu editorial staff 2003; The Hindu editorial staff 2016b). The Veerangal Odai is also involved in another social and political process: the political patronage of local leaders in informally deciding and approving illegal uses of the waterways, there included the construction of permanent structures on top of it (The Hindu editorial staff, 2002). These type of dynamics possibly superimpose on the knowledge of the local hydrology a further layer: that of the geography of political corruption and allegiances which influence the way the hydrology is locally interpreted and engaged with. At a larger scale this should be taken into consideration while further investigating other waterbodies, too.

Sectorial engineering knowledge, compartmentalised infrastructural projects and the lack of an urban planning framework to coordinate them, might have had, as in the other cases highlighted, a severe influence on its hydrological role, superimposing different types of contradicting knowledge, inspired by different objectives. The Veerangal Odai is such a clear case of this occurrence that is one of the few waterbodies that have directly been object of policy oriented studies meant to revise private-public partnership in infrastructure construction, as well reforming participation policies (Santha, 2010). Its current state is also mentioned as a clear example which should make policy-makers reconsider the classification of floods in Chennai re-categorising them from natural to man-made disasters (Stephen, 2016).

Conclusion

This literature review has attempted to disentangle some of the processes investing the built up environment and the hydrology of contemporary South Chennai. It did so by focussing on the single elements that compose the complex local hydrology, which is the result of a longstanding and complex superimposition of man-made structures and the action of meteorological and geological elements. In it, precise borders between human and more-than-human agency are, at times, difficult to pin down and discrepancies and gaps in the information available on these elements, especially as the basis for the construction of "official" knowledge, have been pointed, offering insights for further research.

The role of monsoonal cycles, with their different temporal dimensions, has been brought into the picture in order to understand how they influence several processes: the geological formation of the coastal landscape and its evolution, the modifications of the landscape in order to retain rain water, the recurrence of climate related urban disasters of which they are a concause. All these processes are in turn entangled with the political dynamics of power responsible for the policies shaping the city.

Knowledge shaped around these elements has been accounted for from a critical perspective in order to avoid simplified views on long lost traditional understanding of monsoonal cycles and "nature". But the fragmentary and partial approach with which hydrological elements are understood, interpreted and dealt with in the planning of the city are equally outlined.

Having as an objective the identification of gaps in what is currently researched, this literature review has aimed at giving directions on how to foster new, relevant knowledge on these issues, particularly pointing at how knowledge production and intervention on the hydrology might benefit from comprehensive, integrated understanding of the issues at stake, better integrating locally held knowledge and critical academic production in order to inspire design driven proposals.

Some overarching research questions are here formulated, and articulated in further sub-questions:

To what extent, and in which ways, are the key actors in the administration of the state of Tamil Nadu and of the city of Chennai making decisions on infrastructure and planning, failing to take into consideration monsoonal cycles as complex, multi-scalar phenomena? To which extent are they missing information regarding the local interaction between hydrology, urban forms and locally held knowledge, which could help them make informed decisions?

-Who are the persons taking these decisions, and what is their understanding of the monsoonal cycles? Are these considered or are they substituted by more reductive models based on few variables, such as excess of rain and drought disconnected from one another? Is this gap in the knowledge observable in design and graphic output deriving from the decision making process (plans, planning permits, thematic plans, etc.)?

Is it possible to bridge the current gaps in knowledge about the monsoon cycles, emerging from the literature review, by integrating 'officially held', institutional knowledge with knowledge held locally and produced around local interactions between hydrology, climate and urban forms?

-Which actors and communities have a local, day-to-day understanding of the local hydrology and its interplay with monsoonal cycles, in which way do they produced knowledge that can be used? Can this possibly inform designs? Which of these actors produce knowledge that has not already been tapped into and that is relevant?

-In which ways is design able to take different types of knowledge produced around the monsoonal cycles in the cities, and use them as instruments in order to speculatively reshape how urban and hydrological elements are conceptualised in relation to the monsoon cycles?

In which ways are design explorations capable of putting forward scenarios in order to re-tune elements of the city and the hydrology to the monsoonal cycles? How can these be tested? How can design explorations be used to extract new knowledge in order to mediate, integrate and enhance the ones currently held and used?

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