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KAZHUVELI WETLAND

(TAMIL NADU, SOUTH INDIA)

By R. Mathevet, N. Balachandran, M. Anbarashan,
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Cover photo: Kazhuveli wetland, January 2018 © Mathevet R. – IFP

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Foundation for Ecological Research, Advocacy and Learning: Dr Bhalla R.S. and the FERAL team (resource use surveys and mapping, Prosopis juliflora status assessment).

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Tamil Nadu Forest Department
Villupuram Forest Division

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This project was affected by the pandemic in 2020 and 2021. Our thoughts are with our friends and colleagues who have passed away or whose families were bereaved.

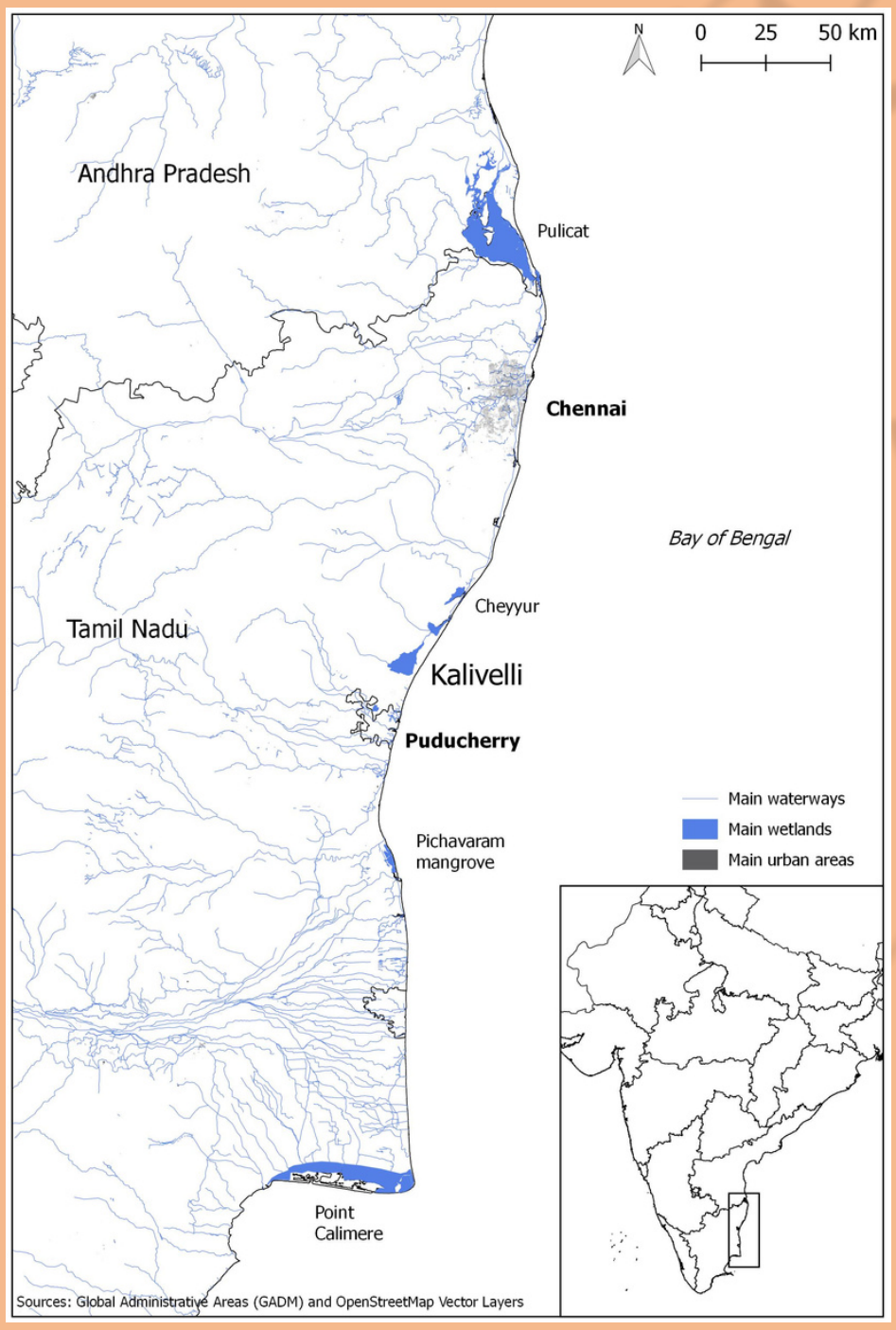
INTRODUCTION

With constantly fluctuating water levels, wetlands are recognised as important areas for many species of flora and fauna. They also support human communities around the world. However, wetlands are under severe pressure all over the world. The average long-term rate of wetland loss is between 54% and 57%, with a 3.7-fold increase in the 20th and 21st centuries. 64%-71% of wetlands have been lost since 1900 AD. The main threats to wetlands in India are encroachment, siltation, aquaculture development, pollution and river control.

The Kazhuveli wetland is a vast swamp where buffaloes graze. It is also home to jackals and a variety of waterfowl. Its only boundary is the horizon, which alternates between sky, water and land.

Kazhuveli Wetland is a brackish water wetland surrounding a shallow lake located on the Coromandel coast, 18 km north of Pondicherry, in the state of Tamil Nadu in southern India. Kalivelli Lake is connected to the Bay of Bengal by the brackish Uppukalli creek and the Edayanthittu estuary. The wetland receives its freshwater directly from monsoon rains and run-off from its catchment area, which consists mainly of cultivated land and around 230 reservoirs linked by a complex network of drainage and irrigation systems. Although it has been identified as one of the most important wetlands in southern India, the Kazhuveli wetland remains largely understudied and its ecological dynamics has yet to be characterised.

Every year, this wetland provides abundant resources (fresh water, grass, reeds, fish, soil, worms, wood, salt) for tens of thousands of people living on its margins. As well as providing a valuable source of income and livelihood, Kazhuveli wetland is also a sanctuary for wildlife. A growing number of ornithologists and naturalists come here to admire the magnificent spectacle of unspoilt nature, still wild despite the encroachment of agriculture, shrimp farms, tourist resorts, road infrastructures and rapidly expanding towns.



Location map of Kazhuveli wetland, among the most important wetlands and lakes of the Coromandel Coast © Desmots E. and Mathevet R. – IFP

A wild place

Looking at the endless marshes and waterways that merge into the sky, it's a wild place. Many of the water birds that nest in India or in the northern hemisphere stop here to rest and feed on their way to the migratory routes. It is one of the largest wetlands in the south of the Indian subcontinent.

It is still wild because of two key natural elements. Water inundates the land for months, but is often scarce for plants and animals. During the long dry season, the land cracks and creaks. Salt is everywhere, but when it crystallizes on the surface, plants get burnt. These two alternating elements may be enough to sum up Kazhuveli. During the dry season the water evaporates intensely, the water bodies dry up, often completely, and salt often comes to the surface from the salty underground water table. During the monsoon, rainfall desalinates the area. However, the intensity and duration of the monsoon is often unpredictable. It can rain for days, weeks or sometimes very little.

It is also wild because of its unfriendly nature. Until a few decades ago, this wetland offered few sites for human settlement that were not precarious. Monsoon floods have destroyed or limited cultivation on its edges, despite the fertilizing effect of the silt from the catchment area. On the other hand, the sea has made incursions and the omnipresent salt prevented any cultivation. As a result of this instability, Kazhuveli wetland has long remained on the fringes of major land schemes designed to support the development of human activity.

But...

To gain arable land at the expense of wet depressions, small canals and dikes were built locally to drain and control the inflow and outflow of fresh water. High levels of evaporation dried out the wetlands, but the immediate consequence was rising salinity levels, which damaged crops. By irrigating fields with water from tanks or wells, rice farming was able to counteract this trend. An anti-saline dam was built downstream of Lake Kalivelli to limit the upwelling of salt water. And although Kazhuveli wetland is not as wild as it once was, this marshland is still particularly rich in biodiversity. What has changed, however, is that the landscape and biodiversity are undergoing significant transformations. Salt pans have been created for the production of food and industrial salt ; there are plans to create a large fishing port at its estuary ; shrimp farms have been established along the creek altering salinity, nutrient levels and antibiotic pollution ; canals and ditches have been created around its periphery to control livestock encroachment ; basins and islands have been created and planted with trees and shrubs to encourage the reproduction of tree-nesting birds ; mangroves and forests have been replanted ; human extractive activities have recently been restricted (fishing, grazing, reed harvesting, worm collecting) ; agriculture and aquaculture have been banned within the area and the site is now protected as a Bird Sanctuary. Some people and the authorities hope that with the construction of more dikes around its perimeter, it could soon be a large freshwater reservoir. These are all forms of land development and management that artificialize the environment and irreversibly disrupt the hydrobiological functioning of the wetland, while at the same time raising a number of issues of social and environmental justice for the users of its natural resources. Depending on their intensity, their use has had both positive and negative effects on the ecological dynamics of the wetland and its biodiversity.

A biodiversity hotspot under threat

Many authors have emphasized the importance of the Kazhuveli wetland as a feeding, resting and breeding, or wintering area for migratory birds of the Central Asian Flyway, especially for ducks, herons, storks, waders and the Spot-billed Pelican. For these reasons, the southern part of the wetland was declared Reserved Land in 2001, paving the way for the establishment of a Bird Sanctuary in December 2021.

Although Kazhuveli is an important wetland, it also appears to be a degraded wetland. The lake suffers from pollution, water depletion, invasion of alien species, landscape and land-use changes through development of hard infrastructure such as roads, ditches, embankments or ponds. Kazhuveli is an important but degraded site for biodiversity conservation. It is also a relatively unknown wetland. In this context, the main objective of our study was to assess the current status of the Kazhuveli wetland and its changes over the last decades by collecting data from multiple sources at different spatial scales. Our objectives were: (*i*) to map the land cover of the Kazhiveli wetland from satellite imagery; (*ii*) to provide a better understanding of the ongoing socio-environmental trajectory of the wetland; (*iii*) and to discuss land cover and land use changes with local stakeholders along with management recommendations to the authority in charge of establishing and managing the new Bird Sanctuary.

Below, we present the main findings of this AFD-funded work, which started in September 2017 and concluded in February 2021, in collaboration with experts from the IFP and two local NGOs (FERAL and UEF).

A family of Indian Spot-billed Duck in Kazhuveli © Gupta B. – UEF

THE WETLAND

Fimbristylis ferruginea in Kazhuveli wetland © Balachandran N. – IFP

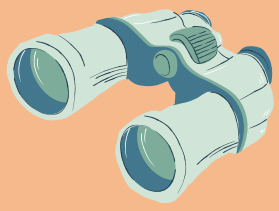
The Kazhuveli wetland is located North of Pondicherry region in the districts of Villupuram and Chengalpattu in Tamil Nadu State, along the Coromandel Coast. This coast is an open sandy coast subject to erosion. The climate of the region is semi-arid and tropical dry. The rainfall is characterised by its irregularity and uncertainty. With a rapidly growing human population, the situation is critical and the region faces water scarcity.

The Coromandel Coast is one of the oldest agricultural regions in India, with evidence of paddy cultivation since the third or fourth century, and the agricultural plain was created by deforestation of the original Tropical Dry Evergreen Forest (TDEF). Most of southern India has a long history of tank and canal irrigation, which declined with the Green Revolution and the development of groundwater irrigation. However, the tanks remain artificial wetlands that function as new biotopes and are part of the wetland diversity found on the Coromandel coast, enabling it to support a wide range of bird species despite its modification by human settlements and activities.

The catchment area of the Kazhuveli wetland extends over 750 km^2. Most of the study area is in Tindivanam taluk of Villupuram district, but the northern part is in Cheyyur taluk of Chengalpattu district. It receives an average rainfall of 1,200 mm, with 60% of the rainfall occurring during the northeast monsoon in October and December. The lake reportedly dries up completely during the dry season and receives water from its catchment area during the monsoon through natural or artificial channels. The average maximum temperature is 28°C in winter and 39°C in summer, and the humidity exceeds 60% for most of the year. The geological formations in Kazhuveli are mainly alluvial in the eastern part and charnockite in the western part. Twenty-two villages surround Lake Kalivelli (i.e. upstream of the check dam) with a total population of about 50,000.

The Kazhuveli wetland is made up of four geomorphologically distinct zones with specific, but ecologically and hydrologically linked landscapes. Lake Kalivelli is a freshwater lake surrounded by freshwater marshes and reed beds, mostly dominated by *Cyperaceae* members (*Scirpus sp*. and *Fimbristylis sp*.). The seasonal variation of the water level is important, and the floodplain of the lake can cover about 70 km^2. Kalivelli Lake is connected to the Bay of Bengal by a brackish creek called Uppukalli with a south-north stream. Just upstream of the estuary is a lagoon where salt has been harvested for centuries.

Lake Kalivelli is a shallow lake with an average depth of one metre during the monsoon and a maximum of two metres after heavy rainfall. A salinity gradient from north to south characterises the lake. During winter, the central sector is flooded with fresh to slightly brackish water, but as it dries out it becomes rather like a brackish lagoon. The central area is a shallow body of water of about 15-20 km^2 on silty ground. It is an open area with *Cyperus* beds (*Fimbristylis ferruginea*, *Fimbristylis sp.*, *Schoenoplectus* (*scirpus*) *articulatus*). On the banks, the main reed species identified were *Scirpus lateriflorus*, *Scirpus spp*, *Fimbristylis miliacea*, *Cyperus rotondus*, *Cyperus sp.*, *Aponogeton sp.* Most of the western shore is covered with *scirpus* beds (*Fimbristylis ferruginea* and *Fimbristylis sp.*) that can be flooded, while the western shore, on sandy soils, is a discontinuous grassland dominated by the halophyte *Cressa cretica*, with some spontaneous or subspontaneous trees (*Gmelina asiatica*, *Prosopis juliflora*). The lake is surrounded by a 500m-wide agricultural belt, which is flooded after heavy rainfall. Some of the lands are cultivated, while others are left fallow for grazing.



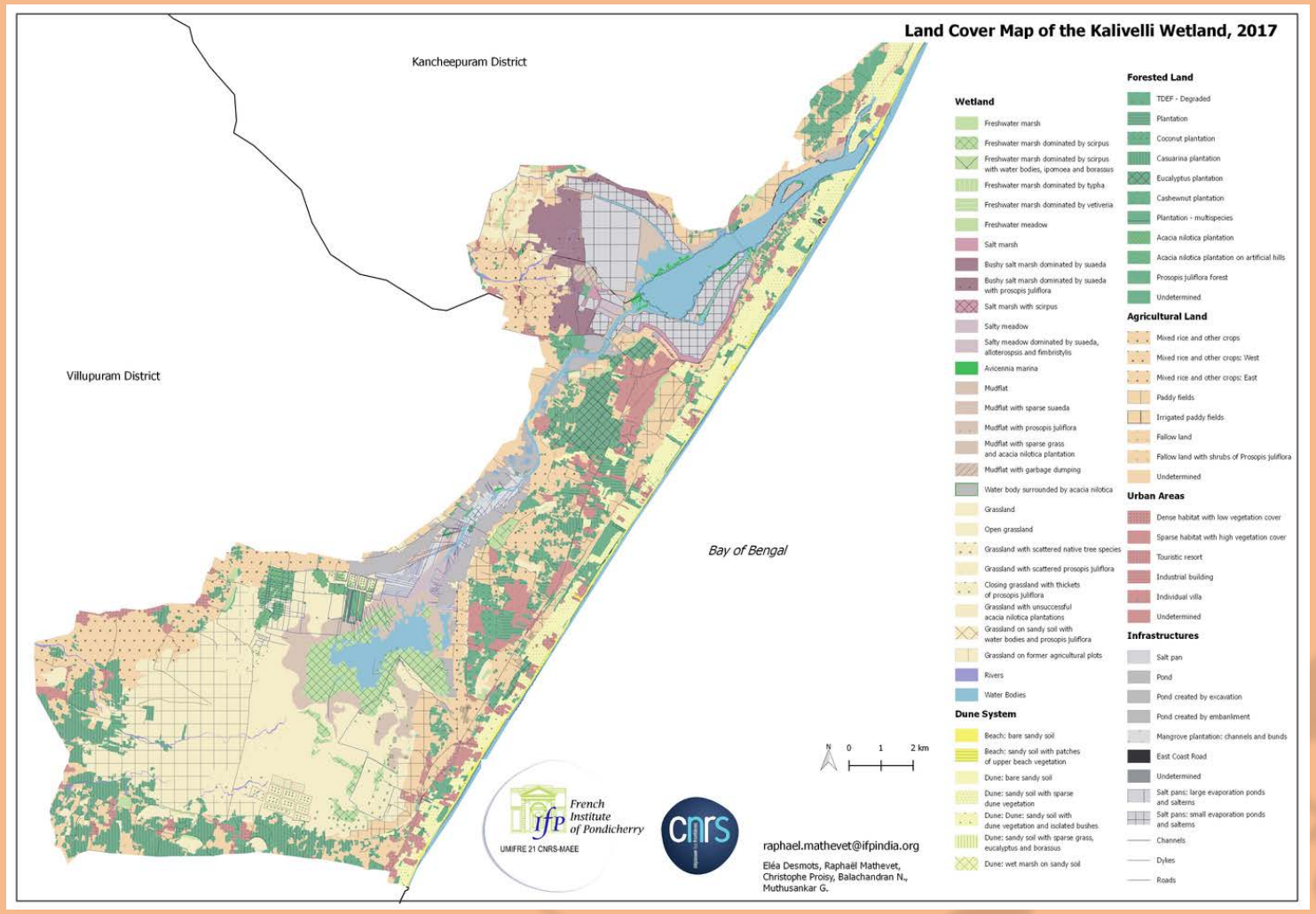
Name, origin and legends – There are several versions of a legend about the formation of the wetland. All are associated with the Shiva temple of Irumbai Mahakaleshwarar. Whether the place suffered from a rainless drought due to the severe penance of an ascetic, or as a result of his anger at the villagers' mockery of him for being disturbed by a female dancer, the creation of the place and the difficulties of its development are linked to ancient accounts. The low-lying area is said to have been called Kazhuveli in Tamil (after the ascetic Kazhuveli Sitthar or Kaduveli Siddhar), with the anglicised variant being Kalivelli. The term is also related to the word 'kaḻimukam', which refers to backwaters or estuaries. It seems that "kaḻi" means "to subtract, to drain" while "veli" can have two meanings: "wide-spread space" (veḻi) or "fence" (vēli). Thus "Kalivelli" is not a proper name, but a generic term referring to wetlands that can be found in other areas.

The area under investigation and its three main constituent parts © ED – IFP

Uppukalli Creek is a brackish, shallow body of water that connects Kalivelli Lake to the Bay of Bengal. This tidal creek is 8 km long. The banks of the creek were once cultivated with rice fields; most of them are now covered with aquaculture ponds or reforested mangroves.

The Yedayanthittu estuary is the mouth of the Uppukalli Creek, preceded by a lagoon system consisting of an area of tidal flats and salt pans, both traditional and industrial. The water is saline and patches of natural mangrove (*Avicennia marina*) can be observed. The estuary was formerly connected to Lake Pulicat (about 100 km north, near Chennai) by the former Buckingham Canal.

Between the wetland and the Bay of Bengal is an **area of dunes and agricultural land, with urban settlements and forest plantations**.


Land Cover Map of the Kalivelli Wetland, 2017
Kancheepuram District
Villupuram District
Bay of Bengal
N 0 1 2 km
Wetland
Freshwater marsh
Freshwater marsh dominated by scirpus
Freshwater marsh dominated by scirpus with water bodies, ipomoea and borassus
Freshwater marsh dominated by typha
Freshwater marsh dominated by vetiveria
Freshwater meadow
Salt marsh
Bushy salt marsh dominated by suaeda
Bushy salt marsh dominated by suaeda with prosopis juliflora
Salt marsh with scirpus
Salty meadow
Salty meadow dominated by suaeda, alloteropsis and fimbristylis
Avicennia marina
Mudflat
Mudflat with sparse suaeda
Mudflat with prosopis juliflora
Mudflat with sparse grass and acacia nilotica plantation
Mudflat with garbage dumping
Water body surrounded by acacia nilotica
Grassland
Open grassland
Grassland with scattered native tree species
Grassland with scattered prosopis juliflora
Closing grassland with thickets of prosopis juliflora
Grassland with unsuccessful acacia nilotica plantations
Grassland on sandy soil with water bodies and prosopis juliflora
Grassland on former agricultural plots
Rivers
Water Bodies
Dune System
Beach: bare sandy soil
Beach: sandy soil with patches of upper beach vegetation
Dune: bare sandy soil
Dune: sandy soil with sparse dune vegetation
Dune: Dune: sandy soil with dune vegetation and isolated bushes
Dune: sandy soil with sparse grass, eucalyptus and borassus
Dune: wet marsh on sandy soil
Forested Land
TDEF - Degraded
Plantation
Coconut plantation
Casuarina plantation
Eucalyptus plantation
Cashewnut plantation
Plantation - multispecies
Acacia nilotica plantation
Acacia nilotica plantation on artificial hills
Prosopis juliflora forest
Undetermined
Agricultural Land
Mixed rice and other crops
Mixed rice and other crops: West
Mixed rice and other crops: East
Paddy fields
Irrigated paddy fields
Fallow land
Fallow land with shrubs of Prosopis juliflora
Undetermined
Urban Areas
Dense habitat with low vegetation cover
Sparse habitat with high vegetation cover
Touristic resort
Industrial building
Individual villa
Undetermined
Infrastructures
Salt pan
Pond
Pond created by excavation
Pond created by embankment
Mangrove plantation: channels and bunds
East Coast Road
Undetermined
Salt pans: large evaporation ponds and salterns
Salt pans: small evaporation ponds and salterns
Channels
Dykes
Roads
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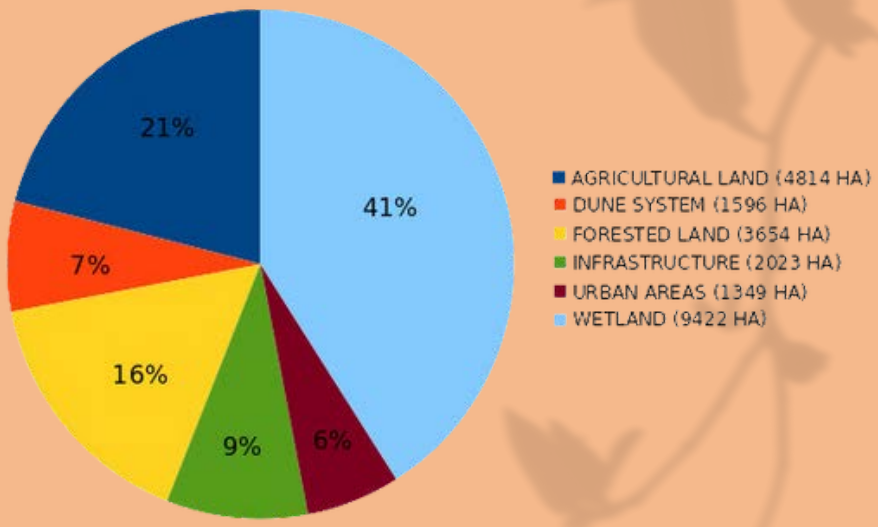
Eléa Desmots, Raphaël Mathevet, Christophe Proisy, Balachandran N., Muthusankar G.

Land cover of Kazhuveli study area in 2017



Within a study area of 22.8 km², a complex mosaic of wetlands, grasslands, freshwater and saltwater marshes and mudflats form the core wetland area, which accounts for approximately 41%, or 9.4 km², of the study area. Agricultural land and woodland each cover 21% of the study area and dunes cover 7%. Considering the 3.2 km² of rice fields as surrogate wetland habitats for waterbirds, amphibians and insects, the total wetland extent reaches about 55% of the study area (12.5 km²). Urban areas and infrastructure (roads, canals, embankments, etc.) cover 15%.


Freshwater marsh dominated by *scirpus*

Freshwater marsh dominated by *typha*

Salty meadow dominated by *suaeda*

Open grassland

Bushy salt marsh dominated by suaeda

Mudflat with sparse grass and *Prosopis*

Mudflat with sparse suaeda

Grassland with scattered native tree species

Mudflat with sparse grass and *Acacia nilotica* plantations

Spontaneous mangrove (in the background)

Water body surrounded by plantations of *Acacia nilotica*

Grassland with scattered shrubs of *Prosopis julifora*

Wetland habitats

Our study area contains 9,422 ha of wetlands, 53% (5,026 ha) of which is grassland, mostly on the floodplain of Lake Kalivelli. Almost half (2,080 ha) of the grassland area is on former agricultural land on the western bank of the floodplain. The road that crosses the wetland marks the eastern boundary of these former rice fields. Most of the grassland landscape is open, but 670 ha are enclosed by scattered dense bushes of the invasive species *Prosopis juliflora* (216 ha). The eastern part of the floodplain, is mostly covered by plantations of *Acacia nilotica*, which did not succeed but caused a slight modification of the topography. The land cover of the Kalivelli floodplain is mainly composed of an area of open water, mudflats, freshwater marshes dominated by *Scirpus* and grassland. A rather pristine habitat of salt marshes dominated by *Suaeda* bushes occupies 503 ha in the north, west of the industrial salt pans. However, this habitat is under threat as almost half of its area has been taken over by *Prosopis juliflora* bushes. It is also threatened by pollution due to its proximity to the industrial salt pans and to an area of tidal flats where waste is dumped (about 39 ha). Mangroves are spontaneous *Avicennia marina* growing in the north of the wetland, in the saltiest part of the south-north salinity gradient. We distinguished these from the mangrove plantations on the banks of the Uppukalli Creek, which were largely unsuccessful. The creek is lined with aquaculture/shrimp farms. This has ecological implications as discussed above. The surface area of the wetlands varies during the year and from year to year. The ratio of land (grasslands, marshes, tidal flats) to water (1,652 ha) can change radically. Water represents 17.5% of the whole wetlands. Lake Kalivelli itself represents 21% of the water area (342 ha).

The vast water bodies and reed beds of Kazhuveli wetland, January 2020 © Mathevet R. – IFP

Kazhuveli is a highly dynamic and variable wetland that is difficult to map

For example, the interpretation of satellite imagery acquired monthly between March 2017 and February 2018 led to the mapping of the extent of flooding across the different wetland covers. We estimated that the area of open water in Kalivelli Lake was 2.2 km² and 12 km² in May and December 2017, respectively, while the total area of reedbeds dominated by *Cyperaceae* members (*Scirpus sp.* and *Fimbristylis sp.*) was highest in December (48.4 km²) and lowest in May (5.5 km²). The inter-annual variability of water levels and the extent of flooding are likely to be high.

Variation of the surface in open water and in mixed open water and reeds, March 2017 to February 2018 © ED – IFP

Dune areas represent 7% of the study area (1,596 ha) and can measure 15 meters or more in the North, near the Yedayanthittu Estuary. Dunes are located mostly between the Bay of Bengal and the East Coast Road (ECR), but some patches of dune vegetation on sandy soil can be found to the west of the ECR.

Forested land (3,654 ha, 16% of the study area) includes both natural and man-made land cover types. Most of the forested land (2,885 ha) consists of filao or "savukku" (Casuarina equisetifolia), coconut and eucalyptus plantations. Kalivelli has a few patches (30 ha) of Tropical Dry Evergreen Forest. These are mostly sacred groves, but are highly degraded due to heavy human use and pollution. 6% (231 ha) of the forested area are *Acacia nilotica* plantations, all of which are within the floodplain. 1/6 of the plantations are made on artificial hills, lined up in large plots of up to 20 ha in the floodplain, surrounded by dikes and canals.

Agricultural land covers 4,814 ha (21% of the study area). Most of it (2,183 ha) is sown with a mixed pattern of rice and other crops. Rice fields (1,027 ha, 21% of the agricultural land) are mainly located on the eastern banks of the floodplain. Fallow land covers 747 ha of which 15% are taken over by *Prosopis juliflora* bushes, indicating that it has not been cultivated for several years.

Urban areas cover 1,349 ha (6% of the floodplain, 10% of the area outside the perimeter of the floodplain and water bodies). 68% of the urban areas are villages with very dense vegetation cover, mainly coconut trees, while 23% are dense towns with very sparse vegetation cover. Tourist resorts account for 3% of urban areas (37 ha), mostly hotels or holiday villages. Industrial buildings (63 ha, 5% of urban areas) are of two main types: chicken farms and shrimp hatcheries.

Finally, **infrastructures** represent 2,023 ha (9% of the study area), to which we must add 261 km of roads, 140 km of canals and 76 km of dikes. Roads are mainly located at the edge of the wetland, but one road crosses the floodplain from south to north, in the western part. Canals are mostly located north of the floodplain to serve the *Acacia nilotica* plantations and on the banks of the creek to serve the shrimp farms and mostly the mangrove plantations. There are two types of salt pans: traditional (603 ha), with small salines and evaporation ponds based on manual labour, and industrial (467 ha), with large evaporation ponds and salines. The ponds (678 ha) are of three types: (*i*) the traditional village ponds on the edge of the wetland (12 ha); (*ii*) the shrimp ponds created by damming (632 ha, 2.8% of the surface area of the study area), mostly on the banks of the Uppukalli creek and between the salt pans; and (*iii*) the ponds created by excavation by the Forest Department to create wildlife habitats. Although the total area of the latter is rather small (34 ha), their distribution throughout the floodplain makes them a structuring element of the wetland landscape. 12% of the infrastructure area is made up of mangrove plantations: as these were mostly unsuccessful, this type of land cover could not be defined by its vegetation (it is mostly bare silty ground or salt marshes), but by its topography, as the landscape here is characterised by small channels.

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DRAWING KAZHUVELI'S SOCIAL-ECOLOGICAL TRAJECTORY

Through a combination of literature review and workshops with local stakeholders and nature conservation activists, we have mapped out the social-ecological trajectory of the Kazhuveli wetland.

The Kazhuveli wetland has undergone several changes in its development model and management regime since the 19th century. The first dominant development pattern was agriculture and pastoralism. The wetland was used as a common pool of natural resources. It provided reed for thatching and grass for grazing, wildlife for fishing and hunting, and freshwater for rainfed agriculture, mainly rice cultivation. The degree of control over natural resources was low: natural resources were variable, mainly due to rainfall fluctuations. Collective management of natural resources supported ecological dynamics for the wetland, i.e. human activities modified the ecosystem, but in a way that reinforced wetland regeneration dynamics (vegetation growth, organic matter flow).

With the Green Revolution after World War II, Kazhuveli shifted to a development model dominated by the intensification of agriculture. Borewells and high-yielding crops made freshwater available all year round and allowed farmers to grow paddy even in the dry season, leading to the settlement of formerly seasonal paddy fields on the margins of the wetlands. The management regime moved from community-based management to individual management of land, in a capitalist economy – though common use of land continued in the collective or government-owned core of the wetland. The use of natural resources began to affect the ecological functioning of the wetland as groundwater irrigation led to the depletion of aquifers and surface water bodies.

As in many other coastal areas of South Asia, agriculture intensified with the Green Revolution and international demand for shrimp and aquaculture developed. Farmers favoured cash crops (bananas, casuarina, tapioca...) with intensive irrigation requirements over subsistence crops. Due to the lack of maintenance, the check dam collapsed in the 1980s. This provided an opportunity for shrimp farmers to settle on the banks of the Uppukalli creek, as saltwater became available in this part of the wetland. Control of the natural resource thus became a source of social conflict, as rice farmers needed fresh water for paddy cultivation. With the introduction of large-scale infrastructure (shrimp ponds) that disrupted the topography of the tidal flats, human modification of the ecosystem crossed a threshold. Social conflicts and national bans on shrimping led to most ponds becoming abandoned. In addition, the project to turn the Kazhuveli wetland into a Bird Sanctuary was encouraged by the Indian government's urge to follow the international wetland conservation agenda.

Regarding the salt pans area near the Yedayanthittu estuary, the major shift was from traditional salt production to a development model based on industrial salt production, with the conversion of 467 ha of tidal water bodies into large industrial saltpans and evaporation ponds.

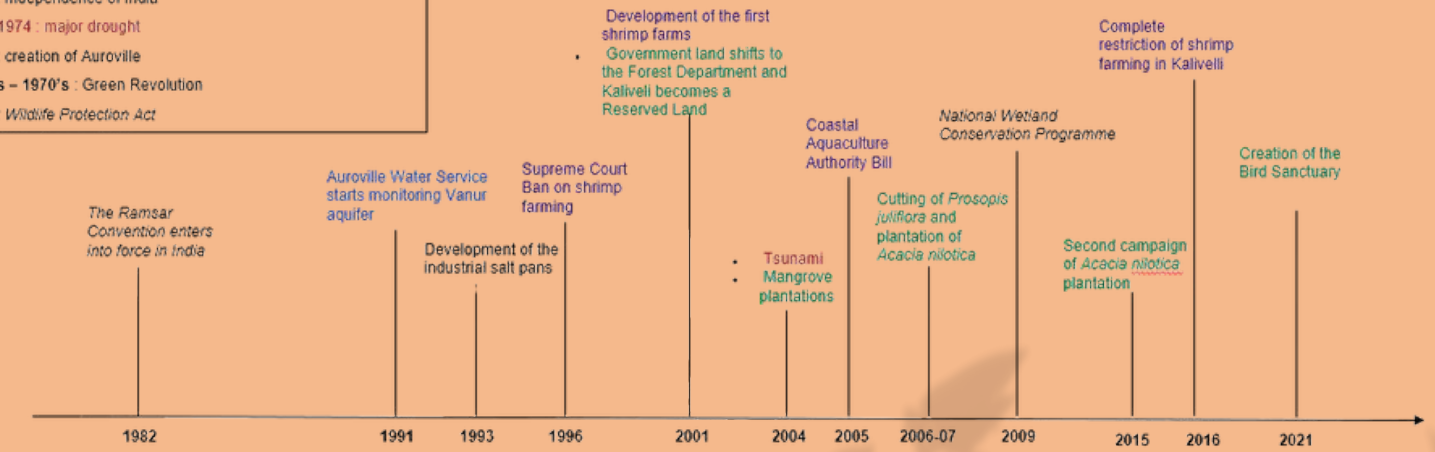
Kazhuveli's new and latest development model is that of a conservation area. Water, vegetation and wildlife are no longer seen as resources but as biodiversity. Surprisingly, the artificialisation of the wetland continues, with ponds being dug for waterfowl, and mangroves and acacias being planted, intensifying the control of natural resources for conservation purposes. At the same time as the Bird Sanctuary is being established, all other uses of the wetland are gradually being banned.

However, in 2021, the Public Works Department built a check dam in the same place as the previous one in the Uppukalli creek to keep the freshwater of the monsoon in the wetland. The project to build a dike around the entire perimeter of the wetland to convert it into a freshwater reservoir for regional water supply has been postponed but is still under consideration.

Kazhuveli timeline

Before the 1980's :

- **13th-17th century** (?) : creation of the salt pans in Marakkanam
- 1837 : construction of the Buckingham Canal
- 1932 : construction of the Checkdam
- **1947** : Independence of India
- 1967-1974 : major drought
- **1968** : creation of Auroville
- **1950's – 1970's** : Green Revolution
- *1972 : Wildlife Protection Act*



CONSEQUENCES ON THE WETLAND'S ECOLOGY

Although the first dominant development model of Kazhuveli had a limited impact on the autonomy of the wetland, the increasing artificialisation induced by subsequent models has had various consequences on the biodiversity and dynamics of the ecosystems. From 1932 to the end of the 1980s, the check dam had a strong impact on the hydrological dynamics of Kazhuveli, separating salt water (in the area of the salt pans) from fresh water (in the lake and the creek). The check dam artificialised Kazhuveli's historic backwaters and lagoon system and turned Kalivelli Lake into a freshwater habitat that met the requirements of this first development model. It also extended the period of flooding, creating a new habitat for wildlife.

Groundwater-irrigated agriculture in the context of the Green Revolution created a specialisation of space that reduce the area available for wildlife. Pollution from agricultural inputs caused eutrophication of wet habitats and increased the levels of toxic elements in the food chain. However, rice fields could be a substitute habitat for waterbirds such as herons and storks or waders. Groundwater irrigation maintained satellite wetlands around the dried-up lake during the dry season; although they were ecologically less interesting than the natural wetlands and contributed to the pollution of the lake, they could support a variety of invertebrates and birds.

The negative impact on the wetland increased with the intensification of agriculture and the development of aquaculture. The construction of shrimp ponds on the banks of the creek destroyed most of the mudflats and wet meadows. It destabilised the aquatic habitats (this was also due to the collapse of the dam that prevented salt water from entering the creek). At the same time, the pressure on wildlife increased as the demand for game meat grew.

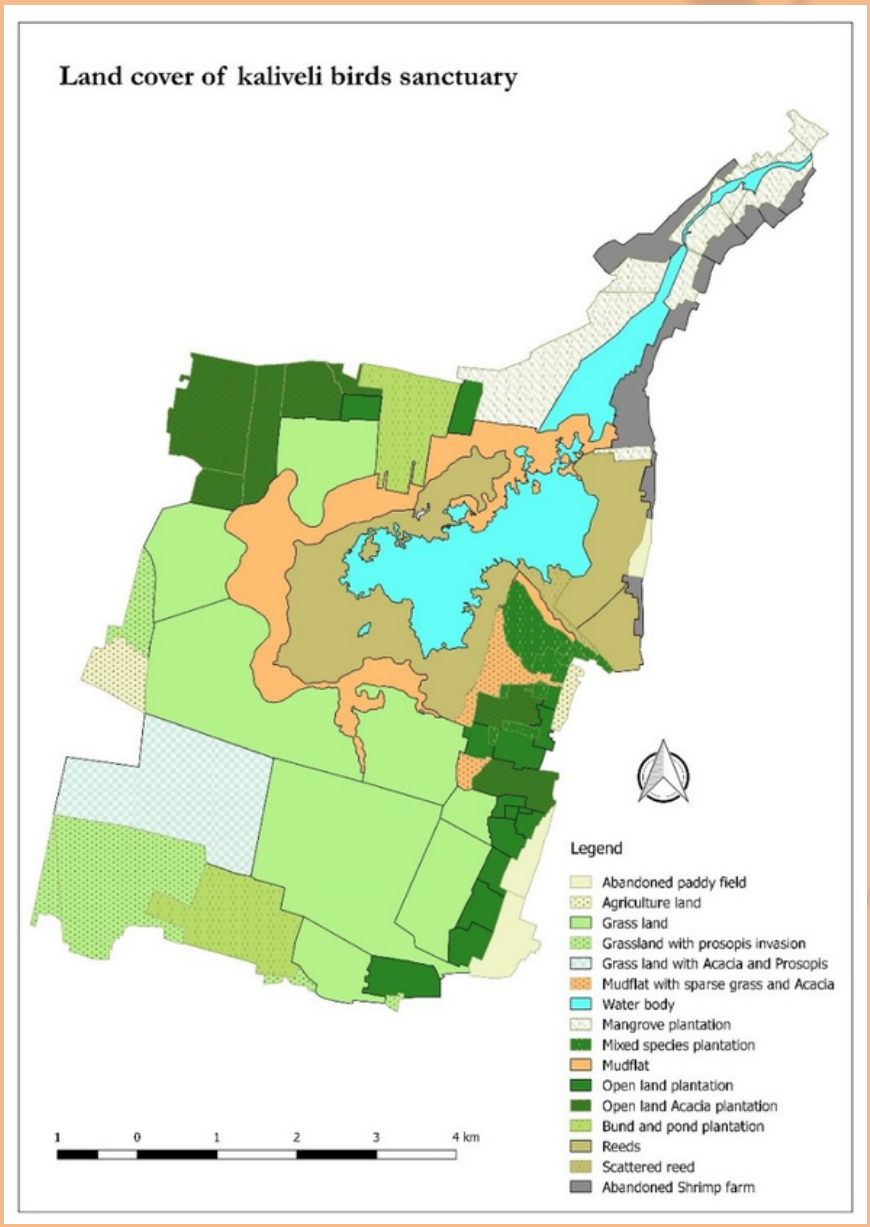
With the latest development model, Kazhuveli saw its hydrological functioning disrupted by the creation of canals and dikes in the floodplain by the Forestry Department. These infrastructures have created new habitats that are not autonomous. In addition, they are designed for a specific, selected fauna: large water birds such as tree-nesting herons, pelicans and storks, which require forested areas for nesting and are made into emblematic species of the wetland. This is being done at the expense of other birds whose habitats have been destroyed by the digging of ponds and the planting of acacia trees: open steppe grassland for birds such as the Oriental Pratincole (*Glareola pratincola*) or the Indian Courser (*Cursorius coromandelicus*), mudflats for waders - although the Forest Department claims to be restoring mudflats for waders.

The recently constructed check dam will prevent tidal inflow to the lake and will have a permanent effect on both water and salinity levels, and thus on the overall ecology of the wetland. The transformation of the temporary flooded and brackish wetland into a more semi-permanent freshwater lake may have positive effects on some habitats and species (ducks, herons, pelicans) and negative effects on others (waders, mammals, amphibians), depending on the dynamics of the different habitats.

LAND COVER OF THE NEW BIRD SANCTUARY

The lake, its tributaries and associated water bodies cover 532 ha (i.e. 30% of the total open water area) and the surrounding reed beds 741 ha (i.e. 83% of the total reed bed area). The Bird Sanctuary protects 2,188 ha of grassland in the floodplain of the lake (i.e. 43% of the total grassland area) and about 1,500 ha of open grassland of very high landscape value. 50% of the mudflats, an important habitat for migratory waders, are within the boundaries of the Bird Sanctuary (482 ha). Plantations developed in the last 15 years now cover a total area of 941 ha (mainly mangroves and acacias) and represent 25% of the total plantations in the study area. Active and abandoned farms (141 ha) and abandoned shrimp farms (168 ha) cover a total of 309 ha. Abandoned shrimp farms represent 25% of the total ponds created by excavation or damming in the areas. Overall, the Bird Sanctuary protects important natural habitats and a significant area of existing wetlands in the region.

The ruins of the old check dam before the works and the brand new salt barrier in 2021
© Balachandran N. – IFP & Kumar S.S. – TH



The total surface area of the Bird Sanctuary is 5,209 ha (i.e. 55% of the whole wetland area)
© Anbarashan M. – IFP

RESOURCE USE DYNAMICS

Traditional hand-cutting of reeds in Kazhuveli wetland – April 2018 © R. Mathevet – IFP

There are about 22 villages in and around the Kazhuveli wetland that are dependent on the natural resources of the wetland. For generations, the villagers have used the lakebed to cultivate, graze and collect natural resources such as reeds, firewood, clay, fish, etc. Resource use in Kazhuveli follows a seasonal pattern. There are ready markets for many of the products harvested from the wetlands. These include products such as milk, reeds, cattle and fish. Milk is usually sold to local cooperatives. Reeds are bought by nearby restaurants, neighbouring villages or sold to buyers in Chennai, Auroville or Pondicherry. In the case of cows and goats, a trader usually buys the produce. Sales of goats and cows are higher during festivals such as Diwali, Ramzan and Pongal. Cattle and goats are also a fallback resource and are occasionally sold in times of financial distress. Fish is generally used for domestic consumption, and any excess catch is sold locally.

Seasonality of resource use in the Kazhuveli wetland

Activities	Tamil Month	English Month
Cultivation	Adi to Thai	July to Mid February
Reed Harvest	Chithirai to Vaigasi	Mid April to Mid June
Fishing	Panguni to Vaigasi	Mid March to Mid June
Soil collection	Chithirai to Aani	Mid April to Mid July

A number of activities and uses considered traditional and customary by the neighbouring villages have been stopped by the declaration of the Bird Sanctuary and the consequent restrictions imposed by the Forest Department. This has put financial pressure on the villagers. Men are becoming wage labourers for loading and unloading and are increasingly involved in agricultural activities as day labourers to cope with the financial crisis. It is also common for them to work as masons or painters in neighbouring towns such as Auroville, Pondichery or Marakkanam. Some members of the community have found work in the nearby beach resorts and are paid on a monthly basis. Agriculture is another sector in which women are involved. They benefit from the NREGA* programme as well.

*Mahatma Gandhi National Rural Employment Guarentee Act 2005 is an Indian social welfare measure that aims to enhance livelihood security in rural areas.

Reed harvesting

Reeds were once the most valuable resource harvested from the wetland. They were harvested in seven of the nine villages and sold to customers as far away as Chennai and neighbouring villages such as Aruvadai and Edacheri, which did not traditionally collect reeds. Today, only Chettikuppam village continues to collect reeds. Similarly, eight out of eleven colony settlements used to harvest reeds, excluding villages such as Aruvadi and Urani. Now members of the Chettkuppam colony alone continue this practice, while others have been stopped by the forest department. Overall, the pressure on reeds has changed for reasons other than forest department restrictions. Much of the harvest was used for roofing in the villages and not for sale. Over the years, concrete roofs have replaced the traditional thatch, reducing demand. The combined effect of this fall in demand and the restrictions imposed by the Forest Department has led to a significant reduction in reed collection from around 1300 ha to around 300 ha (-75%).

Reed harvest in Kazhuveli wetland – April 2018 © R. Mathevet – IFP

Shrimp farming

The total area of shrimp farms in the zone is about 678 ha, mostly consisting of abandoned ponds more or less covered with grass, small water bodies, *Typha* and *Prosopis*. Only a few of them have been restored and converted into rice fields. Most of the embankments are degraded, eroded by the cattle that roam freely in this part of the wetland, but also by wind and rain. Some ponds and embankments are interesting nesting sites for Bee-eaters, Black-winged stilts, Reed warblers and Lapwings, and feeding grounds for Marsh harriers, waders, herons and ducks. The abandoned shrimp farms on the periphery of the Bird Sanctuary cover 168 hectares and could be the place of an ambitious ecological restoration project to reshape the landscape to store water, provide breeding and feeding grounds for water birds and organise ecotourism activities.

Rice fields, abandoned and operating shrimp farms in the northern part of the bridge over the creek in Jan. 2020 © Mathevet R. – IFP
(East is on the bottom left of the image, and West is top right, North on the right)

Dried and flooded abandoned ponds, mangrove plantation and water flow in the northern part of the Bird Sanctuary at the level of the bridge in Jan. 2020 © Mathevet R. – IFP
(East is on the bottom left of the image, and West is top right, North on the right)

The Black-tailed Godwit is a regular visitor to the Kazhuveli wetland © Gupta B. – UEF

Grazing

Grazing is the most important form of resource use in the Kazhuveli wetland. However, this activity has been greatly reduced due to restrictions imposed by the Forest Department. Only five out of eleven Scheduled Caste (SC) settlements and six out of nine Backward Caste (BC) settlements still practise cattle grazing in the wetland. The Forest Department has dug a deep and wide ditch along the boundary of the designated sanctuary, effectively preventing cattle from entering the wetland. This has caused much hardship and resentment among the affected villagers. However, grazing continues where the ditch has not been completed. Preventing cattle from grazing in the wetland has resulted in less fodder and a drop in cattle production, leading to a fall in income. Under these circumstances, some villagers have had to sell their cattle and goats. Based on our surveys in 2019 and 2020, before the Bird Sanctuary was declared, the total grazing area was approximately 2,300 ha (i.e. 44% of the Bird Sanctuary). Most of the grassland was more or less grazed and maintained in this open grassland ecological condition. In total, we were able to count around 1,200 domestic animals grazing or roaming in the identified areas. We were not able to assess the grazing pressure, as this would have required at least one specific seasonal survey. However, we can say that 13% of the livestock observed were goats and sheep, 81% were cattle and 6% were buffalo. The actual number of livestock may be higher, and future studies will need to cross-check the survey data with declarative data collected during focus groups with local communities to refine the method.

Traditional buffaloes grazing in Kazhuveli wetland – March 2019 © Mathevet R. – IFP

Unspoilt landscape and grasslands of the Kalivelli floodplain (view from south-east).
This amazing landscape should be protected from any dike or canal construction in order to preserve its integrity and authenticity. Its high value should be highlighted in order to preserve the site, its ecological features and its recognition as a Ramsar site. 2020 © Mathevet R. – IFP

Grazing pressure survey in the Southern grasslands of Kaluveli flood plain - 30th January 2020.
We can observe here a small group of buffaloes and cows. © Mathevet R. – IFP

Fuel wood harvesting

Fuelwood collection in the wetland was one of the main activities of villagers. However, with the supply of Liquefied Petroleum Gas (LPG) to all households by the Tamil Nadu government in 2006, LPG has become the preferred source of cooking fuel which has led to a significant reduction in the demand for firewood. Previously seven out of nine BC community settlements used to gather firewood in the wetland, whereas now only the villagers from Killapakkam still do it. Similarly, among the SC community, six out of eleven settlements used to collect firewood for cooking, but now this practice is prevalent only in villages such as Vandipalayam and Kodikuppam.

Fishing

Fishing was one of the activities in the Kazhuveli wetland that would generate additional income for the local communities. They would catch fish, crabs and shrimps using small nets and use earthworms as bait for fishing with hooks. Generally, Irula tribals use polychaetes to catch fish between the Tamil months of Thai and Panguni (February and April). Six out of nine settlements in the BC community and seven out of eleven in the SC community used to fish in the wetland. However, this practice has completely stopped now due to recent restrictions imposed by the Forest Department.

Polychaetes harvesting

Polychaetes are a major component of the bottom fauna of a lagoon in the Kazhuveli wetland and an important part of the food webs of a brackish water ecosystem. Polychaetes also have a high calorific value and are rich in protein, both in the adult and larval stages. Aquaculture traders provide money in advance to collect polychaetes from local people, especially from the Irula tribes of the Kazhuveli region. During our field survey from November 2019 to May 2020, only one polychaetes collection was reported at Narapakkam near Marakkanam.

Soil collection

Collecting soil from the bed of the Kalivelli lake was a common practice of farmers from the surrounding villages. The soil was used as fertiliser on Patta lands. This activity stopped completely when the wetland was notified as a Bird Sanctuary. Before the intervention of the forest department, six out of nine settlements of the BC community and three out of eleven of the SC community were involved in soil collection as the villagers believed that the soil from Kazhuveli was a very good fertiliser for their crops. However now they have switched to using synthetic fertiliser. Regular silt removal, depending on its location, could have created more water-spreading areas and the removal of nutrients would have helped to reduce eutrophication. The current restrictions have not only prevented these beneficial practices, but the switch by farmers to fertilisers may have increased nutrient run-off into the lake from nearby fields. On the other hand, uncontrolled silt and soil removal is a serious problem in a number of water bodies and, when carried out on a mechanised and commercial scale, can become a serious threat in itself.

On the banks of the Uppukalli Creek, waterbirds and traditional local fishing boats, roughly made by hanging a few logs together, February 2018 © Mathevet R. – IFP

Cultivation

Farming in the Kalivelli wetlands has been an important activity in the surrounding villages for generations. The farming communities have their own patta land and in the past they have encroached as much as possible in the neighbouring areas. But the Forest Department has now banned the practice of farming in the wetland. As a result, six out of nine settlements of the BC community and eight out of eleven of the SC community no longer cultivate in the wetland, leading to a significant loss of income for them. However, the BC settlements of Edacheri, Kilappakkam and Karatai continue the practice, as do the SC settlements of Vilvanatham and Devanandal. The village of Chaiyankuppam has never used the wetlands for cultivation. It is unclear whether any of the villages have formally registered for such practices or have applied to have them formally documented.

Women and Wetlands – rice-transplantation on the fringes of Kazhuveli wetland, March 2018
© Mathevet R. – IFP

Harvest on the fringes of Kazhuveli wetland, March 2019 © Mathevet R. – IFP

Plantation

Mangroves are salt-tolerant coastal vegetation found throughout the world in tropical and subtropical countries. They generally grow at the interface between saline water and land, either along the coast or in backwater bays, lagoons, estuaries, etc. The Kazhuveli wetland already favours mangrove vegetation, but towards inland it is represented with mangal associates, especially the species of *Suaeda*. However, the Forest Department tried to develop the mangrove area inland after the impact of the 2004 tsunami. To this end, they constructed fishbone structures over 292 ha of land and planted them with *Avicennia* and *Rhizophora* species.

The Kazhuveli wetland covers more than 9,000 hectares, almost flat but sloping to the north with a shallow catchment area, the water flows through a narrow channel to a salt marsh, a pan, a lagoon and finally to the sea. Altitude ranges from 0 to 3 metres above sea level. In general, the Forest Department has planted over the wetland on flat areas and artificially raised soil. On the flat areas they have planted single species, i.e. *Acacia*, as well as multiple species, including both native and exotic species, while on the raised areas they have planted only *Karuvel*. Based on our field trips, the plantations on the raised surfaces have performed better than those on the flat surfaces. However, along the edges of water stagnation, the death rate of trees was higher than on the mound/bund, even of well grown *Acacia*. This condition was more privileged towards the catchment side. This could be due to heat, increased salinity, electrical conductivity and other factors. To know the factors responsible for the high mortality rate will require regular and long-term study.

Fishbone plantation in the north-west part of Kalivelli lake outlet © Mathevet R. - IFP

Mixed species plantations in the eastern part of the grassland of Kazhuveli wetland
Jan 2020 © Mathevet R. – IFP

Artifical island in the middle of the grassland in Kazhuveli Bird Sanctuary © Mathevet R. – IFP

Kazhuveli grassland: a growing contrasted landscape. On the left the natural and grazed grasslands *vs* on the right the dikes, ponds and plantations – Jan 2020 © Mathevet R. – IFP

Artificial roosting and breeding places in the southern part of the Kalivelli lake flood plain Jan 2020 © Mathevet R. – IFP

Impacts of Protection on *Prosopis juliflora*

Prosopis juliflora is a shrub or small tree native to Central and South America. It has become an invasive weed in Africa, Australia and Asia. The Forest Department had taken proactive steps to remove the *Prosopis* before planting parts of the wetland with native *Acacias*. However, there was high mortality among the saplings and those that survived remained severely stunted, possibly due to water logging and increased salinity caused by nearby shrimp farms.

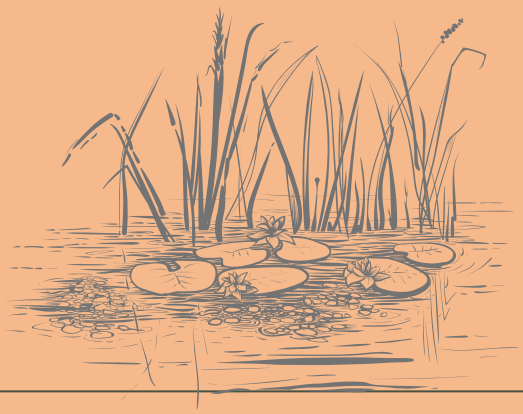
At present, *Prosopis* clumps have re-established themselves and new clumps have formed, particularly in areas that were traditionally cultivated. In the past, the spread of *Prosopis* was controlled by farmers and many of the larger clumps were harvested for fuel and charcoal and grazed by livestock. The spread of *Prosopis* could become a serious management challenge in the future, particularly if restrictions on harvesting and grazing continue.

Prosopis cleaning by the forest department in the Kazhuveli wetland © Balachandran N. – IFP

Acacia plantations in the north-eastern part of the grassland of Kalivelli lake flood plain - Jan 2020 © Mathevet R. – IFP

PLANT DIVERSITY

Cyperus - Schoenoplectus maritimus in Kazhuveli wetland © Balachandran N. – IFP



Our study documented 242 angiospermic species belonging to 186 genera spreading over 62 families from the Kazhuveli wetland, of which 169 are herbaceous followed by 25 trees, 26 shrubs, and 22 climbers (Appendix 1). Interestingly there are 76 IUCN red-listed species and three endemic species recorded in and around the lake.

Obviously, *Poaceae* is the dominant family represented by 28 species followed by *Leguminosae*, *Cyperaceae* and *Rubiaceae*. Among the genera *Cyperus* is dominant with 10 species. The predominant tree species of Kazhuveli wetland is *Acacia nilotica* due to plantation by the Forest Department and *Avicennia officinalis*, a mangrove species. The other important natural and planted tree species along the margins of the wetland are *Azadirachta indica*, *Barringtonia acutangula*, *Borassus flabellifer*, *Leucena leucocephala*, *Morinda coreia* and *Pithacellobium dulce*. Shrubs such as *Acacia auriculata*, *Benkara malabarica*, *Calotropis gigantea*, *Canthium coromandelicum*, *Flueggea leucopyrus*, *Glycosmis mauritiana*, *Gmelina asiatica*, *Jatropha gossyphifolia*, *Memecylon umbellateum* and *Tarenna asiatica* are commonly found around the lake. The common climbers are *Cardiospermum helicacabum*, *Cissus quadrangularis*, *Coccinea grandis*, *Mukia maderaspatana*, and *Tylophora indica*.

Tall grasses, sedges and reeds beneficial to wildlife are *Cyperus procerus*, *Leptochloa neesii*, *Scirpus littoralis*, *Typha angustifolia* and *Vetiveria zizanioides*. Macro hydrophytes recorded from the present study include *Nelumbo nucifera*, *Nymphaea nouchalii*, *Otellia alismoides*, and *Monocharis vaginalis* which are distributed on both shores of the wetland.

Ottelia alismoides commonly known as duck lettuce in Kazhiveli wetland © Balachandran N. – IFP

BIRD BREEDING, MIGRATION & WINTERING

Northern Shovelers are common visitors during winter days in Kazhuveli © Gupta B. – UEF

The wetland supports a wide variety of bird species (Appendix 2), whose presence and abundance varies seasonally. Kazhuveli is an important breeding area for tree-nesting species - egrets, herons, storks, ibises. They live in mixed colonies and nest in trees (acacias, special islands created for them). The roosts and colonies are scattered throughout the wetland and its surroundings. Purple herons and bitterns breed in the reed beds, while gull and tern colonies are found in the saline areas. These habitats are shared with breeding waders such as the Kentish Plover, Redshank, Black-winged Stilt and Lapwing, which may also use rice fields for breeding.

Kazhuveli is also an important stopover for wetland birds such as ducks, waders and terns. It provides a wide range of habitats that are very attractive to these species as they refuel for their long journey to more southerly wintering areas. Kazhuveli is key and its loss would make most migratory patterns dangerous, if not impossible.

Kazhuveli is also an important wintering area for several species of ducks. Bird censuses in the mid-1980s showed that the winter population was around 10,000-30,000 ducks, with an estimated 20,000-40,000 shorebirds and 20,000-50,000 terns during the migration period. The main duck species concerned are whistling ducks, Indian spotted ducks, Garganeys, Northern shovelers, Eurasian wigeons, Northern pintails and Green-winged teals. Poaching and human disturbance from agriculture and fishing are likely to reduce the overall carrying capacity of the wetland. Duck numbers fluctuate between years and seasons, and based on our own surveys (2017-2021), significant declines have been observed for all species. Regional and local factors may have played a role (poaching pressure, development of shrimp farms, urban development, human population growth, water scarcity, change in flood regime with agricultural development), and unknown factors operating in duck breeding and wintering areas in Asia and Siberia or India may also have influenced this trend with climate change. Other species such as grebes, herons, cormorants, waders, gulls and many passerines also use the diverse habitats and rich food resources offered by Kazhuveli in winter.

Bird census by IFP team, Kazhuveli wetland, March 2020 © Mathevet R. – IFP

A group of islands form the main tree-nesting site in the area. Hundreds of Painted storks, Spotted-billed Pelicans, Black-headed Ibises, Grey Herons, Great Egrets, Spoonbills and a few Asian Woolly-necked Storks progressively breed there during the January-March period. However, in 2021 we found that half of the islands were in poor condition, with more than 50% of the trees dead. A specific study should address this issue in order to plan (*i*) plantation of new trees outside the breeding season; (*ii*) a new breeding area in the northern part of the lake with a cluster of islands and/or in the abandoned ponds through an ambitious ecological restoration project.

One of the 5 nesting islands created in the 2000s within Kalivelli lake (Island 7 view from the south) © Mathevet R. – IFP

SYNTHESIS OF KEY NATURAL HERITAGE ISSUES

Installation of water pump in progress to irrigate ricefields from a temporarily-flooded area in Kazhuveli wetland – Feb. 2018 © R. Mathevet – IFP

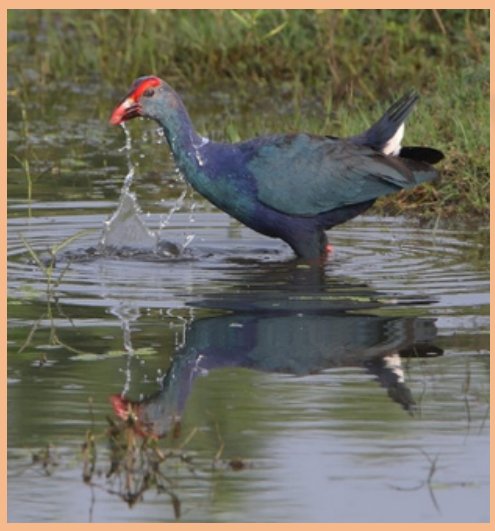
The Painted stork is a large wader that is found in the wetlands of Tamil Nadu and especially in the Kazhuveli wetland – Sept 2017 © Mathevet R. – IFP

The Asian openbills feed predominantly on molluscs in the ricefields and wetlands surrounding Lake Kalivelli – Feb 2018 © Mathevet R. – IFP

The major issues related to the conservation of natural heritage are: (*i*) Maintaining good quality freshwater inflows (i.e. limiting eutrophication and the salinity balance of soils and waters) and maintaining hydrological and biological exchanges between the lagoon downstream and the ocean, and the lake and its floodplain; (*ii*) Ensuring a wise management of exploited natural resources (worms, fish, reed, wood...) and fighting against poaching that is still widespread in the whole area; (*iii*) Conserving all ecosystems (e.g. mudflats, wet meadows, reed beds, open water, salt marshes and steppes...) and their fauna and flora. Management will have to take into account the dynamics and mobility of these ecosystems in time and space; and it will also have to limit the impact of human activities upstream and downstream, on their margins and within the wetland perimeter.

The Indian Pond Heron is easy to observe in Kazhuveli wetland
Oct. 2017 © Mathevet R. – IFP

Spot-billed pelican is a near-threatened species in India that feeds and nests in the Kazhuveli wetland © Gupta B. – UEF



The magnificent Gray-headed Swamphen can be a common inhabitant of the reed beds of Kazhuveli © Gupta B. – UEF

A few other very important issues are identified:

The long-term maintenance of favourable breeding conditions especially for Spotted-billed pelican, Painted stork, Spoonbill, Black-headed ibis, as well as tree-nesting herons. This issue is broader in scope than Tamil Nadu and the Coromandel Coast. Kazhuveli wetland has the potential to sustain an important nesting site.

The integration of the site into an overall management plan for the populations of small colonial Charadriiforms nesting along the Coromandel Coast. In the short term, measures to encourage the establishment of large colonies may be considered.

The maintenance, or even strengthening, of the conditions necessary for migrating and wintering waterbirds. While the creation of the Bird Sanctuary should favour waterbirds in general, and ducks and waders in particular, it should also seek to maintain their tranquillity in those areas which are (or will become) essential for their resting and feeding.

The conservation of existing mudflats, salt meadows and grasslands, and their restoration in the areas of abandoned fish farms or failed plantations where they have disappeared. The restoration of these important habitats for migratory shorebirds would also help to increase populations of breeding warblers or pipits and Collared pratincole, which use these habitats and are themselves a conservation concern on the site.

The conservation of Cyperus-dominated reed beds is an issue, with some areas appearing to be moving towards open water in recent years. Local restoration of favourable hydrological conditions for these communities should be investigated.

Other issues to be considered in the future management of the site are:

⇨ Ecological restoration and management of marshes located in the development zone of former aquaculture farms, including issues of landscape redesign with islands and plantations, and management of hydroperiods, *Prosopis* limitation and restoration of environments conducive to bird reproduction.

⇨ Assessment of existing artificial ponds and temporary marshes. A diagnosis of these little-studied environments with their associated fauna (i.e. dragonflies, butterflies, turtles, fish, etc. see Appendices 3, 4 and 5) is awaited.

⇨ A diagnosis of the status of the mammals that are present (e.g. jackals, bats, etc.) is expected to feed the management plan (Appendix 6).

On the basis of this general synthesis, the main principles which, in our opinion, should govern any management plan are as follows:

⇨ In order to preserve the natural and wild character of the landscape, to refrain from constructing water conservation structures or heavy installations such as ditches, canals, dikes, ponds, islands that compartmentalize space in the grassland area;

⇨ To maintain the ecological dynamics of the floodplain through grazing and control of invasive species;

⇨ To restore degraded environments especially abandoned aquaculture ponds;

⇨ To maintain or develop breeding sites for birds that nest in trees, but also on islands with little or no vegetation;

⇨ To maintain and restore mudflats for migratory shorebirds.

Cypereus pygmaeus is a clustered annual grass that is found in the mud cracks of Kazhuveli wetland © Balachandran N. – IFP

MAIN RECOMMENDATIONS

Fence and new ditch along the perimeter of the future Bird Sanctuary may limit undesirable human access but transforms the hydrology of the Kazhuveli wetland March 2018 © Mathevet R. – IFP

The floodplain and lake play an important role in making this wetland an outstanding natural site in Tamil Nadu and India due to the high degree of naturalness of the site. The wilderness experience is very strong here for any visitor. This landscape quality, which also allows the presence of remarkable biodiversity at the scale of the site, should be preserved. The authenticity and biophysical integrity of the wetland should be maintained by stopping any further development of ditches, canals, dikes, embankments and plantations. The challenge is clearly to maintain the character of an open landscape dominated by wet grassland. There is an urgent need to maintain domestic grazing while reducing the risk of overgrazing. An additional study should characterise the best grazing pressure according to location and season, in collaboration with local herders.

It could also assess the feasibility of reintroducing some wild herbivores such as Spotted deer and Blackbuck in the long term to help diversify grazing patterns and plant populations. It is also desirable to carry out a study of grassland management by fire, to be combined with specific work on the control of *Prosopis* (e.g. with or without local firewood harvesting) in order to contain its invasion as soon as possible.

Overall, existing plantations show a high level of failure. This is mainly due to inappropriate hydrological and salinity conditions during the whole or part of the year. We recommend stopping all new planting within the perimeter of the site, if not at its edges, to promote a buffer effect with the rest of the wetland against disturbance from peripheral human activities. Beyond the mangrove and acacia plantations, the highly structuring features (mounds and ponds) should not be further developed. Their current size and imminent maturation appear to be sufficient to potentially support nesting birds, despite their non-optimal geographical location. We suggest that any new development efforts for wildlife be concentrated in the areas of abandoned shrimp farms.

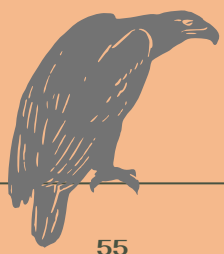
The creation of new ponds and potential nesting sites should be concentrated on former aquaculture ponds. We recommend that these areas be redesigned, with the maintenance and/or destruction of embankments, the planting of marginal and central trees, and the creation of ponds and islands with and without vegetation to favour tern and wading bird species, but also pelicans and storks. This major ecological restoration operation could easily be valued by the Forestry Department and could be an experience that helps to demonstrate its commitment to the conservation of wetlands and migratory birds at both national and international levels (i.e. Ramsar Convention).

Monthly and annual monitoring of waterbirds, as well as water levels and salinity, are critical to any wise management of the area in collaboration with natural resource users, conservation NGOs and the Public Works Department.

TOWARDS AN ENVIRONMENTAL STEWARDSHIP OF THE KAZHUVELI WETLAND?

Ruined house on the fringes of Kalivelli flood plain, Tamil Nadu – India
Nov. 2017 © Mathevet R. – IFP

Our study provides a first state of reference on the land cover of the Kazhuveli wetland. It has been carried out despite the inherent difficulties in describing such a highly dynamic, variable wetland, subject to various influencing natural and anthropogenic factors. To the best of our knowledge, it also provides the first narrative of the history of Kazhuveli. Thus, this first attempt can be considered an important milestone, as narratives are important in building environmental concern and care for ecological issues. Above all, it shows that large-scale artificialisation through the construction of infrastructure is a process that affects the whole wetland, regardless of land ownership. Such a fragmentation process, through the construction of different infrastructures in the four landscape zonations, influences the hydrology and ecology of the wetland and increases the specialisation of small areas. In the core wetland area (Kalivelli Lake and floodplain), wildlife ponds are being dug by the Forest Department and surrounded by *Acacia nilotica* plantations, canals and embankments, together with Acacia plantations of round artificial hills in straight lines. Along Uppukalli Creek, shrimp ponds have replaced rice paddies on most of the banks. Mudflats and salt marshes have been transformed by the creation of canals and the planting of mangroves. Although most of the plantations have failed, the topology of the landscape has been profoundly altered. In the north of Kazhuveli, traditional salt pans that have existed for centuries now coexist with industrial salt pans with much larger ponds, and an entire area is devoted to the dumping of chemical industrial waste. Along the coast, urbanisation has increased with the construction of the East Coast Road in the 1990s, and agriculture has intensified thanks to irrigation. The dunes have been planted for crops (e.g. coconut, cashew, casuarina and eucalyptus plantations) or to protect the coast from tsunamis.

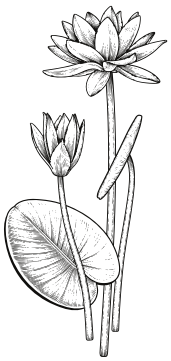


In the context of climate change, global environmental degradation and ecological crisis, it is more important than ever to study and protect wetlands. The main issue is to make the conservation of wetlands truly effective, without creating social injustice and environmental inequality. For this purpose, it is important to think of Kazhuveli not only within the boundaries of the Bird Sanctuary, not even within the boundaries of the study area, but at the level of the entire watershed, in order to understand the entire hydrological dynamics of the wetland. This hydrological and territorial rationality can be the basis for an adaptive co-management based on social-ecological stewardship. Kazhuveli is a wetland that blurs the boundaries between the natural and the artificial. With the Bird Sanctuary established, it is time to think about what nature we want to see in this wetland. What biodiversity do we want to conserve and see evolve alongside human activities? Managing the Kazhuveli Bird Sanctuary based on an environmental stewardship approach could be a positive way forward for both humans and non-humans, landscapes and water.

Burning of an uncontrolled landfill in the Kazhuveli wetland – Oct. 2017 © Mathevet R. – IFP

APPENDIX 1

Plants of Kazhuveli wetland from IFP surveys



Scientific Name	Family Name	Habit
Abrus precatorius L.	Leguminosae	C
Abutilon indicum (L.) Sweet	Malvaceae	H
Acacia auriculata Charp. ex Fourn.	Leguminosae	S
Acacia nilotica (L.) Delile	Leguminosae	T
Acacia leucophloea (Roxb.) Willd	Leguminosae	T
Acalypha indica L.	Euphorbiaceae	H
Achyranthes aspera L.	Amaranthaceae	H
Acorus calamus L.	Acoraceae	H
Actinoscirpus grossus (L.f.) Goetgh. & D.A.Simpson	Cyperaceae	H
Aeluropus lagopoides (L.) Thwaites	Poaceae	H
Aeschynomene aspera Willd.	Leguminosae	H
Albizia lebbeck (L.) Benth.	Leguminosae	T
Alloteropsis cimicina (L.) Stapf	Poaceae	H
Alysicarpus monilifer (L.) DC.	Leguminosae	H
Alysicarpus vaginalis (L.) DC.	Leguminosae	H
Amaranthus viridis L.	Amaranthaceae	H
Ammannia baccifera L.	Lythraceae	H
*Ammannia octandra L.f.**	Lythraceae	H
Andrographis echioides (L.) Nees	Acanthaceae	H
Anisomeles malabarica (L.) R.Br. ex Sims	Lamiaceae	S
Apluda mutica L.	Poaceae	H
Aponogeton natans (L.) Engl. & K.Krause	Aponogetonaceae	H
Aristida adscensionis L.	Poaceae	H
Asystasia gangetica (L.) T.Anderson	Acanthaceae	H
Atalantia monophylla DC.	Rutaceae	T
Avicennia officinalis L.	Acanthaceae	T
Azadirachta indica A. Juss.	Meliaceae	T
Bambusa bambos (L.) Voss	Poaceae	H
Barleria cristata L.	Acanthaceae	H
Barringtonia acutangula (L.) Gaertn.	Lecythidaceae	T
Benkara malabarica (Lam.) Tirveng.	Rubiaceae	S
Bergia capensis L.	Elantiaceae	H
Boerhavia diffusa L.	Nyctaginaceae	H
Bolboschoenus maritimus (L.) Palla	Cyperaceae	H
Borassus flabellifer L.	Arecaceae	T
Brachiaria ramosa (L.) Stapf	Poaceae	H
Brachiaria remota (Retz.) Haines	Poaceae	H
Brachiaria reptans (L.) C.A.Gardner & C.E.Hubb.	Poaceae	H
Bridelia retusa (L.) A.Juss.	Phyllanthaceae	T
Bulbostylis barbata (Rottb.) C.B.Clarke	Cyperaceae	H
Bulbostylis junciformis (Kunth) C.B.Clarke	Cyperaceae	H
Calotropis gigantea (L.) Dryand.	Apocynaceae	S

Canthium coromandelicum (Burm.f.) Alston	Rubiaceae	S
Cardanthera balsamica (L.f.) Benth. ex C.B.Clarke	Acanthaceae	H
Cardiospermum halicacabum L.	Sapindaceae	C
Carissa spinarum L.	Apocynaceae	S
Cassia fistula L.	Leguminosae	T
Catunaregam spinosa (Thunb.) Tirveng.	Rubiaceae	S
Celosia argentea L.	Amaranthaceae	H
Chamaecrista absus (L.) H.S.Irwin & Barneby	Leguminosae	H
Chloris barbata Sw.	Poaceae	H
Chloris montana Roxb.	Poaceae	H
Chloris virgata Sw.	Poaceae	H
Chrozophora rottleri (Geiseler) A.Juss. ex Spreng.	Euphorbiaceae	H
Chrysopogon zizanioides (L.) Roberty	Poaceae	H
Cissus quadrangularis L.	Vitaceae	C
Cissus vitiginea L.	Vitaceae	C
Cleome tenella L.f.	Cleomaceae	H
Cleome viscosa L.	Cleomaceae	H
Coccinia grandis (L.) Voigt	Cucurbitaceae	C
Coldenia procumbens L.	Boraginaceae	H
Commelina attenuata K.D.Koenig ex Vahl	Commelinaceae	H
Commelina benghalensis L.	Commelinaceae	H
Commelina ensifolia R.Br.	Commelinaceae	H
Cressa cretica L.	Convulvaceae	H
Crinum asiaticum L.	Amaryllidaceae	H
Crotalaria prostrata Willd.	Leguminosae	H
Croton bonplandianus Baill.	Euphorbiaceae	H
Cuscuta reflexa Roxb.	Convulvaceae	C
Cyanotis axillaris (L.) D.Don ex Sweet	Commelinaceae	H
Cyanthillium cinereum (L.) H.Rob.	Asteraceae	H
Cymbopogon caesius (Hook. & Arn.) Stapf	Poaceae	H
Cymbopogon citratus (DC.) Stapf	Poaceae	H
Cyperus compressus L.	Cyperaceae	H
Cyperus difformis L.	Cyperaceae	H
Cyperus distans L.f.	Cyperaceae	H
Cyperus haspan L.	Cyperaceae	H
Cyperus michelianus ssp. pygmaeus (Rottb.) Asch. & Graebn.	Cyperaceae	H
Cyperus procerus Rottb.	Cyperaceae	H
Cyperus rotundus L.	Cyperaceae	H
Cyperus squarrosus L.	Cyperaceae	H
Cyperus stoloniferus Retz.	Cyperaceae	H
Cyperus tenuispica Steud.	Cyperaceae	H
Dactyloctenium aegyptium (L.) Willd.	Poaceae	H
Dendrophthoe falcata (L.f.) Ettingsh.	Loranthaceae	C

Dentella repens (L.) J.R.Forst. & G.Forst.	Rubiaceae	S
Desmodium heterophyllum (Willd.) DC.	Leguminosae	H
Dicanthium aristataum	Poaceae	H
Dichrostachys cinerea (L.) Wight & Arn.	Leguminosae	S
Digitaria bicornis (Lam.) Roem. & Schult.	Poaceae	H
Dopatrium nudicaule (Willd.) Benth.	Scrophulariaceae	H
Echinochloa colona (L.) Link	Poaceae	H
Eclipta prostrata (L.) L.	Asteraceae	H
Eleocharis dulcis (Burm.f.) Trin. ex Hensch.	Cyperaceae	H
Emilia sonchifolia (L.) DC. ex DC.	Asteraceae	H
Epaltes divaricata (L.) Cass.	Asteraceae	H
Eragrostis viscosa (Retz.) Trin.	Poaceae	H
Eucalyptus globulus Labill.	Myrtaceae	T
Eugenia involucrata DC.	Myrtaceae	S
Euphorbia hirta L.	Euphorbiaceae	H
Fimbristylis ovata (Burm.f.) J.Kern	Cyperaceae	H
Fimbristylis quinquangularis (Vahl) Kunth	Cyperaceae	H
Fimbristylis triflora (L.) K.Schum. ex Engl.	Cyperaceae	H
Flueggea leucopyrus Willd.	Phyllanthaceae	S
Gahnia javanica Moritzi	Cyperaceae	H
Glinus oppositifolius (L.) Aug.DC.	Molluginaceae	H
Gliricidia sepium (Jacq.) Walp.	Leguminosae	T
Gloriosa superba L.	Colchiaceae	C
Glycosmis mauritiana (Lam.) Tanaka.	Rutaceae	S
Gmelina asiatica L.	Verbenaceae	S
Gomphrena celosioides Mart.	Acanthaceae	H
Gomphrena globosa L.	Acanthaceae	H
Heliotropium currassavicum L.	Boraginaceae	H
Heliotropium supinum	Boraginaceae	H
Heliotropium bracteatum R.Br.	Boraginaceae	H
Heliotropium indicum L.	Boraginaceae	H
Hemidesmus indicus (L.) R. Br. ex Schult.	Apocynaceae	C
Hibiscus cannabinus L.	Malvaceae	H
Hybanthus enneaspermus (L.) F.Muell.	Violaceae	H
Hygrophila auriculata (Schumach.) Heine	Acanthaceae	H
Hyptis suaveolens (L.) Poit.	Lamiaceae	H
Ichnocarpus frutescens (L.) W.T.Aiton	Apocynaceae	C
Ipomoea aquatica Forssk.	Convulvaceae	H
Ipomoea carnea Jacq.	Convulvaceae	C
Ipomoea coptica (L.) Roth ex Roem. & Schult.	Convulvaceae	H
Ipomoea pes-tigridis L.	Convulvaceae	C
Ipomoea quamoclit L.	Convulvaceae	C
Isolepis fluitans (L.) R.Br.	Cyperaceae	H
Jatropha gossypiifolia L.	Euphorbiaceae	S

Kyllinga bulbosa P.Beauv.	Cyperaceae	H
Lantana camara L.	Verbenaceae	S
Leersia hexandra Sw.	Poaceae	H
Leucaena leucocephala (Lam.) de Wit	Leguminosae	T
Leucaena leucocephala (Lam.) de Wit	Leguminosae	T
Leucas aspera (Willd.) Link	Lamiaceae	H
Leucas lavandulifolia Sm.	Lamiaceae	H
Limnophila heterophylla (Roxb.) Benth.	Plantaginaceae	H
Limnophila sessiliflora (Vahl) Blume	Plantaginaceae	H
Lindernia ciliata (Colsm.) Pennell	Linderniaceae	H
Lindernia sp	Linderniaceae	H
Lindernia tenuifolia (Colsm.) Alston	Linderniaceae	H
Lindernia crustacea (L.) F.Muell.	Linderniaceae	H
Lipocarpha squarrosa (L.) Goetgh.	Cyperaceae	H
Ludwigia perennis	Onagraceae	H
Ludwigia prostrata Roxb.	Onagraceae	H
Macrotyloma uniflorum (Lam.) Verdc.	Leguminosae	C
Mallotus repandus (Willd.) Müll.Arg.	Euphorbiaceae	C
*Manisuris myurus L.**	Poaceae	H
Melochia corchorifolia L.	Malvaceae	S
Memecylon umbellatum N. Burman	Melastomataceae	H
Merremia tridentata (L.) Hallier f.	Convulvaceae	H
Mimosa pudica L.	Leguminosae	H
Mollugo nudicaulis Lam.	Molluginaceae	H
Monochoria vaginalis (Burm.f.) C.Presl	Pontederiaceae	H
Morinda coreia Buch.-Ham.	Rubiaceae	T
Mukia maderaspatana (L.) M.Roem.	Cucurbitaceae	C
Murdannia nudiflora Santapau	Commelinaceae	H
Nechamandra alternifolia (Roxb. ex Wight) Thwaites	Hydrocharitaceae	H
Nelumbo nucifera Gaertn.	Nelumbonaceae	H
Neptunia oleracea Lour.	Leguminosae	H
Nymphaea elegans Hook	Nymphaeaceae	H
Nymphaea nouchali Burm.f.	Nymphaeaceae	H
Nymphaea pubescens Willd.	Nymphaeaceae	H
Nymphaea rubra Roxb. ex Andrews	Nymphaeaceae	H
Ocimum tenuiflorum L.	Lamiaceae	H
Oldenlandia corymbosa L.	Rubiaceae	H
Oldenlandia diffusa (Willd.) Roxb.	Rubiaceae	H
Oldenlandia stricta L.	Rubiaceae	H
Oldenlandia tenelliflora (Blume) Kuntze	Rubiaceae	H
Oldenlandia umbellata L.	Rubiaceae	H
Opuntia dillenii (Ker Gawl.) Haw.	Cactaceae	S
Oryza sativa L.	Poaceae	H
Ottelia alismoides (L.) Pers.	Hydrocharitaceae	H

Oxystelma esculentum (L. f.) Sm.	Apocynaceae	C
Pandanus odorifer (Forssk.) Kuntze	Pandanaceae	S
Panicum curviflorum Hornem.	Poaceae	H
Panicum repens L.	Poaceae	H
Parkinsonia aculeata L.	Leguminosae	T
Parthenium hysterophorus L.	Asteraceae	H
Paspalum distichum L.	Poaceae	H
Paspalum scrobiculatum L.	Poaceae	H
Passiflora foetida L.	Passifloraceae	C
Pedalium murex L.	Pedaliaceae	H
Pentatropis capensis (L. f.) Bullock	Apocynaceae	C
Perotis indica (L.) Kuntze	Poaceae	H
Phyla nodiflora (L.) Greene	Verbenaceae	H
Phyllanthus reticulatus Poir.	Phyllanthaceae	C
Phyllanthus virgatus G.Forst.	Phyllanthaceae	H
Physalis minima L.	Solanaceae	H
Pithecellobium dulce (Roxb.) Benth.	Leguminosae	T
Polianthes tuberosa L.	Asparagaceae	H
Polycarpaea corymbosa (L.) Lam.	Caryophyllaceae	H
Portulaca tuberosa Roxb.	Portulacaceae	H
Premna serratifolia L.	Lamiaceae	S
Prosopis juliflora (Sw.) DC.	Leguminosae	T
Pterospermum suberifolium (L.) Willd.	Malvaceae	T
Pycerus sp	Cyperaceae	H
Pycreus polystachyos (Rottb.) P.Beauv.	Cyperaceae	H
Reissantia indica (Willd.) N.Hallé	Hippocrateaceae	C
Reissantia indica (Willd.) N.Hallé	Celastraceae	C
Rhizophora mucronata Lam.	Rhizophoraceae	T
Rhynchosia minima (L.) DC.	Leguminosae	C
Rivea hypocrateriformis Choisy	Convulvaceae	C
Rotala indica (Willd.) Koehne	Lythraceae	H
Rungia repens (L.) Nees	Acanthaceae	H
Saccharum spontaneum L.	Poaceae	H
Sauropus bacciformis(L.) Airy Shaw	Phyllanthaceae	H
Schoenoplectiella articulata (L.) Lye	Cyperaceae	H
Schoenoplectiella supina (L.) Lye	Cyperaceae	H
Sesamum alatum	Pedaliaceae	H
Sesbania sesban (L.) Merr.	Leguminosae	T
Sida acuta Burm.f.	Malvaceae	H
Sida cordifolia L.	Malvaceae	H
Solanum violaceum Ortega	Solanaceae	H
Spermacoce articularis L.f.	Rubiaceae	H
Spermacoce hispida L	Rubiaceae	H
Sphaeranthus indicus L.	Asteraceae	H

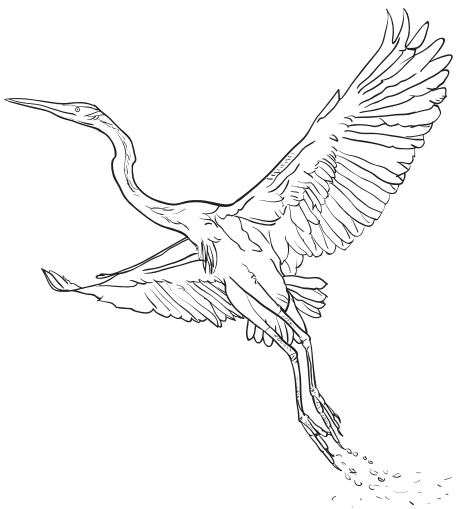
Sphenoclea zeylanica Gaertn.	Sphenocleaceae	H
Stachys byzantina K.Koch	Lamiaceae	H
Stachytarpheta indica (L.) Vahl	Verbenaceae	H
Stemodia viscosa Roxb.	Scrophulariaceae	H
Striga densiflora (Benth.) Benth.	Orobanchaceae	H
Stylosanthes fruticosa (Retz.) Alston	Leguminosae	H
Suaeda nodiflora Moq.	Amaranthaceae	H
Suaeda maritima (L.) Dumort.	Amaranthaceae	H
Suaeda monoica Forssk. ex J.F.Gmel.	Amaranthaceae	H
Syzygium cumini (L.) Skeels	Myrtaceae	T
Talinum portulacifolium (Forssk.) Asch. ex Schweinf.	Talinaceae	H
Tamarindus indica L.	Leguminosae	T
Tarenna asiatica (L.) Kuntze ex K.Schum.	Rubiaceae	S
Tephrosia purpurea (L.) Pers.	Leguminosae	H
Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	Combretaceae	T
Thespesia populnea (L.) Sol. ex Corrêa	Malvaceae	T
Tylophora indica (Burm. f.) Merr.	Apocynaceae	C
Typha angustifolia L.	Typhaceae	H
Utricularia stellaris L.f.	Lentibulariaceae	H
Vigna trilobata (L.) Verdc.	Leguminosae	H
Vigna unguiculata (L.) Walp.	Leguminosae	H
*Vitex negundo L.**	Lamiaceae	S
Volkameria inermis L.	Lamiaceae	S
Waltheria indica L.	Malvaceae	S
Ziziphus oenopolia (L.) Mill.	Rhamnaceae	C

*** Endemic**
H - Herb, S - Shrub, C - Climber, T – Tree

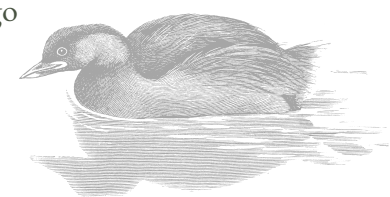
APPENDIX 2

Birds of Kazhuveli wetland from IFP's monthly surveys

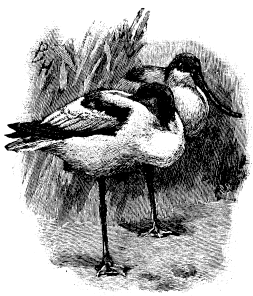
(Kalivelli Lake and its floodplain only i.e. the salt pan area and Uppukalli creek were not counted, 2017 – 2021)



Common name	Scientific name
1. Fulvous Whistling-Duck	*Dendrocygna bicolor*
2. Lesser Whistling-Duck	*Dendrocygna javanica*
3. Knob-billed Duck	*Sarkidiornis melanotos*
4. Cotton Pygmy-Goose	*Nettapus coromandelianus*
5. Garganey	*Spatula querquedula*
6. Northern Shoveler	*Spatula clypeata*
7. Eurasian Wigeon	*Mareca penelope*
8. Indian Spot-billed Duck	*Anas poecilorhyncha*
9. Northern Pintail	*Anas acuta*
10. Green-winged Teal	*Anas crecca*
11. Indian Peafowl	*Pavo cristatus*
12. Gray Francolin	*Ortygornis pondicerianus*
13. Jungle Bush-Quail	*Perdicula asiatica*
14. Greater Flamingo	*Phoenicopterus roseus*
15. Little Grebe	*Tachybaptus ruficollis*
16. Rock Pigeon	*Columba livia*
17. Eurasian Collared-Dove	*Streptopelia decaocto*
18. Red Collared-Dove	*Streptopelia tranquebarica*
19. Spotted Dove	*Spilopelia chinensis*
20. Laughing Dove	*Spilopelia senegalensis*
21. Greater Coucal	*Centropus sinensis*
22. Blue-faced Malkoha	*Phaenicophaeus viridirostris*
23. Chestnut-winged Cuckoo	*Clamator coromandus*
24. Pied Cuckoo	*Clamator jacobinus*
25. Asian Koel	*Eudynamys scolopaceus*
26. Gray-bellied Cuckoo	*Cacomantis passerinus*
27. Common Hawk-Cuckoo	*Hierococcyx varius*



Common name	Scientific name
28. Indian Nightjar	*Caprimulgus asiaticus*
29. Little Swift	*Apus affinis*
30. Asian Palm Swift	*Cypsiurus balasiensis*
31. Eurasian Moorhen	*Gallinula chloropus*
32. Eurasian Coot	*Fulica atra*
33. Gray-headed Swamphen	*Porphyrio poliocephalus*
34. Watercock	*Gallicrex cinerea*
35. White-breasted Waterhen	*Amaurornis phoenicurus*
36. Indian Thick-knee	*Burhinus indicus*
37. Black-winged Stilt	*Himantopus himantopus*
38. Pied Avocet	*Recurvirostra avosetta*
39. Pacific Golden-Plover	*Pluvialis fulva*
40. Yellow-wattled Lapwing	*Vanellus malabaricus*
41. Gray-headed Lapwing	*Vanellus cinereus*
42. Red-wattled Lapwing	*Vanellus indicus*
43. Kentish Plover	*Charadrius alexandrinus*
44. Little Ringed Plover	*Charadrius dubius*
45. Greater Painted-Snipe	*Rostratula benghalensis*
46. Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
47.Whimbrel	*Numenius phaeopus*
48.Eurasian Curlew	*Numenius arquata*
49.Black-tailed Godwit	*Limosa limosa*
50.Ruff	*Calidris pugnax*
51.Curlew Sandpiper	*Calidris ferruginea*
52.Temminck's Stint	*Calidris temminckii*
53.Little Stint	*Calidris minuta*
54.Common Snipe	*Gallinago gallinago*
55.Pin-tailed Snipe	*Gallinago stenura*
56.Terek Sandpiper	*Xenus cinereus*
57.Common Sandpiper	*Actitis hypoleucos*
58.Green Sandpiper	*Tringa ochropus*
59.Common Greenshank	*Tringa nebularia*
60. Marsh Sandpiper	*Tringa stagnatilis*



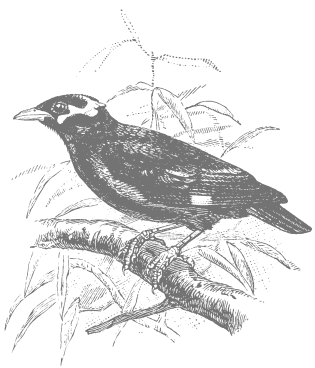
Common name	Scientific name
62. Wood Sandpiper	*Tringa glareola*
62. Common Redshank	*Tringa totanus*
63. Indian Courser	*Cursorius coromandelicus*
64. Oriental Pratincole	*Glareola maldivarum*
65. Black-headed Gull	*Chroicocephalus ridibundus*
66. Brown-headed Gull	*Chroicocephalus brunnicephalus*
67. Little Tern	*Sternula albifrons*
68. Gull-billed Tern	*Gelochelidon nilotica*
69. Caspian Tern	*Hydroprogne caspia*
70. Whiskered Tern	*Chlidonias hybrida*
71. Common Tern	*Sterna hirundo*
72. Asian Openbill	*Anastomus oscitans*
73. Asian Woolly-necked Stork	*Ciconia episcopus*
74. White Stork	*Ciconia ciconia*
75. Painted Stork	*Mycteria leucocephala*
76. Oriental Darter	*Anhinga melanogaster*
77. Little Cormorant	*Microcarbo niger*
78. Great Cormorant	*Phalacrocorax carbo*
79. Indian Cormorant	*Phalacrocorax fuscicollis*
80. Spot-billed Pelican	*Pelecanus philippensis*
81. Yellow Bittern	*Ixobrychus sinensis*
82. Black Bittern	*Ixobrychus flavicollis*
83. Gray Heron	*Ardea cinerea*
84. Purple Heron	*Ardea purpurea*
85. Great Egret	*Ardea alba*
86. Intermediate Egret	*Ardea intermedia*
87. Little Egret	*Egretta garzetta*

Common name	Scientific name
88. Western Reef-Heron	*Egretta gularis*
89. Cattle Egret	*Bubulcus ibis*
90. Indian Pond-Heron	*Ardeola grayii*
91. Striated Heron	*Butorides striata*
92. Black-crowned Night-Heron	*Nycticorax nycticorax*
93. Glossy Ibis	*Plegadis falcinellus*
94. Black-headed Ibis	*Threskiornis melanocephalus*
95. Eurasian Spoonbill	*Platalea leucorodia*
96. Osprey	*Pandion haliaetus*
97. Black-winged Kite	*Elanus caeruleus*
98. Oriental Honey-buzzard	*Pernis ptilorhynchus*
99. Short-toed Snake-Eagle	*Circaetus gallicus*
100. Indian Spotted Eagle	*Clanga hastata*
101. Greater Spotted Eagle	*Clanga clanga*
102. Booted Eagle	*Hieraaetus pennatus*
103. White-eyed Buzzard	*Butastur teesa*
104. Eurasian Marsh-Harrier	*Circus aeruginosus*
105. Pallid Harrier	*Circus macrourus*
106. Montagu's Harrier	*Circus pygargus*
107. Shikra	*Accipiter badius*
108. Black Kite	*Milvus migrans*
109. Brahminy Kite	*Haliastur indus*
110. Spotted Owlet	*Athene brama*
111. Short-eared Owl	*Asio flammeus*
112. Eurasian Hoopoe	*Upupa epops*
113. Common Kingfisher	*Alcedo atthis*
114. White-throated Kingfisher	*Halcyon smyrnensis*
115. Pied Kingfisher	*Ceryle rudis*

Common name	Scientific name
116. Asian Green Bee-eater	*Merops orientalis*
117. Blue-tailed Bee-eater	*Merops philippinus*
118. Indian Roller	*Coracias benghalensis*
119. Coppersmith Barbet	*Psilopogon haemacephalus*
120. Black-rumped Flameback	*Dinopium benghalense*
121. Eurasian Kestrel	*Falco tinnunculus*
122. Red-necked Falcon	*Falco chicquera*
123. Peregrine Falcon	*Falco peregrinus*
124. Rose-ringed Parakeet	*Psittacula krameri*
125. Indian Pitta	*Pitta brachyura*
126. Indian Golden Oriole	*Oriolus kundoo*
127. Ashy Woodswallow	*Artamus fuscus*
128. Common Woodshrike	*Tephrodornis pondicerianus*
129. Common Iora	*Aegithina tiphia*
130. Black Drongo	*Dicrurus macrocercus*
131. Ashy Drongo	*Dicrurus leucophaeus*
132. Indian Paradise-Flycatcher	*Terpsiphone paradisi*
133. Brown Shrike	*Lanius cristatus*
134. Bay-backed Shrike	*Lanius vittatus*
135. Long-tailed Shrike	*Lanius schach*
136. Rufous Treepie	*Dendrocitta vagabunda*
137. House Crow	*Corvus splendens*
138. Large-billed Crow	*Corvus macrorhynchos*
139. Ashy-crowned Sparrow-Lark	*Eremopterix griseus*
140. Jerdon's Bushlark	*Mirafra affinis*
141. Mongolian Short-toed Lark	*Calandrella dukhunensis*
142. Oriental Skylark	*Alauda gulgula*

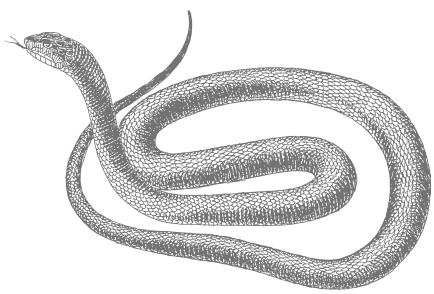
Common name	Scientific name
143. Common Tailorbird	*Orthotomus sutorius*
144. Ashy Prinia	*Prinia socialis*
145. Plain Prinia	*Prinia inornata*
146. Zitting Cisticola	*Cisticola juncidis*
147. Booted Warbler	*Iduna caligata*
148. Paddyfield Warbler	*Acrocephalus agricola*
149. Blyth's Reed Warbler	*Acrocephalus dumetorum*
150. Clamorous Reed Warbler	*Acrocephalus stentoreus*
151. Barn Swallow	*Hirundo rustica*
152. Red-rumped Swallow	*Cecropis daurica*
153. Red-vented Bulbul	*Pycnonotus cafer*
154. White-browed Bulbul	*Pycnonotus luteolus*
155. Lesser Whitethroat	*Curruca curruca*
156. Yellow-billed Babbler	*Argya affinis*
157. Rosy Starling	*Pastor roseus*
158. Brahminy Starling	*Sturnia pagodarum*
159. Common Myna	*Acridotheres tristis*
160. Indian Robin	*Copsychus fulicatus*
161. Oriental Magpie-Robin	*Copsychus saularis*
162. Pied Bushchat	*Saxicola caprata*
163. Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*
164. Purple-rumped Sunbird	*Leptocoma zeylonica*
165. Purple Sunbird	*Cinnyris asiaticus*
166. Loten's Sunbird	*Cinnyris lotenius*
167. Streaked Weaver	*Ploceus manyar*
168. Baya Weaver	*Ploceus philippinus*

Common name	Scientific name
169. Indian Silverbill	*Euodice malabarica*
170. Scaly-breasted Munia	*Lonchura punctulata*
171. White-rumped Munia	*Lonchura striata*
172. Tricolored Munia	*Lonchura malacca*
173. House Sparrow	*Passer domesticus*
174. Yellow-throated Sparrow	*Gymnoris xanthocollis*
175. Gray Wagtail	*Motacilla cinerea*
176. Western Yellow Wagtail	*Motacilla flava*
177. White-browed Wagtail	*Motacilla maderaspatensis*
178. Richard's Pipit	*Anthus richardi*
179. Paddyfield Pipit	*Anthus rufulus*
180. Tawny Pipit	*Anthus campestris*



APPENDIX 3

Reptiles of Kazhuveli wetland (from FERAL, UEF, and IFP surveys)



Common name	Scientific name
1. Indian Black Turtle	*Melanochelys trijuga*
2. Indian Flapshell Turtle	*Lissemys punctata*
3. Common Garden Lizard	*Calotes versicolor*
4. Southern Green	*Calotes calotes*
5. Peninsular Rock Agama	*Psammophilus dorsalis*
6. Fan-throated Lizard	*Sitana ponticeriana*
7. South Asian Chameleon	*Chamaeleo zeylanicus*
8. Eastern Bronze Skink	*Mabuya macularia*
9. Keeled Grass Skink	*Mabuya carinata*
10. Snake Skink	*Lygosoma punctatus*
11. Common Supple Skink	*Eutropis macularius*
12. Bark Gecko	*Hemidactylus leschenaultit*
13. Asian House Gecko	*Hemidactylus frenatus*
14. Termite Hill Gecko	*Hemidactylus triedrus*
15. Bengal Monitor Lizard	*Varanus bengalensis*
16. Red Sand Boa	*Eryx johnit*
17. Checkered Keelback Water Snake	*Xenochrophis piscator*
18. Buff Striped Keelback	*Amphiesma stolatum*
19. Olive Keelback Water Snake	*Atretium schistosum*
20. Indian Trinket Snake	*Coelognathus helena*
21. Common Wolf Snake	*Lycodon aulicus*
22. Common Bronzeback Tree Snake	*Dendrelaphis tristis*
23. Common Vine Snake	*Ahaetulla nasuta*
24. Banded Kukri Snake	*Oligodon arnensis*
25. Common Rat Snake	*Ptyas mucosus*
26. Common Indian Cat Snake	*Boiga trigonata*
27. Common Indian Krait	*Bungarus caeruleus*
28. Spectacled Cobra	*Naja naja*
29. Brahminy Worm Snake	*Ramphotyphlops braminus*
30. Saw-scaled Viper	*Echis carinatus*
31. Russell's Viper	*Daboia russelit*

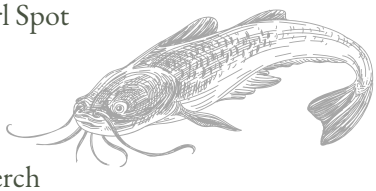
APPENDIX 4

Amphibians of Kazhuveli wetland (from FERAL, UEF, and IFP surveys)

Common name	Scientific name
1. Asian Common Toad	*Duttaphrynus melanostictus*
2. Ferguson's Toad	*Bufo scaber*
3. Painted Kaloula	*Kaloula taporbonica*
4. Skipper Frog	*Euphlyctis cyanophlyctis*
5. Common Tree Frog	*Polypedates maculatus*
6. Indian Green Frog	*Euphlyctis hexadactylus*
7. Skittering Frog	*Euphlyctis cyanophlyctis*
8. Indian Bullfrog	*Hoplobatrachus tigerinus*
9. Indian Burrowing Frog	*Sphaerotheca breviceps*
10. Ornate Narrow-Mouthed Frog	*Microhyla ornata*
11. Marbled Balloon Frog	*Uperodon systoma*

APPENDIX 5

Fish of Kazhuveli wetland (an crustaceans from FERAL, UEF, and IFP surveys)



	Common name	Scientific name
1.	Indian Short finned Eel	*Anguilla bicolor pacifica*
2.	Banded Pearl Spot	*Etroplus suratensis*
3.	Barramundi	*Lates calcarifer*
4.	Cat Fish	*Arius caelatus*
5.	Catla	*Catla catla*
6.	Climbing perch	*Anabas testudineus*
7.	Common Carp	*Cyprinus carpio carpio*
8.	Flathead Mullet	*Mugil cephalus*
9.	Gizzard Shad	*Anodontastoma chacunda*
10.	Glassy perchlet	*Parambassis sp.*
11.	Grass Carp	*Ctenopharyngodon idellus*
12.	Gray eel-catfish	*Plotosus canius*
13.	Indian Gizzard shad	*Anodontostoma chacunda*
14.	Indian Shortfin eel	*Anguilla bicolor*
15.	Mangrove snapper	*Lutjanus argentimaculatus*
16.	Milk Fish	*Chanos chanos*
17.	Mojarra fish	*Pentaprion longimanus*
18.	Mosquito fish	*Gambusia affinis*
19.	Pearl spot	*Etroplus suratensis*
20.	Rohu	*Labeo rohita*
21.	Sand Whiting Silver sillago whiting	*Sillago sihama*
22.	Silver Carp	*Hypothalamicthis molitrix*
23.	Sleepy globy	*Glossogobius giuris*
24.	Spotfin swamp barb	*Puntius sophore*
25.	Streaked spinefoot	*Siganus javus*
26.	Striped dwarf catfish	*Mystus vittatus*
27.	Striped Dwart Catfish	*Mystus vittatus*
28.	Striped Snakehead	*Channa striata*
29.	Striped spiny eel	*Macrognathus pancalus*
30.	Target perch	*Terapon jarbua*
31.	Tilapia	*Oreochromis mossambicu*
32.	Mud crab	*Scylla serrata*
33.	Swimming crab	*Portunus pelagicus*
34.	Indian prawn	*Fenneropenaeus indicus*
35.	Tiger prawn	*Penaeus monodon*

APPENDIX 6

Mammals of Kazhuveli wetland (from FERAL, UEF, and IFP surveys)

	Common name	Scientific name
1.	Bonnet Macaque	*Macaca radiata*
2.	Small Indian Civet	*Viverricula indica*
3.	Common palm Civet	*Paradoxurus hermaphroditus*
4.	Common Indian Mongoose	*Herpetes edwardsi*
5.	Ruddy Mongoose	*Herpestes smithi*
6.	Jackal	*Canis aureus*
7.	Indian porcupine	*Hystrix indica*
8.	Indian Pangolin	*Manis crassicaudata*
9.	Flying Fox	*Pteropus giganteus*
10.	Shortnosed Fruit Bat	*Cynopterus sphinx*
11.	Indian Pipistrelle	*Pipistrellus coromandra*
12.	Three Stripped Palm Squirrel	*Funambulus palmarum*
13.	Indian Gerbil	*Tatera indica*
14.	Indian Mole Rat	*Bandicota bengalensis*
15.	Large Bandicoot	*Bandicota indica*
16.	Indian Field Mouse	*Mus booduga*
17.	Long Tailed Tree Mouse	*Vandeleuria oleracea*
18.	White Tailed Wood Rat	*Cremnomys blanfordi*
19.	Indian Bush Rat	*Golunda ellioti*
20.	Common House Rat	*Rattus rattus*
21.	Bandicoot rat	*Bandicota indica*
22.	House Mouse	*Mus musculus*
23.	Mice	*Mus sp.*
24.	Black Naped Hare	*Lepus nigricolis*

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Fishbone landscape, Kazhuveli wetland 2020 © Mathevet R. – IFP

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