BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE BENCH AT CHENNAI
APPLICATION NO 14 OF 2022

IN THE MATTER OF:
M. Yuvadeeban

... Applicant

Versus

Department of Fisheries & 4 Ors.

...Respondents

INDEX

BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE BENCH AT CHENNAI

APPLICATION NO 14 OF 2022

M. Yuvadeeban
S/o Maragret Lawrence,
Aged about 26 Years,
B2, Ramaniyam Marvel, Seshdripuram, 1st Main Road,
Velacherry,
Chennai – 600 042. ... Applicant

-AND-

1. Department of Fisheries
Government of Tamilnadu
Rep by its Executive Engineer
Fishing Harbour Project Division
Nandanam, Chennai – 600 035
Ph: 9566254546.
tnfisheries@nic.in

2. Tamil Nadu State Environment Impact Assessment Authority

Rep by its Member Secretary,
Third Floor, PanagalMaligai,
No.1 Jeenis Road, Saidapet,
Chennai-600 015,
Tamilnadu.
Tel: 044-24359973
mstnselaa@yahoo.com

3. Principal Chief Conservator of Forests & Chief Wildlife Warden

Forest Department
Government of Tamilnadu
Tel: 044-24321738
pccf-tn@nic.in

Executive Engineer
Fishing Harbour Project Division
Chennai.

4. Tamilnadu State Coastal Zone Management Authority,

Through the Member Secretary,
Panagal Building, Saidapet
Chennai-600 032.
Tel: 044-24336594
mstnsc2ma@yahoo.com

5. Ministry of Environment, Forest and Climate Change,

Through the Principal Secretary,
Panagal Building, Saidapet
Chennai-600 032.
Tel: 044-24336594
mstnsc2ma@yahoo.com

... Respondents

COUNTER AFFIDAVIT OF 1st RESPONDENT

I, M.Murugesan, S/o C.Muthian aged about 59 years, do hereby solemnly affirm and sincerely state as follows.

1. I am the 1st respondent herein, and discharging my duty as the Executive Engineer, 2nd Floor, Integrated Office Complex for Animal Husbandry and Fisheries Department, Nandanam, Chennai – 600 035, as such I am well acquainted with the facts and circumstances of this case from the available records. I have perused the affidavit filed by the applicant in support of documents. I deny all the averments. I am filing this application for myself and on behalf of the respondent 1.
2. The appellant is an individual, who is not an expert in this field and is hardly competent to vouch for the statements made by him in an erratic fashion. None of his statements are based on government authenticated materials.

Executive Engineer
Fishing Harbour Project Division
Chennai.

The para-wise reply for the rejoinder of the appellant is detailed as below.

5. The EIA Report, under section 4.10.2 Impact during Operation Phase has recognized the ecological sensitivity of the estuary along with the Kaluveli Tank, which has been recognized as an important bird area by Birdlife International. Similarly, the Tamil Nadu Forest Department too has recognized the Kaluveli Wetland as an important area that serves as cover for large birds in its publication titled "Kazhuveli Wetland – Tamil Nadu Forest Department by Villupuram Forest Division Tamil Nadu, 2015", annexed as Annexure-1. It is to be noted that the Forest Department has identified only the Kaluveli Tank (Kaluveli Wetland) as an important area that serves as cover for large birds (Page No.5 of the Publication). In an EIA Report, the references can only be cited from authorized publication by the government of India, International Conventions, or EIA Reports of projects that have been appraised to and approved by the Expert Appraisal Committee. Though there are reference to Yedayanthittu Estuary being a link to the Kaluveli Tank / Wetland, it is neither recognized / identified as an area of ecological importance by any state department nor declared as protected area under the Wildlife (Protection) Act, 1972. The reference of Birdlife international / Bombay Natural History Society (BNHS) that the Appellant has cited are publications made by non-governmental organization, and the boundary demarcation of the cited source only demarcates the Kaluveli Tank and does not extend or include the Yedayanthittu Estuary (File C, S.No. 3, Kaluveli Wetland IBA Classification, Page No.8).

6. a) The 1st Respondent acknowledges the citing of the Appellant, however the EIA Report can only be prepared based on references can only be cited from authorized publication by the government of India, International Conventions, or EIA Reports of projects that have been appraised to and

Executive Engineer
Fishing Harbour Project Division
Chennai.

approved by the Expert Appraisal Committee. The quoted declaration of an Important Bird Area (IBA) referenced by the Appellant are based on the claims of two Non-Governmental Organization, Birldlife International and BNHS whose claims cannot be considered as an authorized declaration.

6. b. The 1st Respondent acknowledges the claim of the Appellant that the wetland has been identified as intertidal area. The same has also been mentioned in the EIA Report as well as CRZ Report prepared by the National Centre for Sustainable Coastal Management, Chennai.

6. c. The Annexure A-51 annexed by the Appellant, which cites Wetland of India Portal refers the Kaliveli Tank and Yedayanthittu Estuary part of Thiruvallur District with an area of 7500 hectares which is identified as "Wetland of International Significance". The same portal also refers Kaliveli Lake part of Viluppuram District with an area of 3262 hectares, which is identified as "Other Wetland". The reference to which is annexed as Annexure-2. The Wetland of India Portal has been developed under the Indo-German project on "Wetlands Management for Biodiversity and Climate Protection" (2018-2023), and is still under progress. With the ambiguity in the representation of information of the same area, any information cited from this portal cannot be considered as an authorized information until the time that the project is declared complete, the data validated, and officially approved by the Ministry of Environment, Forest and Climate Change (MoEF&CC).

The Office Memorandum of MoEF&CC dated 8th March, 2022 with the Subject "Protection of Wetlands as per Rule 4 of the Wetlands (Conservation and Management) Rules, 2017" sates that in view of the direction of the Hon'ble Supreme Court vide Order dated 4th October, 2017 in W.P. (C) No. 230 of 2002 that "We make it clear and reiterate that in terms of our order dated 8th February, 2017, 2,01,503 wetlands that have been mapped by the Union of India should continue to remain protected on the same principles as were formulated in Rule 4 of the Wetlands

Executive Engineer
Fishing Harbour Project Division
Chennai.

(Conservation and Management) Rules, 2010", "it is once again clarified / reiterated that the 2,01,503 wetlands (>2.25 ha) as per the national Wetland Inventory and Assessment (NWIA), 2011 should be protected as per Rule 4 of the Wetlands (Conservation and Management) Rules, 2017. This protection is irrespective of the applicability of/notification as per the said rules". It shall be noted that Rule 4 clause (2) subclause (vi) of the Wetlands (Conservation and Management) Rules, 2017 prohibits activities within the wetland, namely "any construction of a permanent nature except for boat jetties within fifty metres from the mean high flood level observed in the past ten years calculated from the date of commencement of these rules". The proposed project for which the Environmental Clearance was granted by the State Environmental Impact Assessment Authority (SEIAA) is considered as a facility for berthing boats and is a permitted activity under the Wetland (Conservation and Management) Rules, 2017

6.d. The 1st Respondent acknowledges citation to the quoted report by the Appellant and recognizes Kaliveli as an Important Coastal and Marine Biodiversity Areas of Peninsular. The map encompasses the entire wetland system from the Kaluveli Tank till the point at which it confluence with the sea. Though the entire system is observed with the biological diversity and recognizing the significance of the biological diversity and density of the area, the Kaluveli Tank has been demarcated as a protected area (Bird Sanctuary) by the Forest Department. The G.O(Ms) No.123 (Environment Climate Change and Forests (FR.5) Department) dated: 06.12.2021 is annexed in Annexure A-5.

6. e. The 1st Respondent acknowledges the statement of the Appellant, and hence the fishing harbours along with the training walls have been proposed for development to improve the tidal fluctuation within the estuary and enhance the biological diversity for improving the catch of artisanal and women fisherfolks who fish along the coast and estuary; thereby enhancing their livelihood.

Executive Engineer
Fishing Harbour Project Division
Chennai.

6. f.,33.,34. The citing of the cetaceans along the Northern coast of Chengalpattu District and Southern Coast of Villupuram District have rare spotting by the fishermen. The reported spotting dates to 2016, and there had been no such spotting or incidents.

7. The ecologically sensitivity of the entire wetland system including the Yedayanthittu Estuary was assessed by the EIA Consulting organization and also was recognized by the Forest Department for Kaluveli Wetland for its ecological significance. The aspects listed under point 7 has been mentioned in the EIA report for which the mitigation measures have been contemplated and presented, that is acknowledged for adoption and implementation by the Department of Fisheries. Furthermore, the construction of the training wall and the shallow deepening of the estuarine region for the conveyance of the boats would only improve the tidal fluctuation and enhance the biological diversity and density of the estuarine aquatic lives. Historically, the mouth of the estuary is mostly close preventing the tidal fluctuation affecting the upstream brackish water aquatic lives, and the estuarine mouth is only opened during the event of floods and cyclones,

8. The two fishing harbours at Alamparaikuppam and Azhagankuppam that have been granted the Environmental Clearance were proposed as a welfare measure upon the request of thousands of fishermen from the surrounding area who are not privileged of having a proper facility to store, pack and sell their daily catch to the market. Currently, the most of the catch are spoilt and discarded which affects the daily livelihood and income of those thousand fishermen and their dependent family. Moreover, the proposed project area is where the fishermen tie their boats which at times get stolen or get washed off into the sea due to the lack of the requisite docking facilities, which again affect those fishermen families.

9. No response sought by the Appellant.

Executive Engineer
Fishing Harbour Project Division
Chennai.

10. It is saddening to note that the Appellant fails to understand the ground reality of the fisherfolk along the coast of Chengalpattu District and Villupuram District. The fishermen in the fishing villages along the coasts of the two districts mount the fishing boats on the beaches at their own risk from being stolen or washed off into the sea. Recognizing the impact on the fishermen and their families' livelihood and survival, and the repeated requests submitted by the local fishermen of the two districts the two fishing harbours have been proposed for development to accommodate all types of Fishing boats without any prejudice against any particular category as stated by the appellant.

11. The two fishing harbours have been proposed by the Department of Fisheries without prejudice against any artisanal, inland, women or small-scale fisherfolk of the two districts. The infrastructure development is developed for better management of the fish catch with hygiene and cleanliness along with the safety of fishing crafts –mechanized, motorized and country boats. The 1stRespondent would like to bring it to the kind attention of the Hon'ble court that the fishes from the Chennai Kasimedu Harbour was banned from being exported to the European Union countries due to the lack of facilities that ensure safety with respect to hygiene and cleanliness of the place where the fishes were cleaned and packed for export. With Chengalpattu and Villupuram Districts having high potential for fish catch of export quality, the Fisheries Department intended to provide the local fishermen, irrespective of the type of fishing activity they're involved, the access to good infrastructure for quality produce and export opportunities.

12. The denial of the para 4 and 5 of the counter affidavit of the 1st Respondent by the Appellant clearly states the inability of the Appellant to comprehend the meaning and the process followed in proposing the sites for development and seeking the requisite Environmental Clearance from the Tamil Nadu State Environmental Impact Assessment Authority. The

Executive Engineer
Fishing Harbour Project Division
Chennai.

preliminary assessment for the Detailed Project Report was undertaken through a globally recognized institution that specializes in physical marine assessment and modelling through their software MIKE 21, which is used by many of the government agencies under the Government of India and other countries. The Department of Fisheries has undertaken the process of feasibility assessment and other due diligences for the proposed fishing harbour is good spirits of upholding environmental protection, governance and livelihood upliftment.

13. The Appellant appears to have a general understanding on the monsoon pattern of the country and the state of Tamil Nadu, however lacks the understanding of how the two monsoons – Southwest and Northeast Monsoons influence the state. It is stated by the India Meteorological Department in its publication titled "Climate Profile of India" that the state of Tamil Nadu benefits from the Northeast Monsoon or Retreating Southwest Monsoon season which sets during mid-October and extends until end of December. The Appellant could have mistakenly understood "Retreating Southwest Monsoon" as "Southwest Monsoon". Hence the baseline collected by the EIA Consultant between 19.07.2020 to 09.10.2020, as acknowledged by Appellant, is in compliance with the CPCB Norms to undertake baseline studies during non-monsoon season.

14. The 1st Respondent has undertaken the ecological assessment and verification by three organizations specialized in coastal biodiversity 1) National Centre for Sustainable Coastal management (MoEFCC, Govt. of India) for CRZ Mapping, 2) Cholamandalam MS Risk Services Limited (NABET Accredited EIA Consulting Organization) for EIA studies, and 3) Centre for Advanced Study in Marine Biology, Annamalai University (national institute of repute in coastal and marine biology) for undertaking special studies on the estuarine and coastal biodiversity as specifically mentioned by the Tamil Nadu State Environmental Impact Assessment Authority in its Terms of Reference for the proposed project. Therefore, the

Executive Engineer
Fishing Harbour Project Division
Chennai.

1st Respondent has considered and acknowledged the environmental aspects of the proposed project and has undertaken the requisite due diligence while submitting the proposal to the Tamil Nadu State Expert Appraisal Committee (SEAC). Therefore, the Appellant claim shall not be accepted.

15. The Appellant's denial of the para 8,9,10 and 11 of the counter affidavit filed by 1st Respondent on the sequence of the events with specific reference to the dates and details of the recommendations of committee leading up to the granting of the Environmental Clearance enunciates their claims against the project to be on personal grounds rather than being sensible. The 1st Respondent has clearly stated in para 11 that "the State Expert Appraisal Committee (SEAC) during its 217th meeting ..... has directed to represent again after submitting further additional detail." When the SEAC seeks additional details mean they had deferred the project during the meeting. The 1st Respondent did not evidently state that the project was deferred, as it was thought the Appellants is conversant with the procedures and terminology in the Environmental Clearance process.

16. To be responded by SEAC / SEIAA

17. It is very evident that the Appellant is not abreast with the regulations and the guidelines issued by the Ministry of Environment, Forest and Climate Change (MoEF&CC) for projects requiring Environmental Clearances. It is to be noted that the MoEF&CC in its Office Memorandum (OM) dated 5th February, 2020 (Annexure-4) has stated that "All the projects requiring Environmental Clearance may be exempted from obtaining the Consent to Establish (CTE). Such project may be directly granted Consent to Operate subject to EC and installation of pollution control devices." The OM also has stated that "If the decision for rejection of CTE is not communicated by the SPCB / UTPCC to the Ministry or SEIAA, as the case may be, before the meeting of EAC, it will be deemed that there are no specific comments / objections to the SPCB." The 1st

Executive Engineer
Fishing Harbour Project Division
Chennai.

Respondent pursuant to the aforementioned OM is compliant to the process without any non-compliance or has illegally commenced the project as stated by the Appellant.

18. 1st Respondent has already filed Counteraffidavit for the appeal raised by appellant.

19.For para 19 and 23, the total shoreline changes of 2005 – 2017 reported to be 60m, it is at the estuary mouth and not thought the shoreline. The estuary mouth is a dynamic in nature and shoreline changes in the estuary region completely depends on the flooding from inland in the monsoon period and on the other side the wave conditions from the ocean, the impact of cyclone/Tsunami will also alter the estuary dynamics to a greater extend. The appellant has failed to understand the DPR. Hence, the allegation is false and baseless.

20.The training walls (breakwater to keep the estuary open all times) proposed will have impact on the northern side but as shore protection measure the proponent has proposed groin fields. The dredged material from the estuary mouth will be dispersed along the groin field and the dispersed sediment will be held between the groin fields. The material later will be transported within the sediment cell makes nullify the erosion impacts on the northern part of the coastline. As far as the beach nourishment is considered the nourishment with groin field will give better results as the sediments are trapped between the groins. Thus, beach nourishment alone will not suffice the problem but groin with beach nourishment will be a technically sound option hence suggested for this case. 1st Respondent appreciates the Appellant for taking time to read through the prefeasibility report and the EIA report the sections pertaining to the shoreline change. But, the Appellant has failed to read the proposed mitigation measures (Section 4.9.1.4), where the dredged material of 0.4 M.Cum from the navigation channel between the two training walls will be

Executive Engineer
Fishing Harbour Project Division
Chennai.

deposited in the area identified as eroding area which will act as a sand bank to counter the predicted erosion.

21.The construction of training wall including the groin along with the beach nourishment is propose in the project, as a part of shoreline management measure will help the existing coastline from erosion. Which is evident from the Application No.04 of 2013, dated 11.04.2022.

22. Considering the need for resolute coastal processes and shoreline management the National Centre for Coastal Research (NCCR), Chennai an attached office of Ministry of Earth Sciences, Government of India has National Shoreline Assessment system (N-SAS) is engaged in mapping the shoreline changes along the Indian Coast to enhance country's preparedness to face coastal hazards like storm surges, Tsunami,etc and guide towards sustainable coastal development. NCCR has prepared a status report i.e., the years 1990, 2000, 2006, 2008, 2012, 2013, 2014, 2015, 2016, 2017, 2018. It provides details of shoreline changes, 3 types of map like shoreline vulnerability for erosion/accretion, landloss/land gain and for the entire mainland coast of India. These maps will be available online for each of the coastal states/ UT on the NCCR's website. As per NCCR's report Nagapattinam district (Poompuhar) comes under High erosion trend, which is more vulnerable and the coast of alagankuppam and alamparaikuppam comes under stable, low and moderate rate of erosion as per NCCR's Report. In severe eroding coast like Poompuhar, any structure will have negative impact. Extract of map from the NCCR's web site for reference is enclosed in Annexure-7. The appellant allegation is denied as false and baseless.

24. It is stated by the India Meteorological Department in its publication titled "Climate Profile of India" that the state of Tamil Nadu benefits from the Northeast Monsoon or Retreating Southwest Monsoon season which

Executive Engineer
Fishing Harbour Project Division
Chennai.

sets during mid-October and extends until end of December. The Appellant could have mistakenly understood "Retreating Southwest Monsoon" as "Southwest Monsoon". Hence the baseline collected by the EIA Consultant between 19.07.2020 to 09.10.2020 which is stated as a non-monsoon season in Section 3.1 of the EIA Report is in compliance with the CPCB Norms to undertake baseline studies during non-monsoon season. Further, the inability of the Appellant to read through the EIA Report by NABET Accredited EIA Consultant and the Marine Biodiversity Impact Assessment by Centre for Advance Study in Marine Biology, Annamalai University has caused the Appellant to make false claims and allegation on the EIA Report and other additional ecological studies undertaken for the proposed fishing harbours.

25. For para 25 and 36, the appellant seems to have no understanding of the estuarine dynamics and the importance of tidal fluctuation in the sustenance and enhancement of aquatic biodiversity. Estuaries serve as a nursery for many marine aquatic organisms and opening of the estuary mouth will increase movement of marine aquatic species into estuary. The increased tidal fluctuation into the estuary will only cause shift in the distribution of the aquatic species towards upstream but will not impact the survival as stated by the Appellant. It is to be noted that the survival of the estuary is solely due to the overflow from the Kaluveli Tank and the tidal fluctuation from the Bay of Bengal. In the event of lean rainfall leading to no downstream flow of freshwater from the Kaluveli Tank, and an estuary whose mouth is closed by siltation would lead to severe collapse of life due to hyper-salinity, a situation that is evidenced at Pulicat Lake. Hence, the claim of the Appellant can logically be treated correct, but scientifically flawed.

26. The Appellant has again failed to do his due diligence on the advertisements for Public Hearing Notices. The Notices for both the Public Hearing for the two proposed fishing harbours were made in Indian Express

Executive Engineer
Fishing Harbour Project Division
Chennai.

on 10th December 2020 in The New Indian Express, in English, and in Dhina Mani, in Tamil and not in English as claimed by the Appellant. It should be noted by the Appellant that the points raised and submitted during the Public Hearing has been judiciously noted and issued to the 1st Respondent by the Tamil Nadu State Pollution Control Board for which the responses have been provided in the EIA Report. Hence, the claim of the Appellant is unsupported and false.

27. The Appellant is unable to comprehend the explanation provided towards the rationale of proposing the two fishing harbours and the due diligence undertaken to understand the ecological sensitivity of the project area along with the abidance to the regulatory procedure for obtaining the CRZ recommendation from the Tamil Nadu Coastal Zone Management Authority (TNSCZMA) and the Environmental Clearance from the TNSEIAA. The appellant has blatantly denied the explanation as false by simple stating them to be repetitive and contrary.

28. The Appellant appears to be approaching this case in a vindictive manner by blatantly lashing out with falsifying claims and replies. It should be noted that the CRZ Maps that were prepared by the National Centre for Sustainable Coastal Management (NCSCM), who are considered the guardian of the CRZ Maps prepared, had prepared the map not only basing on the approved CZMP of the State of Tamil Nadu, but also basing on the evidence collected from ground verification conducted on 3rd January 2020. The ground verification is being undertaken by the MoEF&CC approved agency for preparing the CRZ Map, to assess for any variation from the approved CZMP. The Hon'ble court should note that the proposed site of Alamparaikuppam fishing harbour is marked as an intertidal area in the approved CZMP, however duringground verification the site was spotted with mangrove saplings which has been illustrated in the CRZ map that was prepared in compliance with the CRZ Notification 2011 by NCSCM. Moreover, the CZMP only provides the general demarcation of CRZ-IA, and

Executive Engineer
Fishing Harbour Project Division
Chennai.

does not identify the ecologically sensitive areas) ESAs. The CRZ Map prepared for the project has distinguished the ESAs near the project site as Sand Dunes, Mangroves, Mudflats, Salt Marshes, Reserve Forests, and Archaeological Important and Heritage Sites.Hence, the ESAs classified as CRZ-IA area have been verified and incorporated into the CRZ Maps. Therefore, the claim of the Appellant is denied and baseless. The Appellant is proving to be having limited knowledge of the process and has made false claims as the ESAs that he believes could stop the project from being executed are not present in the project site.

29. The Appellant is being ignorant of the fact that all conservation measures in India is to be governed and administered by the respective Forest Department. The appellant is again found to place his argument based on logics and not on regulatory and scientific reasons. The Appellant should understand the meaning of "Sporadic" which refers to an occasion that occur occasionally or at random instance. The Report by Annamalai University has stated the turtle nesting to be sporadic as the number of turtle nests found were 50-70 within the study area of 10 km radius, which translated the observation of those 50-70 nests in a stretch of 20 km shore, equating to 3.5 nests per km, considering that the nests are evenly spread across the entire stretch. Hence the claim of the Appellant is considered false and baseless.

30. The reference number cited by the Appellant states that 36,000 hatchlings have been released from this coast, but it does not state that the eggs were laid in the coast of Alamparaikuppam of Chengalpattu District or Azhagankuppam of VIllupuram District. It is to be noted that the State Forest Department sets one hatchery per coastal district which collects the eggs laid along the entire shore of the district. If the number of hatchlings is accounted for the entire district, either Villupuram or Chengalpattu, the ratio of hatchlings to coastal shoreline will result in a very low percentage of nesting. Also, based on the number of nests

Executive Engineer
Fishing Harbour Project Division
Chennai.

identified at Azhagankuppam by the State Forest Department, which is 33 nests at a distance 3.17 km from the project site, qualifies that the coastal stretch near the proposed training wall site houses a sporadic nesting of sea turtles. Further, the Appellant should note that when turtles return to the shore from where they were released, they do not arrive to the same exact location, and there would be a shift in their rookery based on the feasibility and suitability of nesting landscape. Therefore, the claim by the Appellant can be treated as null and void.

31. The Appellant is discounting and not considering any of the reports / G.O on turtle nesting sites published by both central and state government authorities. The G.O Ms. No. 146 by Animal Husbandry, dairying and Fisheries (FS-3) dated 27th September 2016 is enclosed in Annexure-6 has listed all the potential turtle nesting sites along the coast of Tamil Nadu. The villages listed in the G.O were sites identified by the Central Marine Fisheries Research Institute and Department of Forest as stated in it, which falls in line with the statement made by the Appellant "Nesting grounds can be identified based on nesting data that is available with the forest department". It is requested that the Appellant shall do a proper review of the documents he is quoting before making false allegation on the Tamil Nadu Department of Fisheries.

32.The Appellant has once again made a logical reasoning and has failed miserably to apply his mind due to his misconception on how a harbour operates and how frequent the fishermen venture into the sea. The Appellant must be aware that MFVs venture into sea on long fishing expeditions for more than three days. In order to keep the continuous movement of vessels into the sea for sustained availability of fish catch, the fishing vessels venture into the sea in batches of 55 vessels a day from both proposed fishing harbours at Azhagankuppam and Alaparaikuppam. Therefore, the claim of increased traffic due to movement of 220 vessels causing spell death knell for turtles is absurd and baseless.

Executive Engineer
Fishing Harbour Project Division
Chennai.

33.For para 37, the 1st Respondent will not introduce any non-native mangrove species into the ecosystem, as it could have an ecological impact which can either be positive or negative. Acknowledging the recommendation of the Appellant no non-native mangroves will be introduced into the Kaluveli Ecosystem. However, the proposed fishing harbours project will have a significant positive impact on the avian, terrestrial and aquatic life of the Kaluveli wetland system, which the Appellant will realize post commissioning of the two harbours.

34. For para 38, the two fishing harbours along with two training walls at the mouth of the estuary have been proposed as a project for better and sustainable management of the resources within the estuarine system. This claim is based on the fact that the training walls will aid in improving the aquatic and terrestrial lives of the estuarine system, not only in close vicinity but also upstream. Further, the proposed fishing harbour would serve as a platform for the fishermen of both the districts to market their catch better due to the better quality of fishes that they would be able to offer from the supporting facilities proposed within the two harbours. The project should be seen holistically as a welfare project than being advertised as a project causing harm to the environment, which is falsely being claimed and publicized by the Appellant due to his evident limited knowledge on resource conservation, management and livelihood development.

35. After 2015, The Department of Fisheries has taken several initiatives as per Tamilnadu Marine Fishing Regulation Act, (Tamilnadu Act 8 of 1983) and issued G.O.(Ms) No.186 dated 30.09.2015 for Mandatory use of Turtle Excluder Device in Trawl nets during the Specified period(Breeding and nesting period of Turtles). The CIFT-TED design was approved on 22.08.2022. The Effective implementation is done by marine enforcement wing.

Executive Engineer
Fishing Harbour Project Division
Chennai.

In the light of above facts and circumstances, it is most respectfully prayed that this Honourable Tribunal may please to

1. Dismiss this application under grounds that the facts stated by the applicant is totally false, against truth, baseless and motivated.
2. May be allowed to continue the work, as the fisheries department has followed all the procedures and norms in obtaining CRZ and environmental clearances.
3. Being the public welfare scheme and Government project, delay in execution affects the general public in getting their basic rights in time and also escalation in project cost, which is again the public money will be spent for creating this Fishing Harbour.

solemnly affirmed at Chennai on
this day of 23 September 2022 and singed
in my presence.

Before me

Advocate: Chennai

Executive Engineer
Fishing Harbour Project Division
Chennai.

Annexure-1


KAZHUVELI WETLAND
Tamil Nadu Forest Department
Villipuram Forest Division
Tamil Nadu
2015

Villupuram division

Villupuram territorial division, formed in 1957, is one of the oldest divisions in Tamil Nadu and is part of Villupuram and Cuddalore Districts. Total area under this Division is 48703.13 Ha, out of which 24017.24 ha. was leased out to TAFCORN. Of the remaining 24685 Ha., 20707.92 Ha. falls under Villupuram District and 3977.97 Ha. belongs to Cuddalore District.

Kazhuveli wetland

Kazhuveli, the second largest brackish water wetland in South India, with an area of 7040 ha. is located in Tindivanam Range of Villupuram Forest Division, Villupuram District of Tamil Nadu. It is about 18 Km to the north of Pondicherry with catchment of 73.81 Sq. Km. It is located between 11° 55' and 12° 10'N and 79° 35' and 79° 55'E. The Kazhuveli Watershed falls under 2 Blocks viz., Vanur and Marakkanam in Villupuram District.


Kazhuveli translates to mean "a pathway through the backwaters"
Cattle Egret in breeding plumage
Information is a way to Conserve!

"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

- Ramsar Convention.

Wise use of wetlands is the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development."

Spot-billed Pelican

Satellite Location of Kazhuveli Wetland

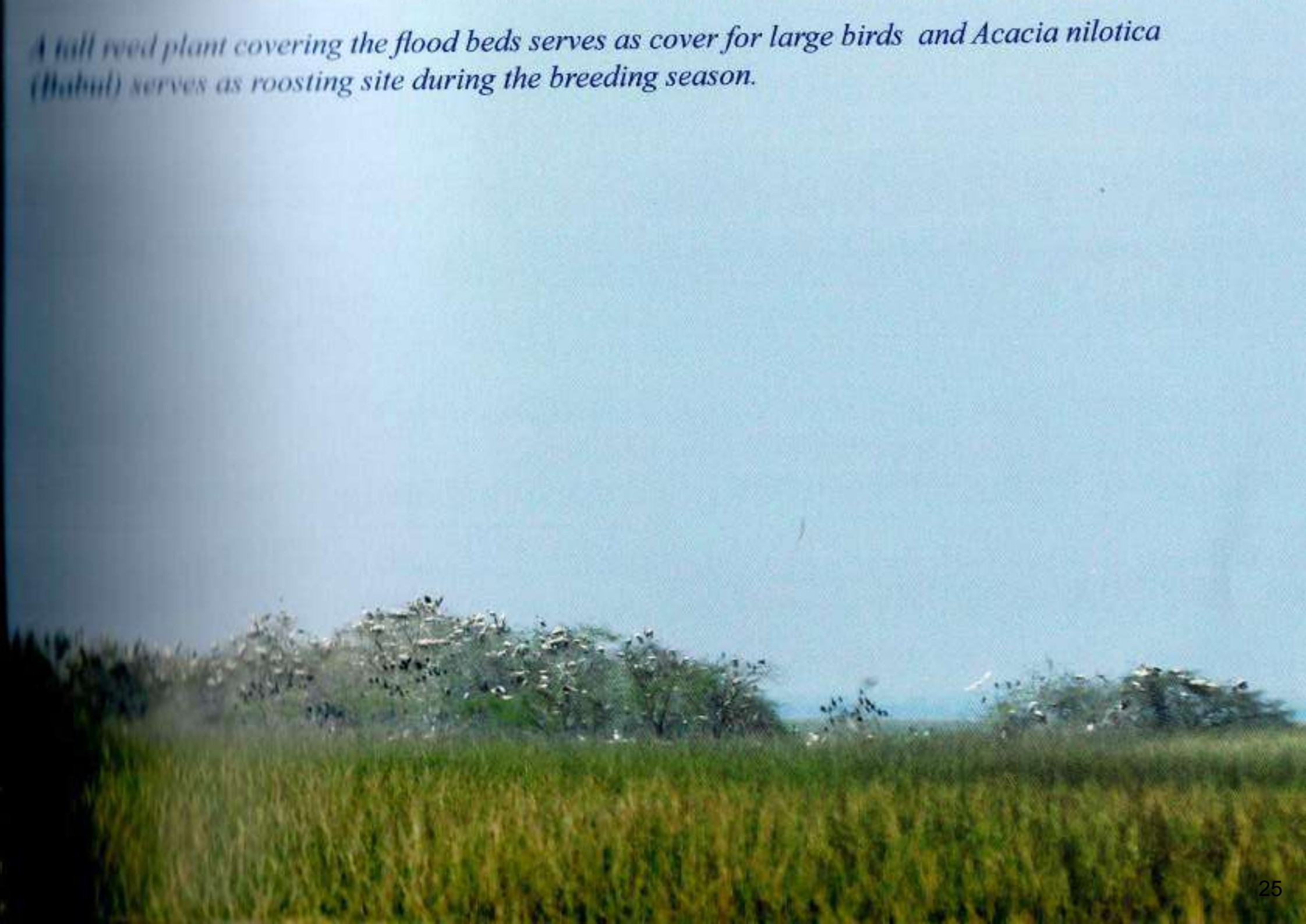
Kazhuveli wetland is linked to the scenic Yedayanthittu estuary through a tidal creek Uppukali, 8 Km further north. Being a narrow strip of land Uppukalli creek joins the southern and western fresh water body with the saline estuarine portion to the north east.

The wetland opens out to the Bay of Bengal at the Yedayanthittu estuary in the North and extends southwards parallel to the east coast. So the wetland comprises of 2 distinct parts, an estuarine part at its mouth and a fresh water part towards the southern and eastern end.

Summary of Kazhuveli Wetland

Location	*Tindivanam Tk, Villupuram Dt, Tamil Nadu. Between Marakanam and Pondicherry, 18 km North of Pondicherry. 11° 55' and 12° 10' north and 79° 35' and 79° 55' east.*
Altitude	*maximum of 5 m above MSL*
Rain fall	*127 cm per annum*
Temperature	*23°C - 35°C*
Area	*70.47 Sq. Km.*
No. of villages around the wetland	*16 +*
Dependent Population	*64,800*

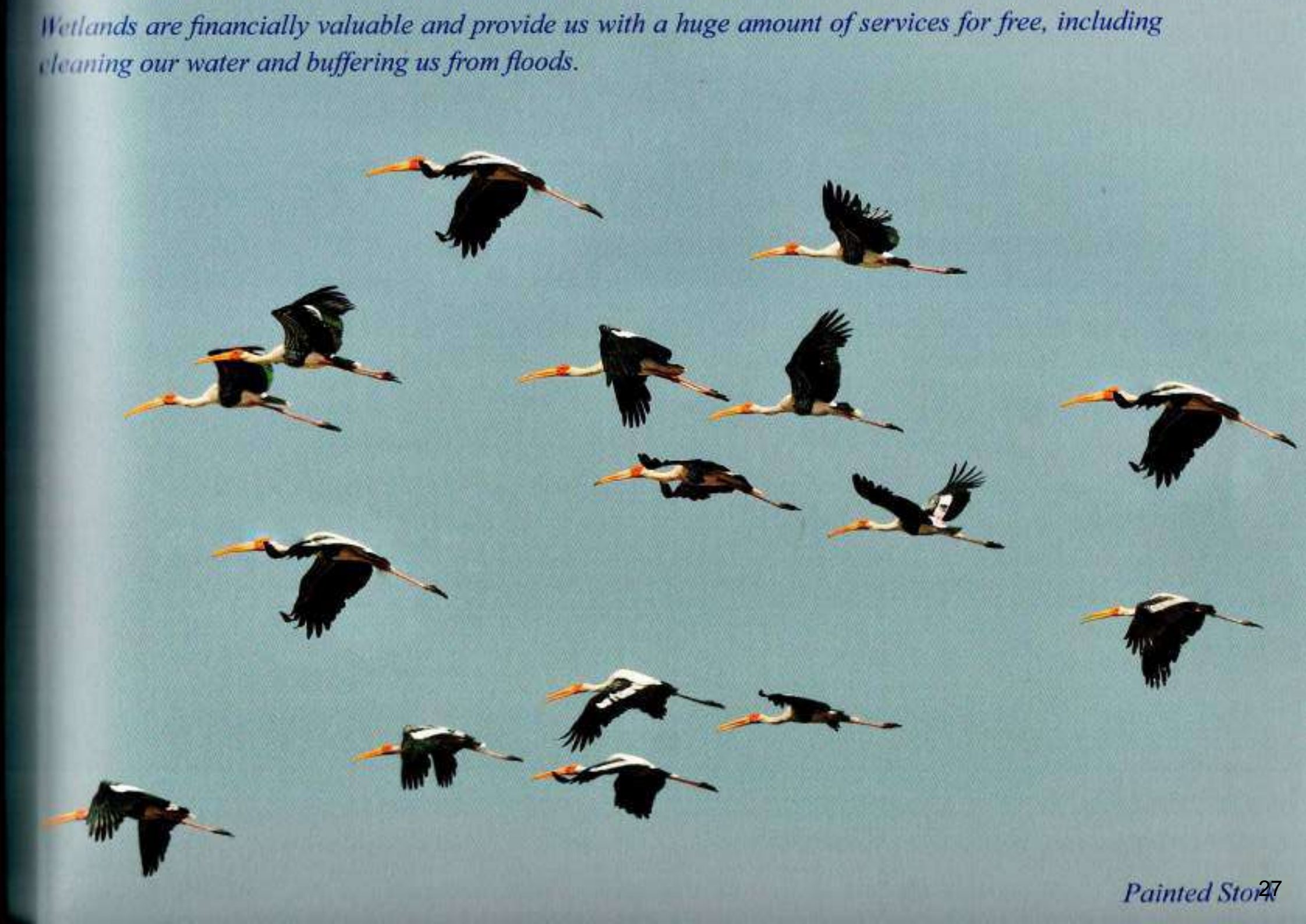
A tall reed plant covering the flood beds serves as cover for large birds and Acacia nilotica (Babul) serves as roosting site during the breeding season.



World had lost about half its wetlands in the last 100 years. Most of the losses globally are due to the wetlands being drained for agriculture or to be built upon.

Greater Flamingo

Wetlands are financially valuable and provide us with a huge amount of services for free, including cleaning our water and buffering us from floods.



Painted Stork

Without wetlands, the water, carbon and nutrient cycles would be significantly altered, mostly detrimentally.

Black-headed Gull

Wetlands are crucial in maintaining the water cycle which, in turn, underpins all ecosystem services and therefore sustainable development.

Pied Kingfisher


Wetlands are life line for a very large number of people. Nearly 80% of the paddy cultivation is directly or indirectly dependent on wetlands.
Little Gre

2nd February of each year is World Wetlands Day.

Painted Sto

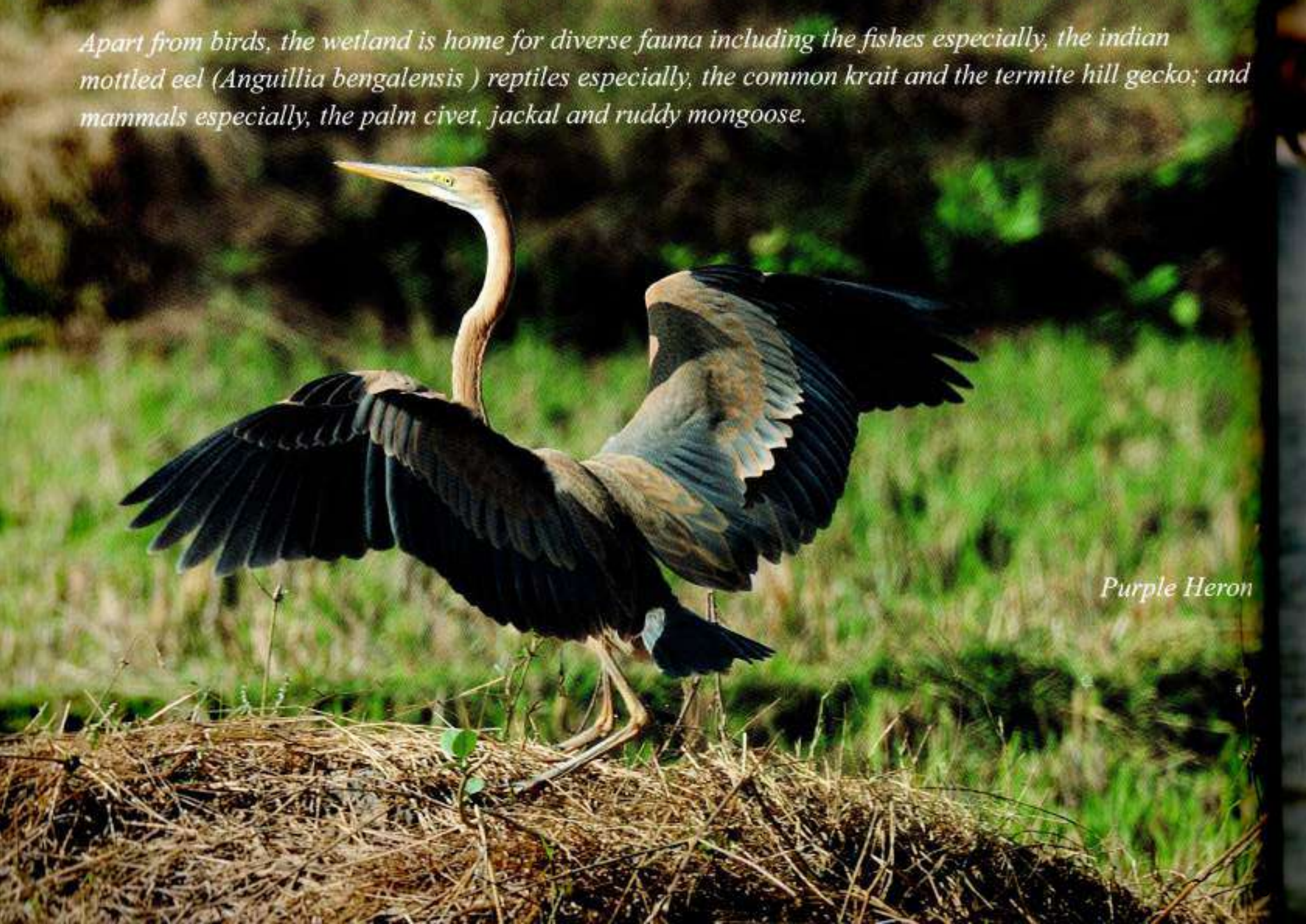
Tamil Nadu has 902534 ha of wetland, which is around 6.92 percent of the state geographical area.

Oriental Pratincole

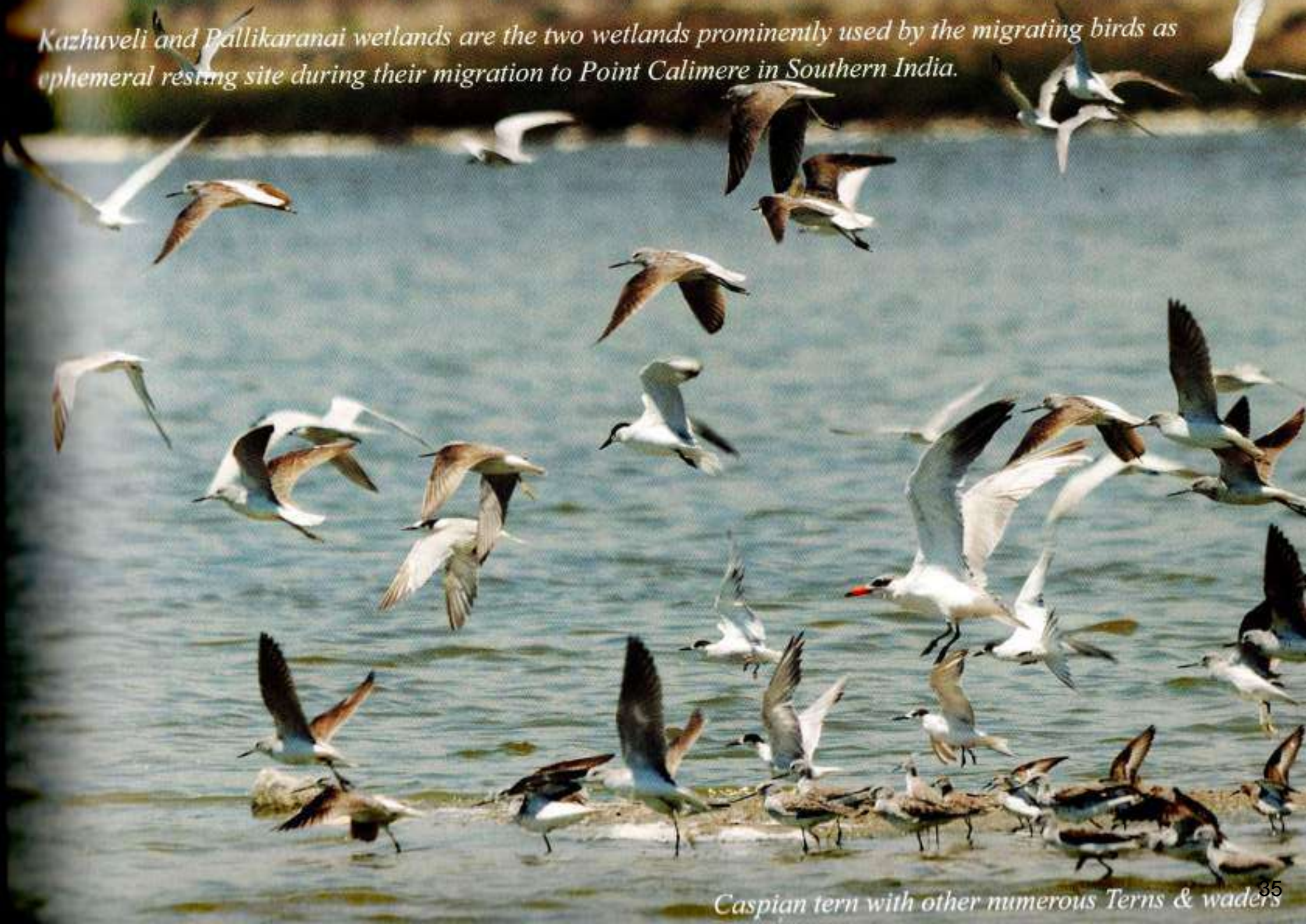
Out of the total area of 73.81 Sq km, forest department had notified 4722.20.5 ha of the wetland under section 26 of the Tamil Nadu Forest act, 1882.

Indian Spot-billed Duc

Apart from birds, the wetland is home for diverse fauna including the fishes especially, the indian mottled eel (Anguillia bengalensis) reptiles especially, the common krait and the termite hill gecko; and mammals especially, the palm civet, jackal and ruddy mongoose.



Purple Heron



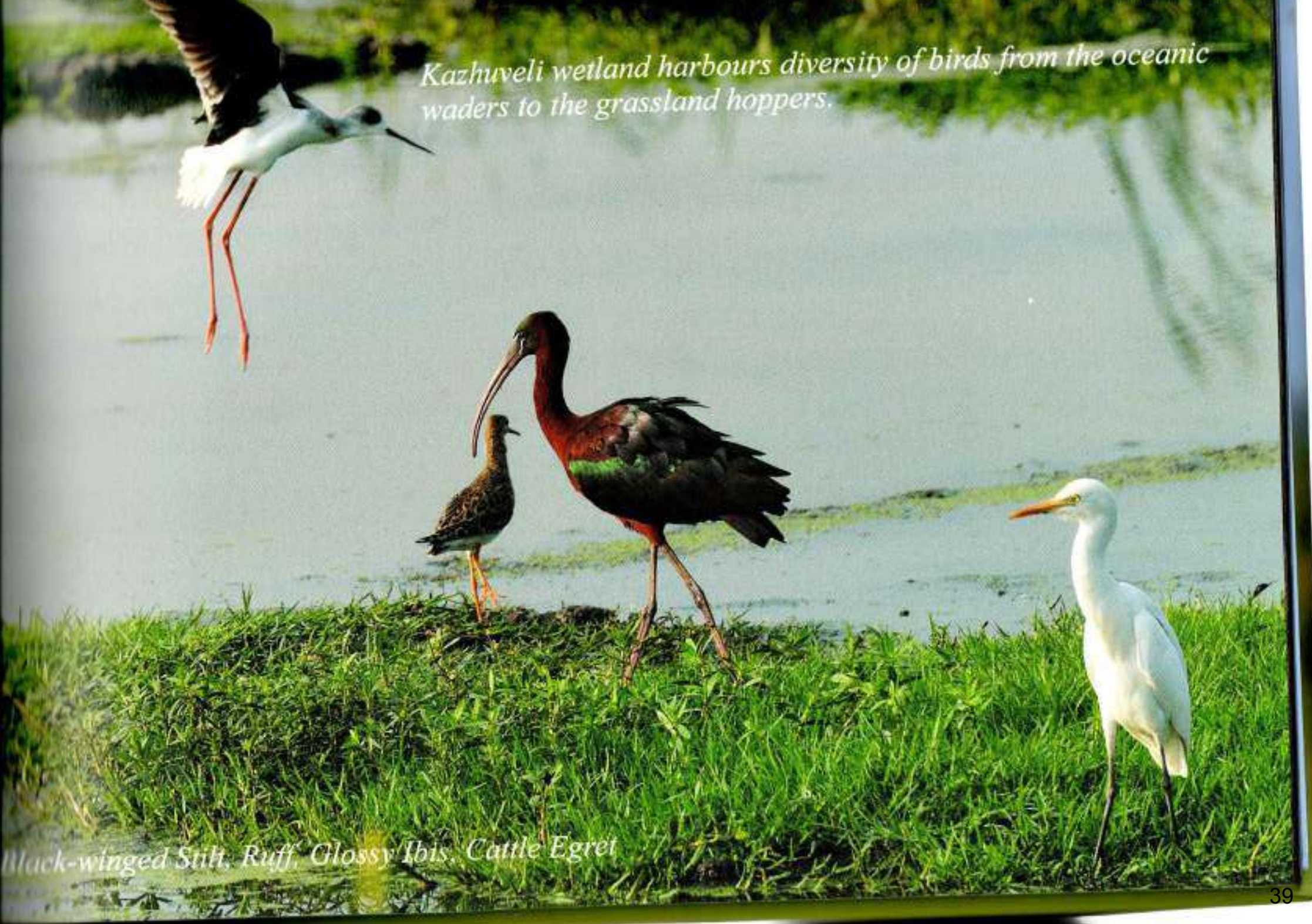
Kazhuveli and Pallikaranai wetlands are the two wetlands prominently used by the migrating birds as ephemeral resting site during their migration to Point Calimere in Southern India.

Caspian tern with other numerous Terns & waders

Indian Cormorant

Kazhuveli wetland is one of the 115 wetlands listed in the Wetlands identified under National wetland Conservation Programme of Ministry of Environment, Forests and Climate Change.


Eurasian Coot
A total of 190 minor irrigation tanks and ponds drain into the Kazhuveli Wetland


Kazhuveli wetland harbours diversity of birds from the oceanic waders to the grassland hoppers.
Black-winged Stilt, Ruff, Glossy Ibis, Cattle Egret

Kezhuveli birds find their home beyond the borders, especially in the agricultural fields adjoining the wetland. The lands and the birds are mutually benefitted.

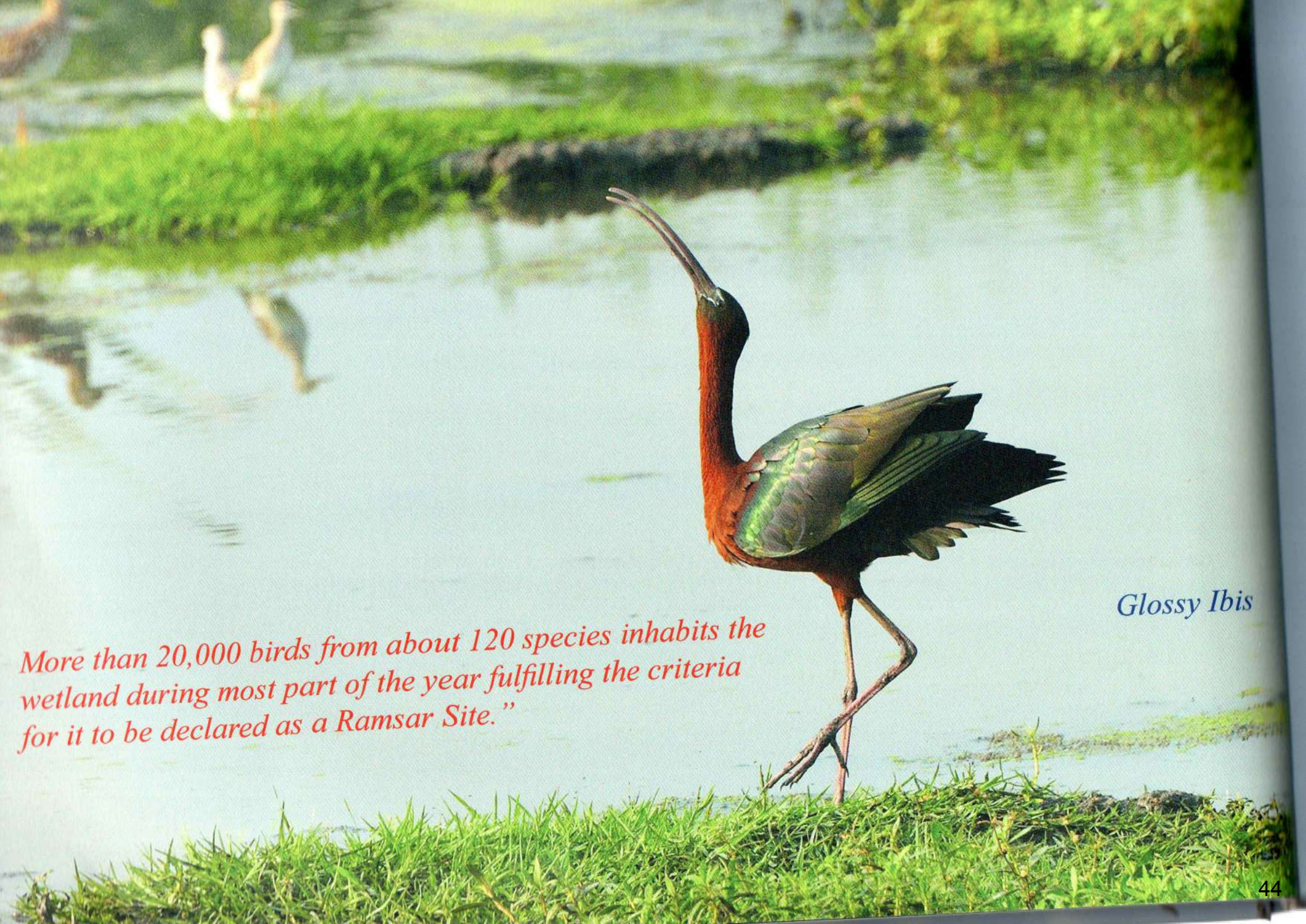
Asian Openbill

Vadhuveli Wetland is subjected to the expanding agricultural encroachments on their southern boundary.

Cattle Egret

Panoramic view showing the beginning of

violations on all sides of the Wetland.



More than 20,000 birds from about 120 species inhabits the wetland during most part of the year fulfilling the criteria for it to be declared as a Ramsar Site."

Glossy Ibis

Efforts are being initiated to declare the Kazhuveli Wetland as a Bird Sanctuary.

Osprey

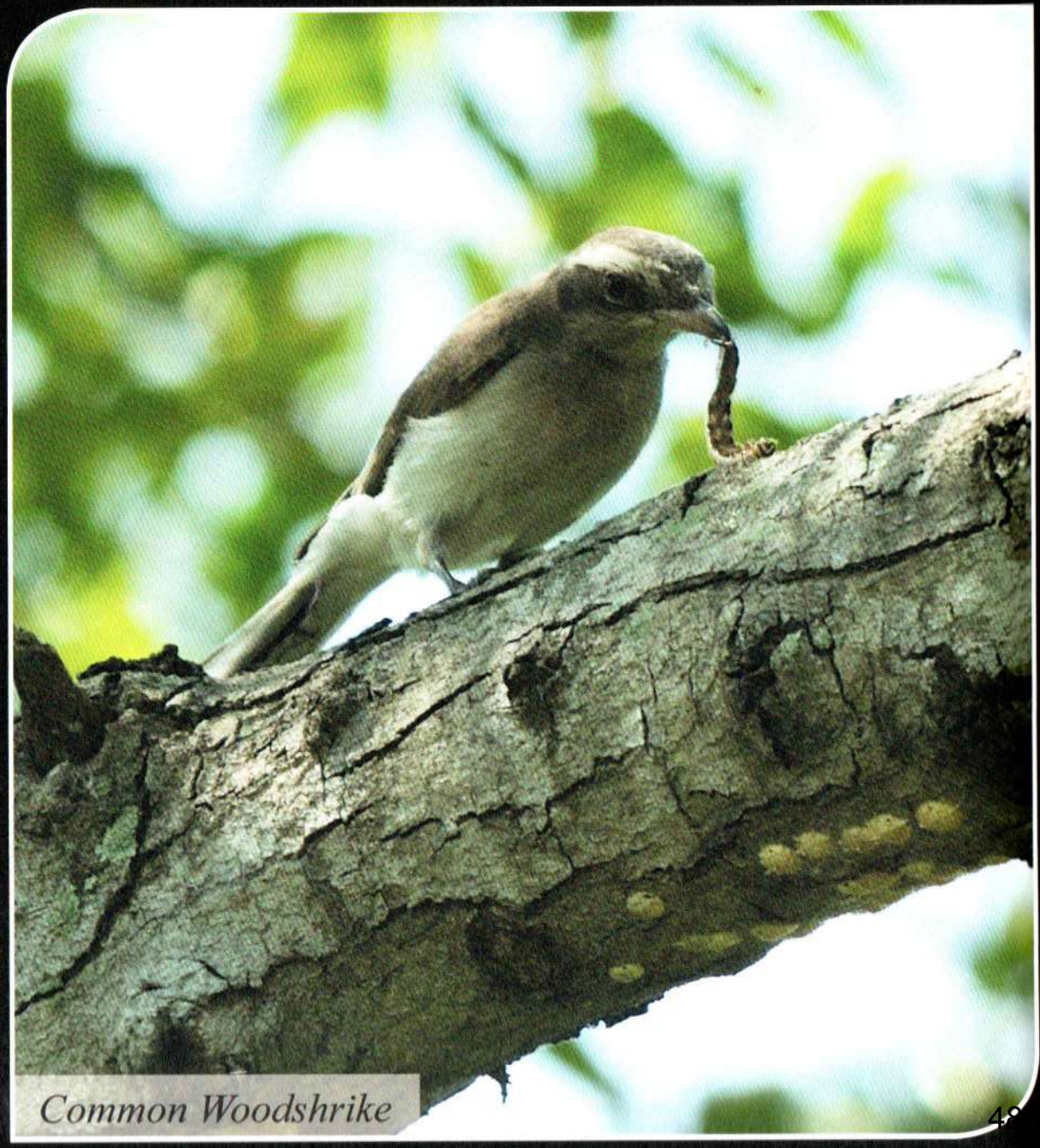
Spot-billed Pelican

Open billed storks, Spot billed pelicans, Painted storks and Flamingos are the prominent birds sheltering the wetland among many other bird species.

Feathered Bipeds of Kazhuveli

Grey Francolin

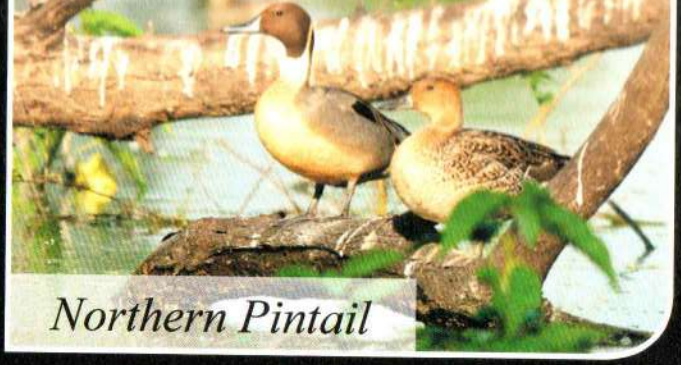
Indian Courser



Common Woodshrike

Montagu's Harrier ♂

Montagu's Harrier ♀



Northern Pintail

Grey Heron

Northern Shoveler

Oriental Pratincole

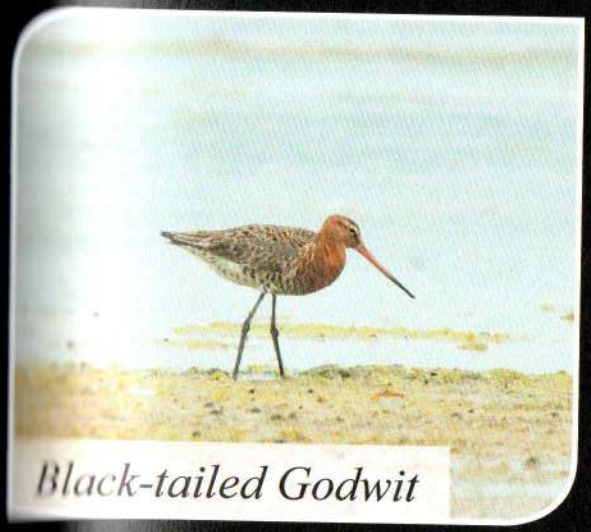
Asian Openbill

Spot-billed Pelican

Little Ringed Plover
in Non-breeding plumage

Pallid Harrier ♂

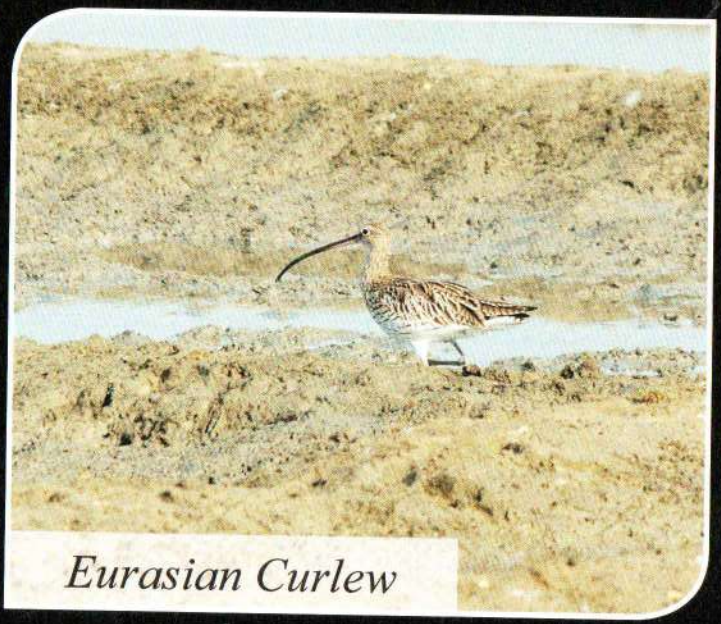
Brahminy Starling



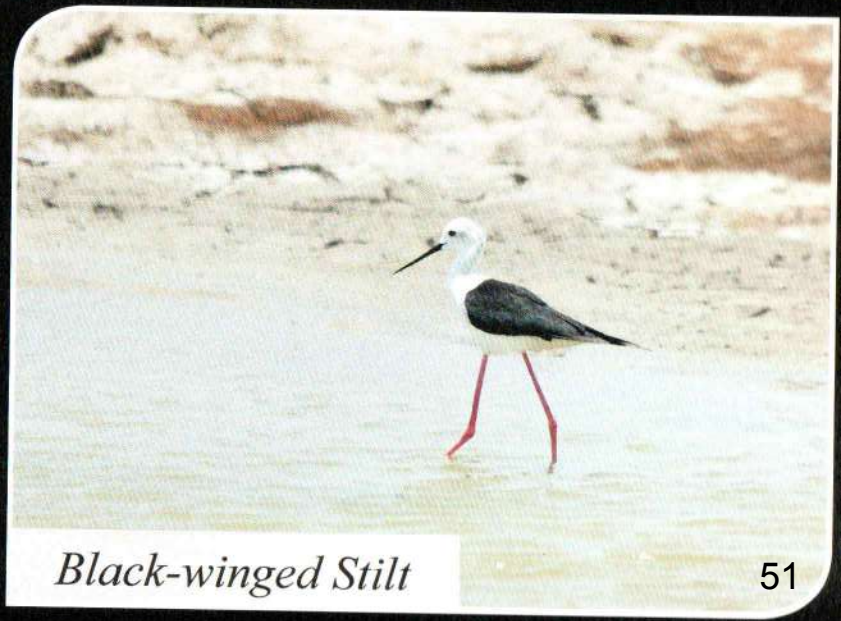
Black-tailed Godwit

Ashy-crowned Sparrow-Lark ♂

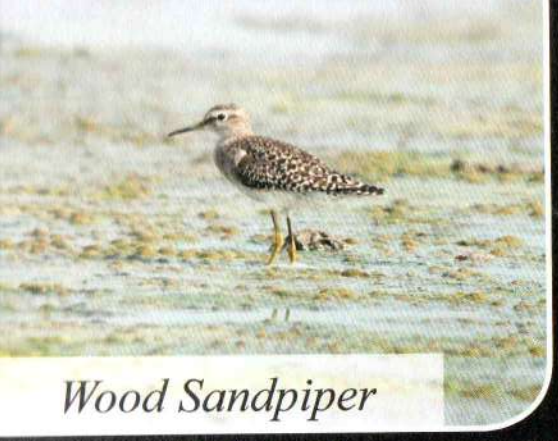
Ashy Prinia



Eurasian Curlew



Black-winged Stilt

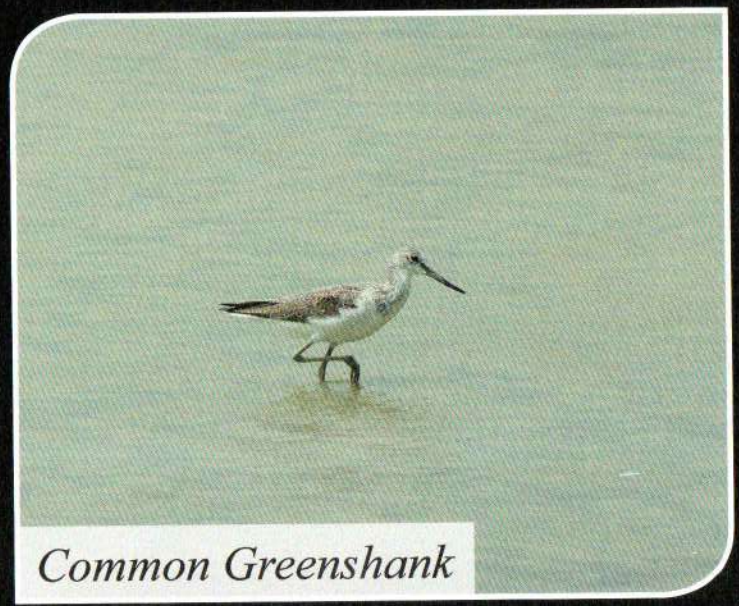


Wood Sandpiper

White-eyed Buzzard

Little Ringed Plover

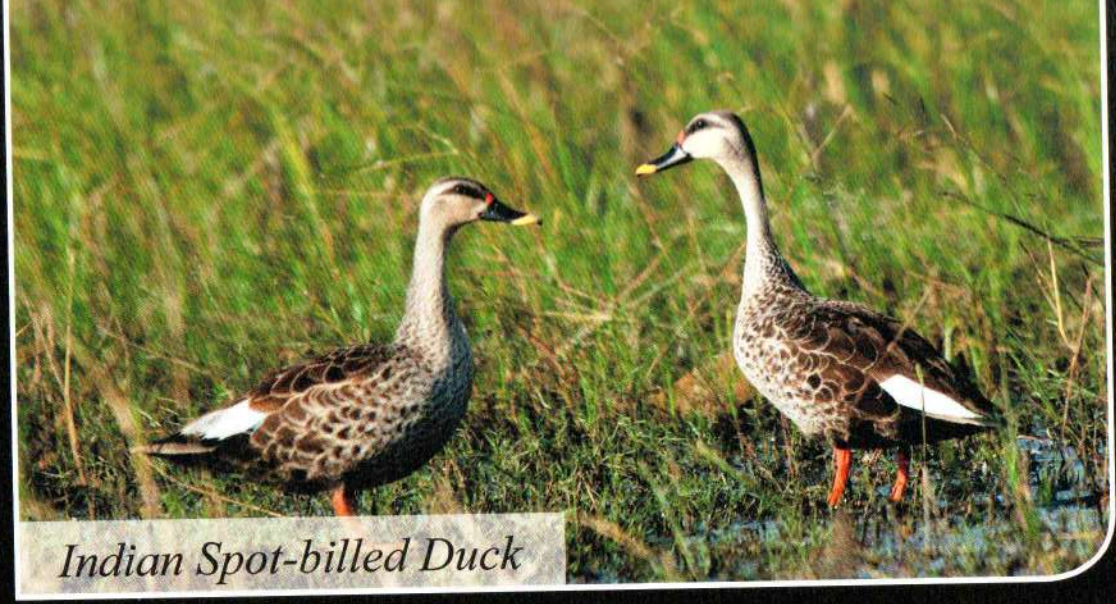
Scaly-breasted Munia



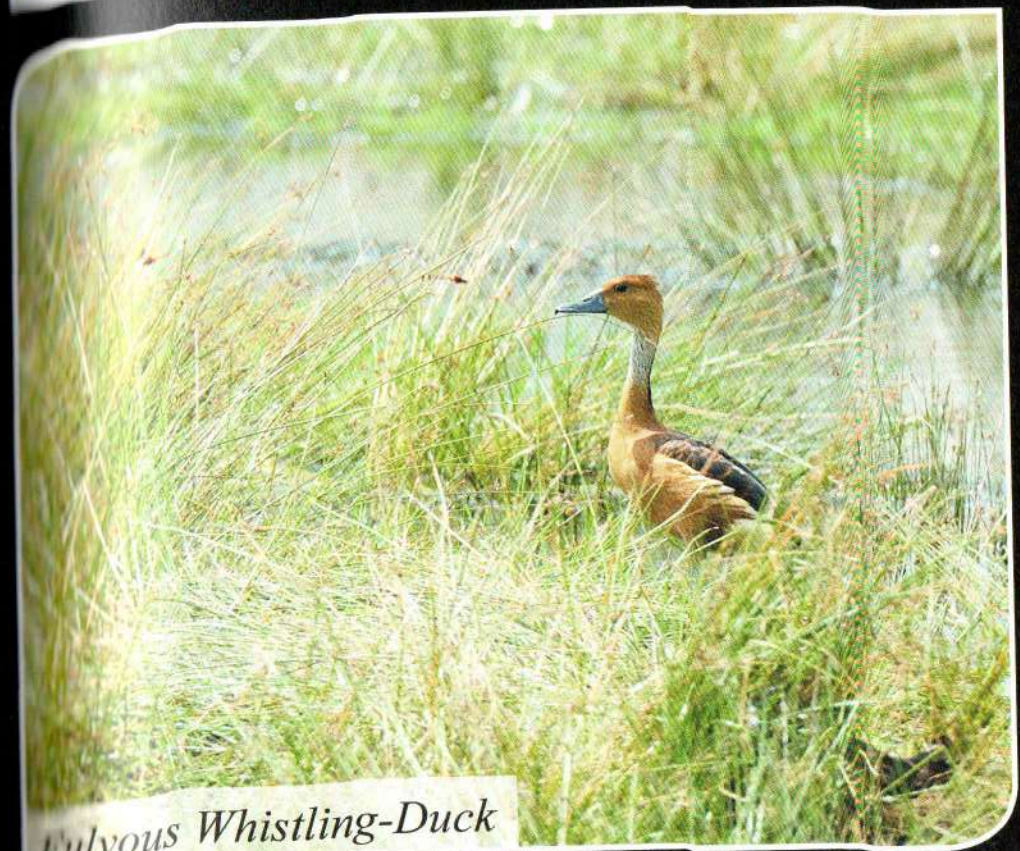
Common Greenshank

Yellow Bittern

Common Kingfisher



Indian Spot-billed Duck



Fulvous Whistling-Duck

Yellow-wattled Lapwing

Threats of Kazhuveli Wetland

Over Grazing by animals numbering from 5000 to 7000 from the nearby villages have made the land very hard and thereby removing the fertile top soil. This is unfavorable for regeneration of native flora.

Agriculture is the prime occupation of the people living in this area and shrimp farms dominate near the areas containing brackish water. While the southern parts of Kazhuveli Wetland are encroached for agricultural purposes, the northern parts are susceptible to encroachment by shrimp farm owners.

Fishing for subsistence and recreation is a common feature in Kazhuveli.

Pied Kingfisher

Bund and mound planting of Acacia nilotica expands the scope of the wetland amidst prominent weeds like Prosopis juliflora and Ipomea aquatica.


Conservation Measures tak

ures taken by Department

Conservation Measures - Bund and MoundPlanting

Most of the regeneration works done during earlier years are subjected to heavy grazing pressure. In order to off-set this biotic pressure and also further improve upon the existing vegetation it was proposed to dig cattle proof trenches duly complemented with plants on the bunds to a distance of 50 km.

Common Tern

Management Strategies of Kazhuveli

- *Creating institutional structures to ensure sustainable management of the wetland and its resources.*
- *Understand the Kazhuveli biological system and make interventions to prevent any anthropogenic activity affecting the system.*
- *Understand the soil and water shifts in their salinity and moisture gradients respectively to initiate habitat improvement works.*
- *Train the local people to involve themselves in ensuring the ecosystem process in Kazhuveli wetland ecosystem. Develop holistic knowledge on Kazhuveli ecosystem that can serve as basis for long term management.*

Little Cormorant

Conservation tasks such as bio-upgradation, eco-development, community development works, protection, monitoring and evaluation are being implemented sheltering the wetland among many other bird species.

Little Egret

Objectives of Kazhuveli Management Plan:

1. *To set up institutional structures in the villages for the sustainable management of Kazhuveli wetland and its natural resources. This will include:*

a. *Management structures to ensure optimum utilization of the watershed's natural resources like land, water, vegetation, etc.*

b. *The Village Forest Committees and Self Help Groups will ensure the generation and development of the human and other economic resources of the village through savings and other income-generation activities*

2. *To undertake intensive and extensive soil and water conservation and afforestation in the Kazhuveli Wetland with participation of local communities. This will include:*

a. *Sustained community based implementation of soil and water conservation and afforestation measures in Kazhuveli tank to enhance and manage the natural resource base of the watershed*

b. *Adoption by and capacity building of the community in simple, easy and affordable technological solutions which build upon local technical knowledge and available materials.*

3. *To promote the Socio Economic condition of the Kazhuveli dependant villages aiming to create short term benefits to the local communities.*

a. *Enhancement of the employment opportunities through plantation activities in existing barren lands and mudflats*

b. *Involving local communities especially the Women Self Help Groups towards conservation of natural resources in Kazhuveli wetland.*

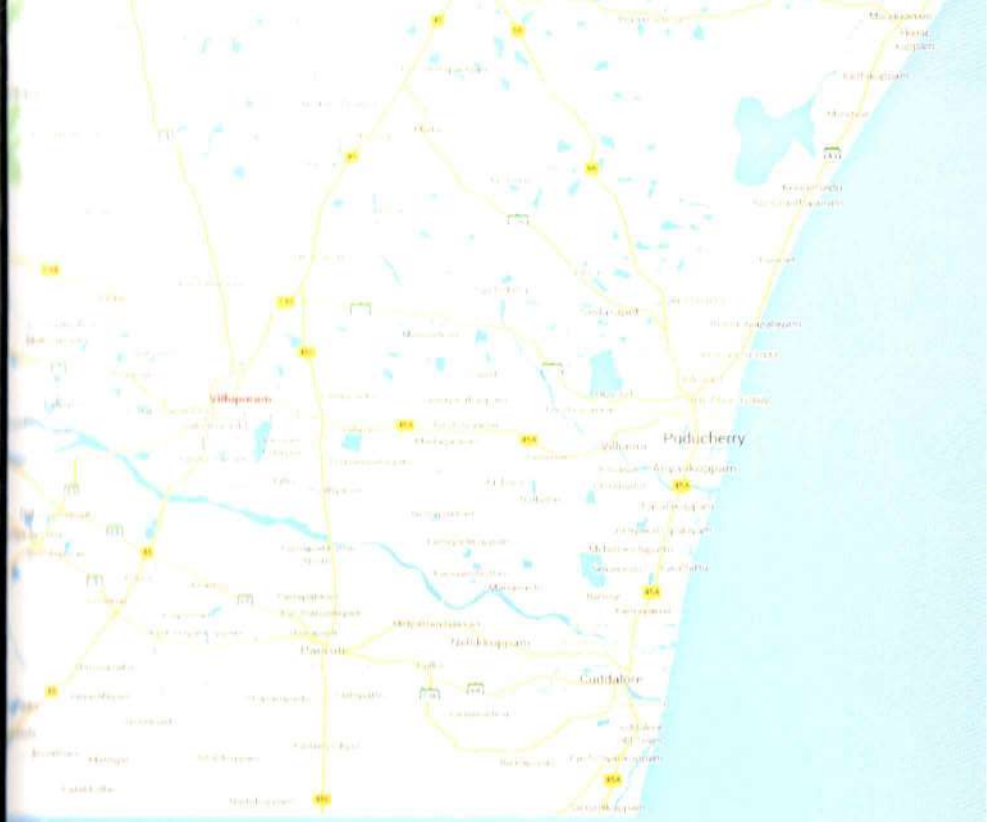
c. *Improve the Socio-Economic status of the local communities through promoting the Income Generation activities.*

4. *Revitalization and Upgradation of the Biodiversity and promote suitable ecosystem for flora and fauna through the following activities*

a. *Conservation and Revitalization of Wetland ecosystem through imparting awareness to the local communities and plantation of appropriate species.*

b. *Creation of safe haven for Wildlife including migratory birds through upgradation of Biodiversity of these hitherto barren and degraded lands.*

c. *Transformation of Kazhuveli area from a feeding ground to breeding ground for all the fauna.*



Map showing Villupuram District

Map showing Kazhuveli

Photo Courtesy

Karthick Ramalingam is passionate about nature and wildlife Photography- Bangalore.

R.T. Shriram is passionate about nature and bird Photography - chennai.






Contact :
District Forest Officer
Villupuram Forest Division
Villupuram District - Pin 605602
Tamil Nadu
Ph : 04146 - 223743
Email : dfovpm@yahoo.com

Annexure-2

Wetlands of India Portal

Ministry of Environment, Forest and Climate Change
Government of India

<

https://indianwetlands.in>

Search

Search By | State/UT: Tamil Nadu | District: All | Click to view wetlands

85 wetlands added on the portal
covering **1,37,204.75** ha in Tamil Nadu as per data uploaded on portal

14 Ramsar Sites
covering **94,610** ha in Tamil Nadu as per data uploaded on portal

42,978 wetlands
covering **9,02,534** ha in Tamil Nadu as per the National Wetlands Atlas

24,684 wetlands (> 2.25 ha)
covering **8,84,240** ha in Tamil Nadu as per the National Wetlands Atlas

Show 10 entries

Search: Kaliveli

#	Name	District	State/UT	Area (Hectares)	Wetland Type	Remarks
16	Kaliveli Lake < https://indianwetlands.in/view-wetland/?profile=Mzl0>	Viluppuram	Tamil Nadu	3262.00		
17	Kaliveli Tank and Yedayanthittu Estuary < https://indianwetlands.in/view-wetland/?profile=MTIxMg==>	Thiruvallur	Tamil Nadu	7500.00		Wetlands of International Significance

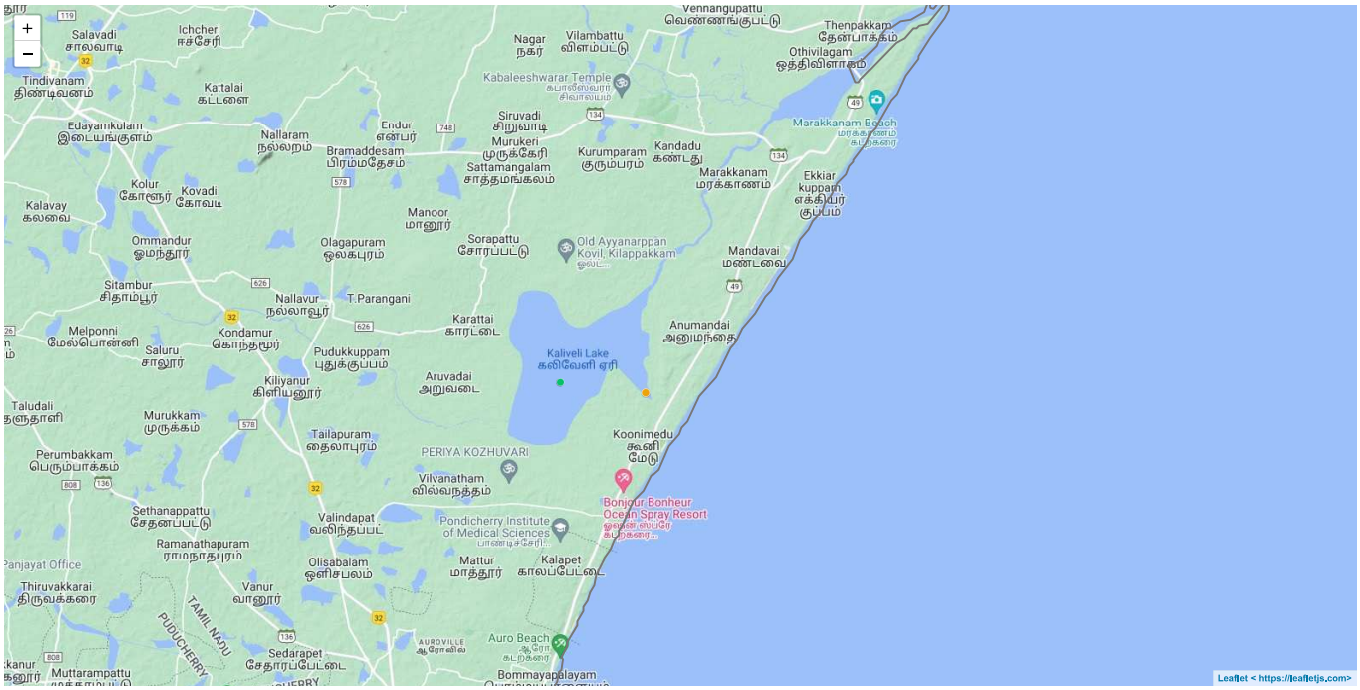
Showing 1 to 2 of 2 entries (filtered from 85 total entries)

Previous 1 Next

Interactive Wetland Map

Ramsar Sites | Other Wetlands | Wetlands of International Significance

** Displays data as uploaded on portal*



Ministry of Environment, Forest and Climate Change
Government of India

Quick Links

- Home < https://indianwetlands.in/>
- About the Portal < https://indianwetlands.in/about-us/about-the-portal/>
- Contact Us < https://indianwetlands.in/contact-us/>

Important Links

- Copyright Policy < https://indianwetlands.in/copyright-policy/>
- Disclaimer < https://indianwetlands.in/disclaimer/>
- Terms and Conditions < https://indianwetlands.in/terms-and-conditions/>
- Sitemap < https://indianwetlands.in/sitemap/>
- Hyperlinking Policy < https://indianwetlands.in/hyperlinking-policy/>
- Privacy Policy < https://indianwetlands.in/privacy-policy-2/>

Connect With Us

Indira Paryavaran Bhawan, Jorbagh Road, New Delhi – 110 003 INDIA.

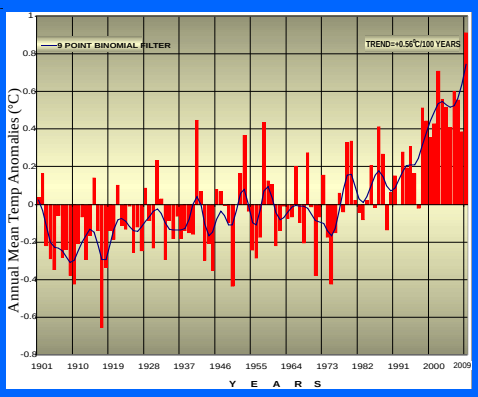
Annexure-3

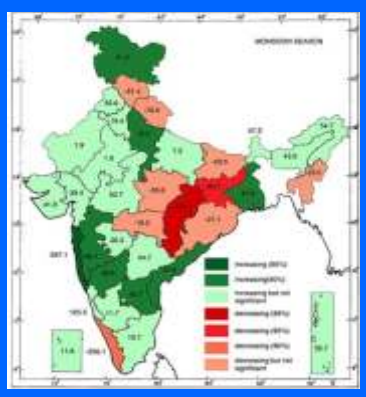
Government of India
Ministry of Earth Sciences
India Meteorological Department

Met Monograph No. Environment Meteorology-01/2010

CLIMATE PROFILE OF INDIA

S. D. Attri and Ajit Tyagi





2010

Met Monograph No.
Environment Meteorology-01/2010

CLIMATE PROFILE OF INDIA

Contribution to the
Indian Network of Climate Change Assessment
(NATIONAL COMMUNICATION-II)
Ministry of Environment and Forests

S D Attri and Ajit Tyagi

India Meteorological Department
Ministry of Earth Sciences
New Delhi

2010

Disclaimer and Limitations

IMD is not responsible for any errors and omissions. The geographical boundaries shown in the publication do not necessarily correspond to the political boundaries.

Published in India

By

Environment Monitoring and Research Centre,
India Meteorological Department, Lodi Road, New Delhi- 110003 (India)
Phone: 91-11-24620701
Email: met_emu@yahoo.com

PREFACE

The beginnings of meteorology in India can be traced to ancient times from the philosophical writings of the Vedic period, contain serious discussion about the processes of cloud formation and rain and the seasonal cycles caused by the movement of earth round the sun. But, the Modern Meteorology is regarded to have had its firm scientific foundation in the 17th century after the invention of thermometer, barometer and the formulation of laws governing the behaviour of atmospheric gases. India is fortunate to have some of the oldest meteorological observatories of the world like those at Calcutta (now Kolkata) in 1785 and Madras (now Chennai) in 1796 for studying the weather and climate of India

India Meteorological Department (IMD) has progressively expanded its infrastructure for meteorological observations, communications, forecasting and weather services and it has concurrently contributed to scientific growth since its inception in 1875. One of the first few electronic computers introduced in the country was provided to IMD for scientific applications in meteorology. India was the first developing country in the world to have its own geostationary satellite, INSAT, for continuous weather monitoring of this part of the globe and particularly for cyclone warning. It has ventured into new areas of application and service, and steadily built upon its infra-structure during its history of 135 years. It has simultaneously nurtured the growth of meteorology and atmospheric science in India for sectoral services. Systematic observation of basic climate, environmental and oceanographic data is vital to capture past and current climate variability.

IMD has provided climatic observations and products to the national requirements including National Communication (NATCOM). To meet the future need, it is in process of augmenting its weather and climate-related observation systems that underpins analytical and predictive capability which is critical for minimising extreme climate variability impacts.

I am hopeful that this publication on “Climate Profile of India” will contribute to the “India’s National Communication-II” to be submitted to UNFCCC next year. The publication is based on the work mainly carried out by IMD scientists. I extend my sincere thanks to Sh. A K Bhatnagar, Dr A Mazumdar, Dr Y E A Raj, Sh B. Mukhopadhyay, Sh N Y Apte, Dr Medha Khole, Dr M Mohapatra, Dr A K Srivastava and Dr J Sarkar for providing requisite inputs.

October 2010
New Delhi

Ajit Tyagi
Director General of Meteorology

INDIA METEOROLOGICAL DEPARTMENT
DOCUMENT AND DATA CONTROL SHEET

1	Document title	Climate Profile of India
2	Document type	Met Monograph
3	Issue No.	Environment Meteorology-01/2010
4	Issue date	October 2010
5	Security Classification	Unclassified
6	Control Status	Uncontrolled
7	No. of Pages	122
8	No. figures	39
9	No. of reference	62
10	Distribution	Unrestricted
11	Language	English
12	Authors	S D Attri and Ajit Tyagi
13	Originating Division/Group	EMRC
14	Reviewing and Approving Authority	DGM
15	End users	Ministries / Departments of Central and State Governments, Research organisations, INCCA (NATCOM), Scientific community, Public etc.
16	Abstract	Normal climatic pattern and long term trends over India during last more than 100 years have been presented here. The publication contains studies with latest data on various aspects of important weather / climate systems viz. Monsoons, Cyclone, Drought, Floods and observational weather / climate mechanism in the country. Status and trends in parameters of atmospheric environment viz. radiation, ozone, precipitation chemistry etc has been depicted. The publication is also intended to provide requisite details for Indian Network of Climate Change Assessment (INCCA) to address climate change issues.
17	Key words	Climate Change, Cyclone, Monsoon, Drought, Flood, Environment

CLIMATE PROFILE OF INDIA

CONTENTS

Chapter - I

CLIMATE PROFILE

1. Introduction

India is home to an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas act as a barrier to the frigid katabatic winds flowing down from Central Asia keeping the bulk of the Indian subcontinent warmer than most locations at similar latitudes. As such, land areas in the north of the country have a continental climate with severe summer conditions that alternates with cold winters when temperatures plunge to freezing point. In contrast are the coastal regions of the country, where the warmth is unvarying and the rains are frequent.

The country is influenced by two seasons of rains, accompanied by seasonal reversal of winds from January to July. During the winters, dry and cold air blowing from the northerly latitudes from a north-easterly direction prevails over the Indian region. Consequent to the intense heat of the summer months, the northern Indian landmass becomes hot and draws moist winds over the oceans causing a reversal of the winds over the region which is called the summer or the south-west monsoon This is most important feature controlling the Indian climate because about 75% of the annual rainfall is received during a short span of four months (June to September). Variability in the onset, withdrawal and quantum of rainfall during the monsoon season has profound impacts on water resources, power generation, agriculture, economics and ecosystems in the country. The variation in climate is perhaps greater than any other area of similar size in the world. There is a large variation in the amounts of rainfall received at different locations. The average annual rainfall is less than 13 cm over the western Rajasthan, while at Mausiram in the Meghalaya has as much as 1141 cm. The rainfall pattern roughly reflects the different climate regimes of the country, which vary from humid in the northeast

(about 180 days rainfall in a year), to arid in Rajasthan (20 days rainfall in a year). So significant is the monsoon season to the Indian climate, that the remaining season are often referred relative to the monsoon.

The rainfall over India has large spatial as well as temporal variability. A homogeneous data series has been constructed for the period 1901-2003 based on the uniform network of 1476 stations and analyzed the variability and trends of rainfall. Normal rainfall (in cm) pattern of the country for the four seasons and annual are depicted in Fig 1 and Fig 2 respectively. Normal monsoon rainfall more than 150cm is being observed over most parts of northeast India, Konkan & Goa. Normal monsoon rainfall is more than 400cm over major parts of Meghalaya. Annual rainfall is more than 200 cm over these regions.

For the country as whole, mean monthly rainfall during July (286.5 mm) is highest and contributes about 24.2% of annual rainfall (1182.8 mm). The mean rainfall during August is slightly lower and contributes about 21.2% of annual rainfall. June and September rainfall are almost similar and contribute 13.8% and 14.2% of annual rainfall, respectively. The mean south-west monsoon (June, July, August & September) rainfall (877.2 mm) contributes 74.2% of annual rainfall (1182.8 mm). Contribution of pre-monsoon (March, April & May) rainfall and post-monsoon (October, November & December) rainfall in annual rainfall is mostly the same (11%). Coefficient of variation is higher during the months of November, December, January and February.

India is characterised by strong temperature variations in different seasons ranging from mean temperature of about 10°C in winter to about 32 °C in summer season (Fig 3). Details of weather along with associated systems during different seasons are presented as under:

1.1 Winter Season / Cold Weather Season (January and February)

India Meteorological Department (IMD) has categorised the months of January and February in winter season. However, December can be included in this season for north-western parts of the country. This season starts in early December

associated with clear skies, fine weather, light northerly winds, low humidity and temperatures, and large daytime variations of temperature . The cold air mass extending from the Siberian region, has profound influence on the Indian subcontinent (at least all of the north and most of central India) during these months. The mean air temperatures increase from north to south up to 17°N, the decrease being sharp as one moves northwards in the north-western parts of the country. The mean temperatures vary from 14 °C to 27°C during January. The mean daily minimum temperatures range from 22 °C in the extreme south, to 10 °C in the northern plains and 6 °C in Punjab. The rains during this season generally occur over the western Himalayas, the extreme north-eastern parts, Tamil Nadu and Kerala. Western disturbances and associated trough in westerlies are main rain bearing system in northern and eastern parts of the country.

1.2 Pre-monsoon season/ Summer season/ Hot weather season/ Thunderstorm season (March, April and May)

The temperatures start to increase all over the country in March and by April, the interior parts of the peninsula record mean daily temperatures of 30-35 °C. Central Indian land mass becomes hot with daytime maximum temperatures reaching about 40°C at many locations. Many stations in Gujarat, North Maharashtra, Rajasthan and North Madhya Pradesh exhibit high day-time and low night-time temperatures during this season. The range of the daytime maximum and night-time minimum temperatures in found more than 15 °C at many stations in these States. Maximum temperatures rise sharply exceeding 45 °C by the end of May and early June resulting in harsh summers in the north and north-west regions of the country. However, weather remains mild in coastal areas of the country owing to the influence of land and sea breezes.

The season is characterised by cyclonic storms, which are intense low pressure systems over hundreds to thousands of kilometres associated with surface winds more than 33 knots over the Indian seas viz. Bay of Bengal and the Arabian Sea. These systems generally move towards a north-westerly direction and some of them recurve to northerly or northeasterly path. Storms forming over the

Bay of Bengal are more frequent than the ones originating over the Arabian Sea. On an average, frequency of these storms is about 2.3 per year.

Weather over land areas is influenced by thunderstorms associated with rain and sometimes with hail in this season. Local severe storms or violent thunderstorms associated with strong winds and rain lasting for short durations occur over the eastern and north eastern parts over Bihar, West Bengal, and Assam. They are called norwesters or "Kal Baisakhis" as generally approach a station from the northwesterly direction. Thunderstorms are also observed over central India extending to Kerala along wind-discontinuity lines. Hot and dry winds accompanied with dust winds ("andhis") blow frequently over the plains of north-west India.

1.3 South-west Monsoon/ Summer Monsoon (June, July, August and September)

The SW monsoon is the most significant feature of the Indian climate. The season is spread over four months, but the actual period at a particular place depends on onset and withdrawal dates. It varies from less than 75 days over West Rajasthan, to more than 120 days over the south-western regions of the country contributing to about 75% of the annual rainfall.

The onset of the SW monsoon normally starts over the Kerala coast, the southern tip of the country by 1 June, advances along the Konkan coast in early June and covers the whole country by middle of July. However, onset occurs about a week earlier over islands in the Bay of Bengal. The monsoon is a special phenomenon exhibiting regularity in onset and distribution within the country, but inter-annual and intrannual variations are observed. The monsoon is influenced by global and local phenomenon like El Nino, northern hemispheric temperatures, sea surface temperatures, snow cover etc. The monsoonal rainfall oscillates between active spells associated with widespread rains over most parts of the country and breaks with little rainfall activity over the plains and heavy rains across the foothills of the Himalayas. Heavy rainfall in the mountainous catchments under 'break' conditions results flooding over the plains. However, very uncomfortable weather due to high humidity and temperatures is the feature associated with the Breaks.

Cyclonic systems of low pressure called 'monsoon depressions' are formed in the Bay of Bengal during this season. These systems generally form in the northern part of the Bay with an average frequency of about two to three per month and move in a northward or north-westward direction, bringing well-distributed rainfall over the central and northern parts of the country. The distribution of rainfall over northern and central India depends on the path followed by these depressions. SW monsoon current becomes feeble and generally starts withdrawing from Rajasthan by 1st September and from north-western parts of India by 15th September. It withdraws from almost all parts of the country by 15th October and is replaced by a northerly continental airflow called North-East Monsoon. The retreating monsoon winds cause occasional showers along the east coast of Tamil Nadu, but rainfall decreases away from coastal regions.

1.4 Post-monsoon or Northeast monsoon or Retreating SW Monsoon season (October, November and December)

North-East (NE) monsoon or Post-monsoon season is transition season associated with the establishment of the north-easterly wind regime over the Indian subcontinent. Meteorological subdivisions namely Coastal Andhra Pradesh Rayalaseema , Tamil Nadu, Kerala and South Interior Karnataka receive good amount of rainfall accounting for about 35% of their annual total in these months. Many parts of Tamil Nadu and some parts of Andhra Pradesh and Karnataka receive rainfall during this season due to the storms forming in the Bay of Bengal. Large scale losses to life and property occur due to heavy rainfall, strong winds and storm surge in the coastal regions. The day temperatures start falling sharply all over the country. The mean temperatures over north-western parts of the country show decline from about 38°C in October to 28°C in November. Decrease in humidity levels and clear skies over most parts of north and central India after mid-October are characteristics features of this season (NATCOM 2004, IMD 2010).

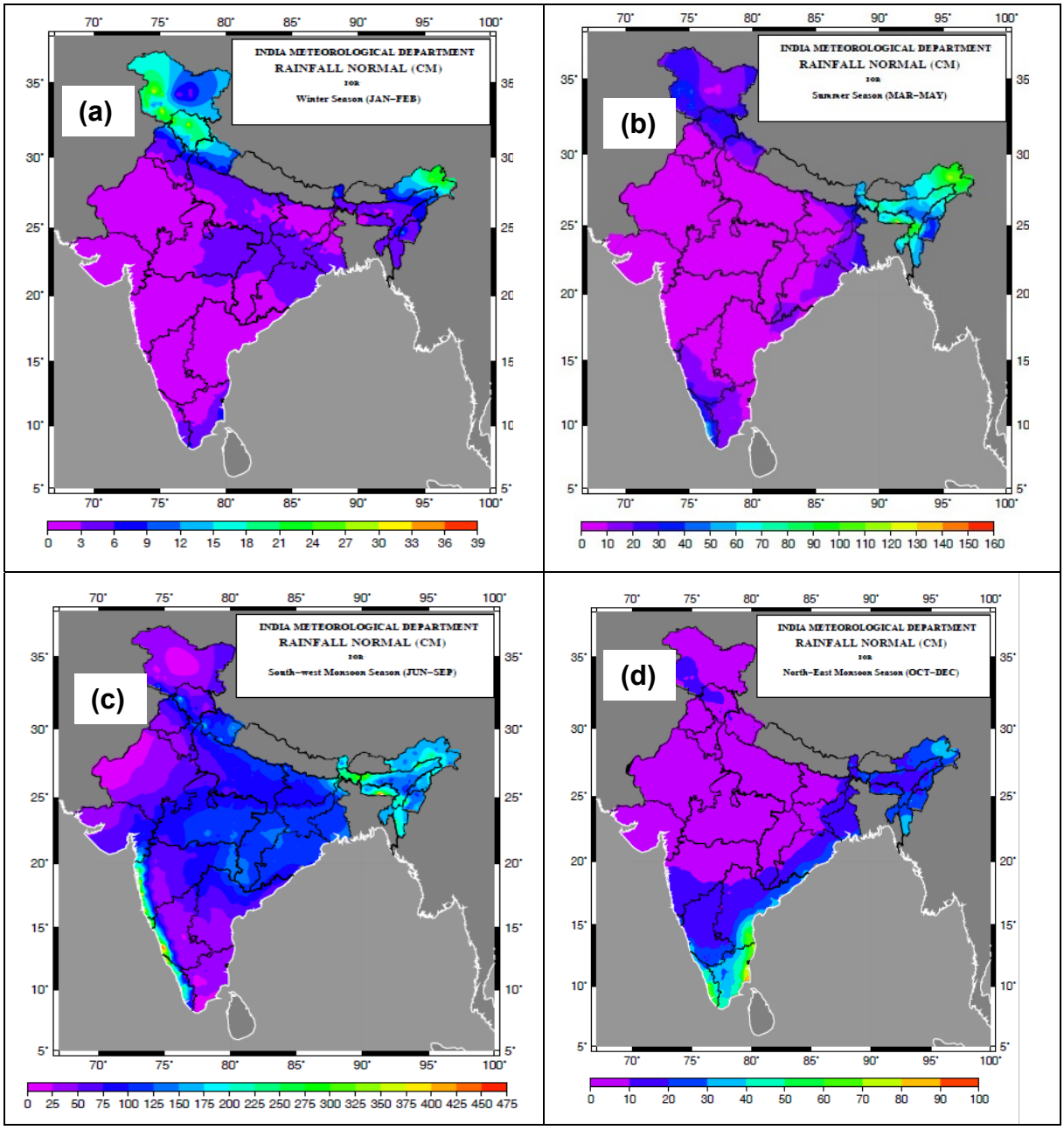


Fig 1: Normal rainfall pattern (cm) during (a) Winter (b) Pre-monsoon (c) Monsoon and (d) Post-Monsoon seasons for the period 1941-90

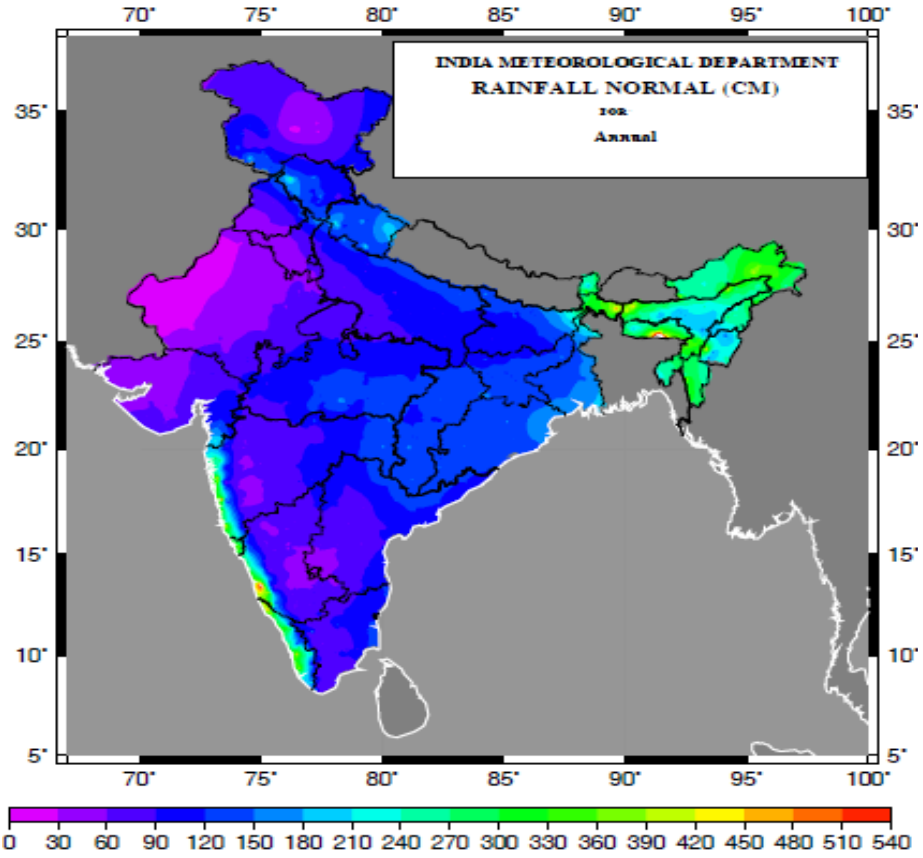


Fig 2: Annual normal rainfall pattern (cm) during 1941-90

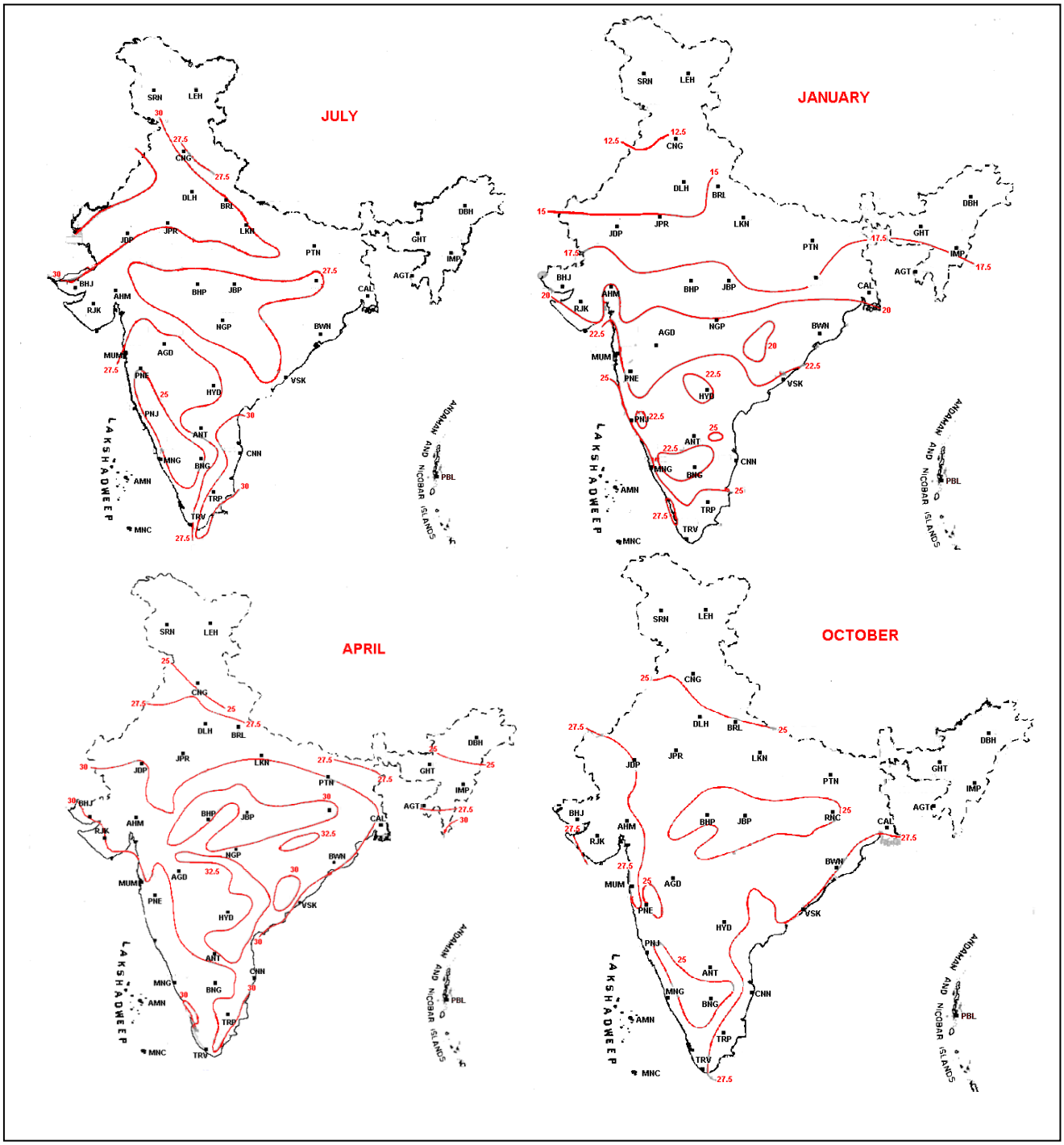


Fig. 3: Seasonal temperature distribution over India

Chapter - II

SYSTEMATIC OBSERVATIONS

Agriculture based economy under favourable climatic conditions of the summer monsoon has necessitated a closer linkage with weather and climate since the Vedic period. Ancient Indian literature by Varahmihir, the *'Brihat-Samhita'*, is an example of ancient Indian weather research. Modernized meteorological observations and research in India was initiated more than 200 years ago, since 1793, when the first Indian meteorological observatory was set up at Madras (now Chennai). IMD was formally established in 1875 with a network of about 90 weather observatories for systematic observation and research. Agricultural-meteorology directorate was created in 1932 to further augment the observation network. Many data and research networks have been added during the 135 years for climate-dependent sectors, such as agriculture, forestry, and hydrology, rendering a modern scientific background to atmospheric science in India. The inclusion of the latest data from satellites and other modern observation platforms, such as Automated Weather Stations (AWS), and ground-based remote-sensing techniques, has strengthened India's long-term strategy of building up a self-reliant climate data bank for specific requirements, and also to fulfill international commitments of data exchange for weather forecasting and allied research activities. The latest observational network in depicted in Table 1.

2.1 Institutional arrangements

The Ministry and Environment and Forests (MoEF), Ministry of Earth Sciences (MoES), Ministry of Science and Technology (MST), Ministry of Agriculture (MoA), Ministry of Water Resources (MWR), Ministry of Human Resource Development (MHRD), Ministry of Nonconventional Energy (MNES), Ministry of Defence (MoD), Ministry of Health and Family welfare (MoHFW), Indian Space Research Organization (ISRO) and India Meteorological Department (IMD) promote and undertake climate and climate change-related research in the country. The MoES, MoEF, MST, MHRD and MOA also coordinate research and observations in

many premier national research laboratories and universities. The IMD possesses a vast weather observational network and is involved in regular data collection basis, data bank management, research and weather forecasting for national policy needs.

2.2 Atmospheric monitoring

There are 25 types of atmospheric monitoring networks that are operated and coordinated by the IMD. This includes meteorological/climatological, environment/ air pollution and other specialized observation of atmospheric trace constituents. It maintains 559 surface meteorological observatories, about 35 radio-sonde and 64 pilot balloon stations for monitoring the upper atmosphere. Specialized observations are made for agro-meteorological purposes at 219 stations and radiation parameters are monitored at 45 stations. There are about 70 observatories that monitor current weather conditions for aviation. Although, severe weather events are monitored at all the weather stations, the monitoring and forecasting of tropical cyclones is specially done through three Area Cyclone Warning Centres (Mumbai, Chennai, and Kolkata) and three cyclone warning centres (Ahmedabad, Vishakhapatnam and Bhubaneswar), which issue warnings for tropical storms and other severe weather systems affecting Indian coasts. Storm and cyclone detections radars are installed all along the coast and some key inland locations to observe and forewarn severe weather events, particularly tropical cyclones. The radar network is being upgraded by modern Doppler Radars, with enhanced observational capabilities, at many locations.

In another atmospheric observation initiative, the IMD established 10 stations in India as a part of World Meteorological Organization's (WMO) Global Atmospheric Watch (GAW, formerly known as Background Air Pollution Monitoring Network or BAPMoN). The Indian GAW network includes Allahabad, Jodhpur, Kodaikanal, Minicoy, Mohanbari, Nagpur, Port Blair, Pune, Srinagar and Visakhapatnam. Atmospheric turbidity is measured using hand-held Volz's Sunphotometers at wavelength 500 nm at all the GAW stations. Total Suspended Particulate Matter (TSPM) is measured for varying periods at Jodhpur using a High Volume Air Sampler. Shower-wise wet only precipitation samples are collected at all the GAW stations using specially designed wooden precipitation collectors fitted with stainless

steel or polyethylene funnel precipitation collectors. After each precipitation event, the collected water is transferred to a large storage bottle to obtain a monthly sample. Monthly mixed samples collected from these stations are sent to the National Chemical Laboratory, Pune, where these are analyzed for pH, conductivity, major cations (Ca, Mg, Na, K, NH_4+) and major anions ($SO_4$2-, NO_3-, Cl-).

The IMD established the glaciology Study Research Unit in Hydromet. Directorate in 1972. This unit has been participating in glaciological expedition organized by the GSI and the DST. The unit was established for the: (a) determination of the natural water balance of various river catchment areas for better planning and management of the country's water resources; (b) snow melt run-off and other hydrological forecasts; (c) reservoir regulation; (d) better understanding of climatology of the Himalaya; and (e) basic research of seasonal snow cover and related phenomena. The IMD has established observing stations over the Himalayan region to monitor weather parameters over glaciers.

In view of the importance of data in the tropical numerical weather prediction, IMD has been in the process of implementing a massive modernization programme for upgrading and enhancing its observation system. It is establishing 550 AWS out of which about 125 will have extra agricultural sensors like solar radiation, soil moisture and soil temperature, 1350 Automatic Rain Gauge (ARG) stations and 10 GPS in 2009 and will increase these to 1300, 4000 and 40, respectively . In addition to this, a network of 55 Doppler Weather Radar has been planned of which 12 are to be commissioned in the first phase. DWR with the help of algorithms can detect and diagnose weather phenomena, which can be hazardous for agriculture, such as hail, downbursts and squall. A new satellite INSAT-3D is scheduled to be launched during 2011. INSAT-3D will usher a quantum improvement in satellite derived data from multi spectral high resolution imagers and vertical sounder. In addition to above, IMD is also planning to install wind profilers and radiometer to get upper wind and temperature data.

It is also augmenting its monitoring capability of the parameters of atmospheric environment. Trace gases, precipitation chemistry and aerosols will be monitored in the country on a long term basis at 2 baseline and 4 grab sample

GHG monitoring stations, Aerosol monitoring at 14 stations using sky radiometers, Black carbon measurement at 4 stations using aethelometers, Ozone measurements in NE and Port Blair in addition to existing stations in India and Antarctica, Turbidity and Rain Water chemistry at 11 stations and Radiation measurements at 45 stations. The data will be monitored and exchanged globally as per GAW / WMO protocols and quality control will be ensured as per international standards. Such data will be used in C-cycle models to accurately estimate radiation forcing and quantify source and sink potential for policy issues under UN framework.

The IMD, in collaboration with the NPL plays an important role for climate change-related long-term data collection at the Indian Antarctic base-Maitri. Continuous surface meteorological observations for about 22 years are now available for Schirmacher Oasis with National Data Centre of IMD.

The IMD collects meteorological data over oceans by an establishment of cooperation fleet of voluntary observing ships (VOF) comprising merchant ships of Indian registry, some foreign merchant vessels and a few ships of the Indian Navy. These ships, while sailing on the high seas, function as floating observatories. Records of observations are passed on to the IMD for analysis and archival.

2.3 Data archival and exchange

The tremendous increase in the network of observatories resulted in the collection of a huge volume of data. The IMD has climatological records even for the period prior to 1875, when it formally came into existence. This data is digitized, quality controlled and archived in electronic media at the National Data Centre, Pune. The current rate of archival is about three million records per year. At present, the total holding of data is about 9.7 billion records. They are supplied to universities, industry, research and planning organizations. The IMD prepared climatological tables and summaries/ atlases of surface and upper-air meteorological parameters and marine meteorological summaries. These climatological summaries and publications have many applications in agriculture, shipping, transport, water resources and industry.

The IMD has its own dedicated meteorological telecommunication network with the central hub at New Delhi. Under the WWW Global Telecommunication System, New Delhi functions as a Regional Telecommunication Hub (RTH) on the main telecommunication network. This centre was automated in early 1976, and is now known as the National Meteorological Telecommunication Centre (NMTC), New Delhi. Within India, the telecommunication facility is provided by a large network of communication links. The websites of IMD viz. *http://www.imd.gov.in* / http://www.mausam.gov.in operational from 1 June, 2000 contains dynamically updated information on all-India weather and forecasts, special monsoon reports, satellite cloud pictures updated every three hours, Limited Area Model (LAM), Global Circulation Model (GCM) generated products and prognostic charts, special weather warnings, tropical cyclone information and warnings, weekly and monthly rainfall distribution maps, earthquake reports, etc. It also contains a lot of static information, including temperature and rainfall normal over the country; publications, data archival details, monitoring networks and a brief overview of the activities and services rendered by IMD.

2.4 Augmentation of Weather and Climate forecasting capabilities (short, medium and long range)

In view of growing operational requirements from various user agencies, IMD has embarked on a seamless forecasting system covering short range to extended range and long range forecasts. Such forecasting system is based on hierarchy of Numerical Weather Prediction (NWP) models. For a tropical country like India where high impact mesoscale convective events are very common weather phenomena, it is necessary to have good quality high density observations both in spatial and temporal scale to ingest into assimilation cycle of a very high resolution non-hydrostatic mesoscale model. A major problem related to skill of NWP models in the tropics is due to sparse data over many parts of the country and near absence of data from oceanic region.

Data from AWSs, ARGs, DWRs, INSAT-3D and wind profilers are available in real time for assimilation in NWP models. A High Power Computing (HPC) system with 300 terabyte storage has been installed at NWP Centre at Mausam Bhavan. All

the systems have started working in an integrated manner in conjunction with other systems, such as all types of observation systems, AMSS, CIPS, HPCS, synergy system etc., in a real-time and have greatly enhanced IMD capability to run global and regional models and produce indigenous forecast products in different time scales. It has also started running a number of global and regional NWP models in the operational mode . IMD also makes use of NWP Global model forecast products of other operational centres, like NCMRWF T-254, ECMWF, JMA, NCEP, WRF and UKMO to meet the operational requirements of day to day weather forecasts. Very recently, IMD has implemented a multimodel ensemble (MME) based district level five days quantitative forecasts in medium range.

Climate-related risks are likely to increase in magnitude and frequency in future. There is need to prioritize actions to improve monitoring of such extremes and refine models for their prediction and projection in longer scale. New levels of integrated efforts like Global Framework for Climate Services/ National Framework for Climate Services (GFCS/NFCS) are required to strengthen climate research at existing and newer institutions to:

- Develop improved methodologies for the assessment of climate impacts on natural and human system
- Characterize and model climate risk on various time and space scales relevant to decision-making and refine climate prediction skills
- Enhance spatial resolution of climate predictions, including improvements in downscaling and better regional climate models
- Improve climate models to represent the realism of complex Earth system processes and their interactions in the coupled system
- Develop a better understanding of the linkages between climatic regimes and the severity and frequency of extreme events
- Enable progress in improving operational climate predictions and streamlining the linkages between research and operational service providers.

IMD is taking initiatives for creation of Indian Climate Observation System (ICOS) to support such services in long run.

A dynamical statistical technique is developed and implemented for the real-time cyclone genesis and intensity prediction. Numbers of experiments are carried out for the processing of DWR observations to use in nowcasting and mesoscale applications. The procedure is expected to be available in operational mode soon. Impact of INSAT CMV in the NWP models has been reported in various studies. Various multi-institutional collaborative forecast demonstration projects such as, Dedicated Weather Channel, Weather Forecast for Commonwealth Games 2010, Land falling Cyclone, Fog Prediction etc. are initiated to strengthen the forecasting capabilities of IMD.

Table 1
Atmospheric monitoring networks

1	Surface observatories	559
2	Pilot balloon observatories	65
3	RS/RW observatories	3
4	Aviation current weather observatories	71
6	Storm detecting radar stations	17
7	Cyclone detection radar stations	10
8	High-wind recording stations	4
9	Stations for receiving cloud pictures from satellites	
	a Low-resolution cloud pictures	7
	b High-resolution cloud pictures	1
	c INSAT-IB cloud pictures(SDUC stations)	20
	d APT Stations in Antarctica	1
	e AVHRR station	1
10	Data Collection Platforms through INSAT	100
11	Hydro-meteorological observatories	701
	a Non-departmental rain gauge stations	
	i Reporting	3540
	ii Non-reporting	5039
	b Non-departmental glaciological observations (non-reporting)	
	i Snow gauges	21
	ii Ordinary rain gauges	10
	iii Seasonal snow poles	6
12	Agro-meteorological observatories	219
13	Evaporation stations	222
14	Evapotranspiration stations	39
15	Seismological observatories	58
16	Ozone monitoring	
	a Total ozone and Umkehr observatories	5
	b Ozone-sonde observatories	3
	c Surface ozone observatories	6
17	Radiation observatories	
	a Surface	45
	b Upper air	8
18	Atmospheric electricity observatories	4
19	*a Background pollution observatories*	10
	b Urban Climatological Units	2
	c Urban Climatological Observatories	13
20	Ships of the Indian voluntary observing fleet	203
21	Soil moisture recording stations	49
22	Dew-fall recording stations	80
23	AWS	550
24	ARG	1300
25	GPS	10

Chapter – III

CLIMATE CHANGE SCENARIO

India Meteorological Department (IMD) maintains a well distributed network of more than 500 stations in the country for more than a century. The salient findings of the IMD studies (IMD Annual Climate Summary, 2009, Tyagi and Goswami, 2009, Attri 2006) are summarized as under:

3.1 Temperature

Analysis of data for the period 1901-2009 suggests that annual mean temperature for the country as a whole has risen by 0.56^0C (Fig 4) over the period. It may be mentioned that annual mean temperature has been generally above normal (normal based on period, 1961-1990) since 1990. This warming is primarily due to rise in maximum temperature across the country, over larger parts of the data set (Fig 5). However, since 1990, minimum temperature is steadily rising (Fig 6) and rate of its rise is slightly more than that of maximum temperature (IMD Annual Climate Summary, 2009). Warming trend over globe of the order of 0.74^0C has been reported by IPCC (2007)

Spatial pattern of trends in the mean annual temperature (Fig 7) shows significant positive (increasing) trend over most parts of the country except over parts of Rajasthan, Gujarat and Bihar, where significant negative (decreasing) trends were observed (IMD Annual Climate Summary, 2009).

Season wise, maximum rise in mean temperature (Fig 8) was observed during the Post-monsoon season (0.77^0C) followed by winter season (0.70^0C), Pre-monsoon season (0.64^0C) and Monsoon season (0.33^0C). During the winter season, since 1991, rise in minimum temperature is appreciably higher than that of maximum temperature over northern plains. This may be due to pollution leading to frequent occurrences of fog.

Upper air temperatures have shown an increasing trend in the lower troposphere and this trend is significant at 850 hPa level, while decreasing trend (not significant) was observed in the upper troposphere (Kothawale and.Rupa Kumar, 2002).

3.2 Precipitation Trends

The country as a whole, the all India annual and monsoon rainfall for the period 1901-2009 do not show any significant trend (Fig. 9a & 9b). Similarly rainfall for the country as whole for the same period for individual monsoon months also does not show any significant trend. The alternating sequence of multi-decadal periods of thirty years having frequent droughts and flood years are observed in the all India monsoon rainfall data. The decades 1961-70, 1971-80 and 1981-90 were dry periods. The first decade (1991-2000) in the next 30 years period already experienced wet period.

However, during the winter season, rainfall is decreasing in almost all the sub-divisions except for the sub-divisions Himachal Pradesh, Jharkhand and Nagaland, Manipur, Mizoram & Tripura. Rainfall is decreasing over most parts of the central India during the pre-monsoon season. However during the post-monsoon season, rainfall is increasing for almost all the sub-divisions except for the nine sub-divisions (Fig 10).

The analysis for the monthly rainfall series of June, July, August, and September (% variation) for all the 36 subdivisions (Guhathakurta, P. and Rajeevan 2008) shows significant variations on the regional scale (Fig. 11) which are summarized as under:

- June rainfall has shown increasing trend for the western and southwestern parts of the country whereas decreasing trends are observed for the central and eastern parts of the country. Its contribution to annual rainfall is increasing in 19 subdivisions and decreasing in the remaining 17 subdivisions.

- The contribution of July rainfall is decreasing in central and west peninsular India (significantly in South interior Karnataka (95%), East M.P.(90%) Vidarbha (90%), Madhya Maharashtra (90%), Marathwada (90%), Konkan & Goa (90%), and North interior Karnataka (90%)), but has increased significantly in the northeastern parts of the country
- In August, four (ten) subdivisions have shown decreasing (increasing) trends in rainfall. It has increased significantly (at 95% significance level) over the subdivisions Konkan and Goa, Marathwada, Madhya Maharashtra, Vidarbha, West M.P., Telangana and west U.P.
- September rainfall is increasing significantly (at 95% level of significance) in Gangetic West Bengal and decreasing significantly (at 90% level of significance) for the sub-divisions Marathwada, Vidarbha and Telangana.

During the season, three subdivisions viz. Jharkhand (95%), Chattisgarh (99%), Kerala (90%) show significant decreasing trends and eight subdivisions viz. Gangetic WB (90%), West UP (90%), Jammu & Kashmir (90%), Konkan & Goa (95%), Madhya Maharashtra (90%), Rayalseema (90%), Coastal A P (90%) and North Interior Karnataka (95%) show significant increasing trends. The trend analyses of the time series of contribution of rainfall for each month towards the annual total rainfall for each year in percentages suggest that contribution of June and August rainfall exhibited significant increasing trends, while contribution of July rainfall exhibited decreasing trends.

However, no significant trend in the number of break and active days during the southwest monsoon season during the period 1951–2003 (Fig 12) were observed (Rajeevan et al 2006).

3.3 Extreme Rainfall events

A large amount of the variability of rainfall is related to the occurrence of extreme rainfall events. The extreme rainfall series at stations over the west coast north of 12°N and at some stations to the east of the Western Ghats over the central parts of the Peninsula showed a significant increasing trend at 95% level of

confidence. Stations over the southern Peninsula and over the lower Ganga valley have been found to exhibit a decreasing trend at the same level of significance. Various studies on extreme rainfall over India have found the occurrences of 40 cm or more rainfall along the west and east cost of India, Gangetic West Bengal and north eastern parts of India. Country's highest observed one day point rainfall (156.3 cm) and also world's highest 2-day point rainfall (249.3cm) occurred in Cherrapunji of northeast India in the year 1995 (IMD 2006).

Significant increasing trend was observed in the frequency of heavy rainfall events over the west coast (Sinha Ray & Srivastava, 2000). Most of the extreme rainfall indices have shown significant positive trends over the west coast and northwestern parts of Peninsula. However, two hill stations considered (Shimla and Mahabaleshwar) have shown decreasing trend in some of the extreme rainfall indices (Joshi & Rajeevan, 2006). Increase in heavy and very heavy rainfall events and decrease in low and moderate rainfall events in India have been reported by Goswami et al (2006). Rao et al (2010) have assessed the role of Southern Tropical Indian Ocean warming on unusual central Indian drought of summer monsoon – 2008.

The recent exceptionally heavy rainfall of 944 mm over Mumbai (Santacruz) on 26th July, 2005 was very unprecedented in nature, which led to many more studies on frequency and variability of heavy rainfall events. The development of a high resolution (1° X1° lat./long.) gridded daily rainfall dataset for the Indian region by IMD is very helpful in undertaking such studies. Based on the amount of rainfall in a day, IMD has classified into six categories. However, for extreme event studies, rain has been regrouped into three broad categories viz. i) light to rather heavy rainfall ($0 < R \leq 64.4$ mm), ii) heavy rainfall ($64.4 < R \leq 124.4$ mm) and iii) very heavy to exceptionally heavy rainfall ($R > 124.4$ mm). Rainfall > 124.4 mm will be referred hereafter as extreme rainfall events (Pattanaik and Rajeevan, 2010).

The frequency of extreme rainfall (Rainfall $\geq$ 124.4 mm) shows increasing trend over the Indian monsoon region during the southwest monsoon season from June to September (JJAS) and is significant at 98% level **(**Fig. 13). It is also found that the increasing trend of contribution from extreme rainfall events during JJAS is balanced by a decreasing trend in category-i (rainfall $\leq$ 64.4 mm/day) rainfall events. Similarly on monthly

scale, the frequency of extreme rainfall events show significant (95% level) increasing trend during June and July, whereas during August and September the increasing trend is not significant statistically (Fig. 14). Like the frequency of extreme rainfall events, the contribution of extreme rainfall to the total rainfall in a season is also showing highly significant increasing trend during the monsoon season from June to September and during June and July on monthly scale. It is observed that the mean monthly contribution of heavy and extreme rainfall events (rainfall > 64.4 mm in a day) during June-July is 5 to 6% higher than that during August-September and hence contributes significantly to the total rainfall during the first half of the season (June and July).

3.4 Cloud cover over the Indian Seas

Both total and low cloud cover over Arabian Sea and the equatorial Indian Ocean are observed to decrease during the ENSO events. However, cloud cover over Bay of Bengal is not modulated by the ENSO events. On inter-decadal scale, low cloud cover shifted from a "low regime" to a "high regime" after 1980 which may be associated with the corresponding inter-decadal changes of sea surface temperatures over north Indian Ocean observed during the late 1970s (Rajeevan et al., 2000).

3.5 Heat Wave and Cold Wave

A significant increase was noticed in the frequency, persistency and spatial coverage of both of these high frequency temperature extreme events (heat and cold wave) during the decade (1991-2000) (Pai et al. 2004).

3.6 Discomfort indices

It has been found that in general, there is an increasing trend (significant) in the discomfort indices from the last 10 days of April to June over most of the Indian cities (Srivastava, et al. 2007).

This publication is confined to observed climate change. However, future scenario of climate change in India have been brought out by Indian Institute of Tropical Meteorology, Pune (NATCOM 2004, Rupa kumar et al 2006, Krishan Kumar 2009, INCCA 2009)

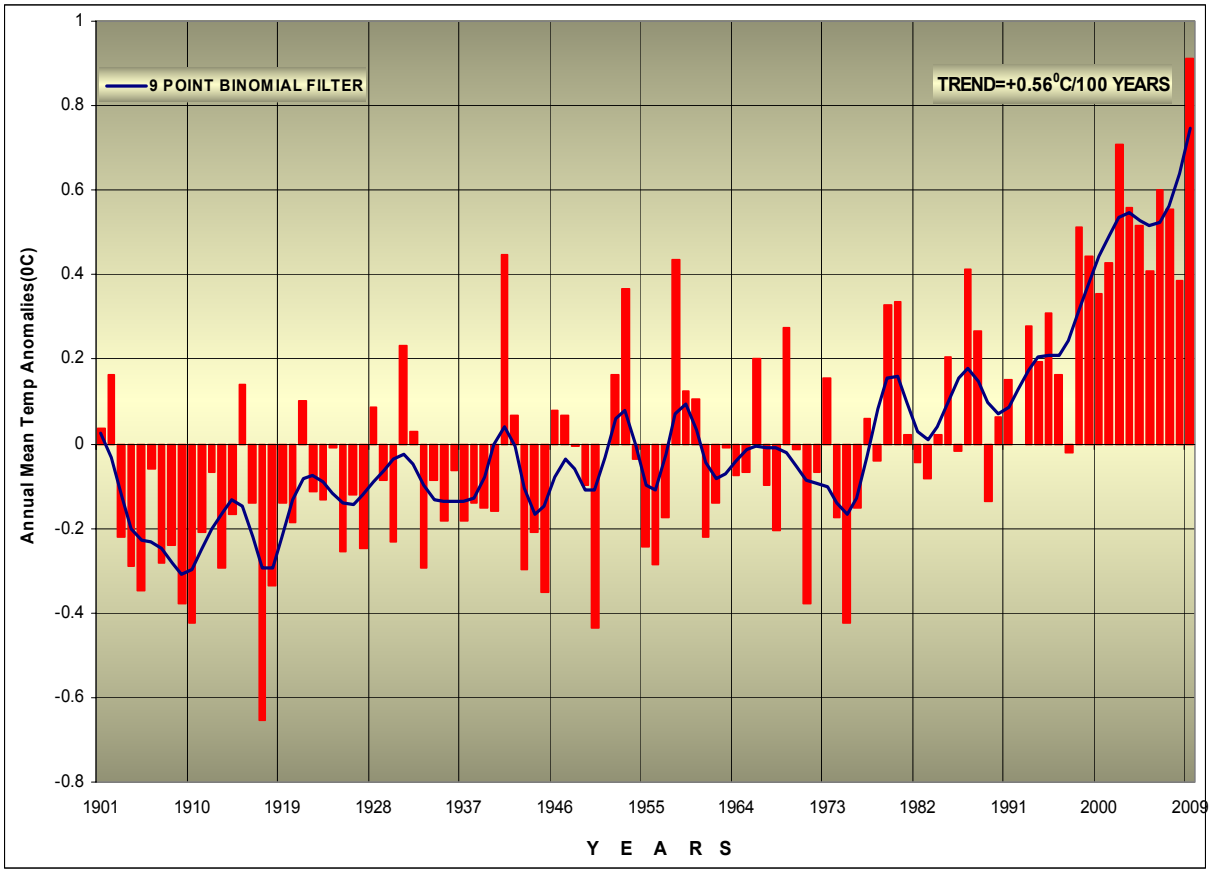


Fig 4: All India annual mean temperature anomalies for the period 1901-2009 (based on 1961-1990 average) shown as vertical bars

(***The solid blue curve show sub-decadal time scale variations smoothed with a binomial filter)***

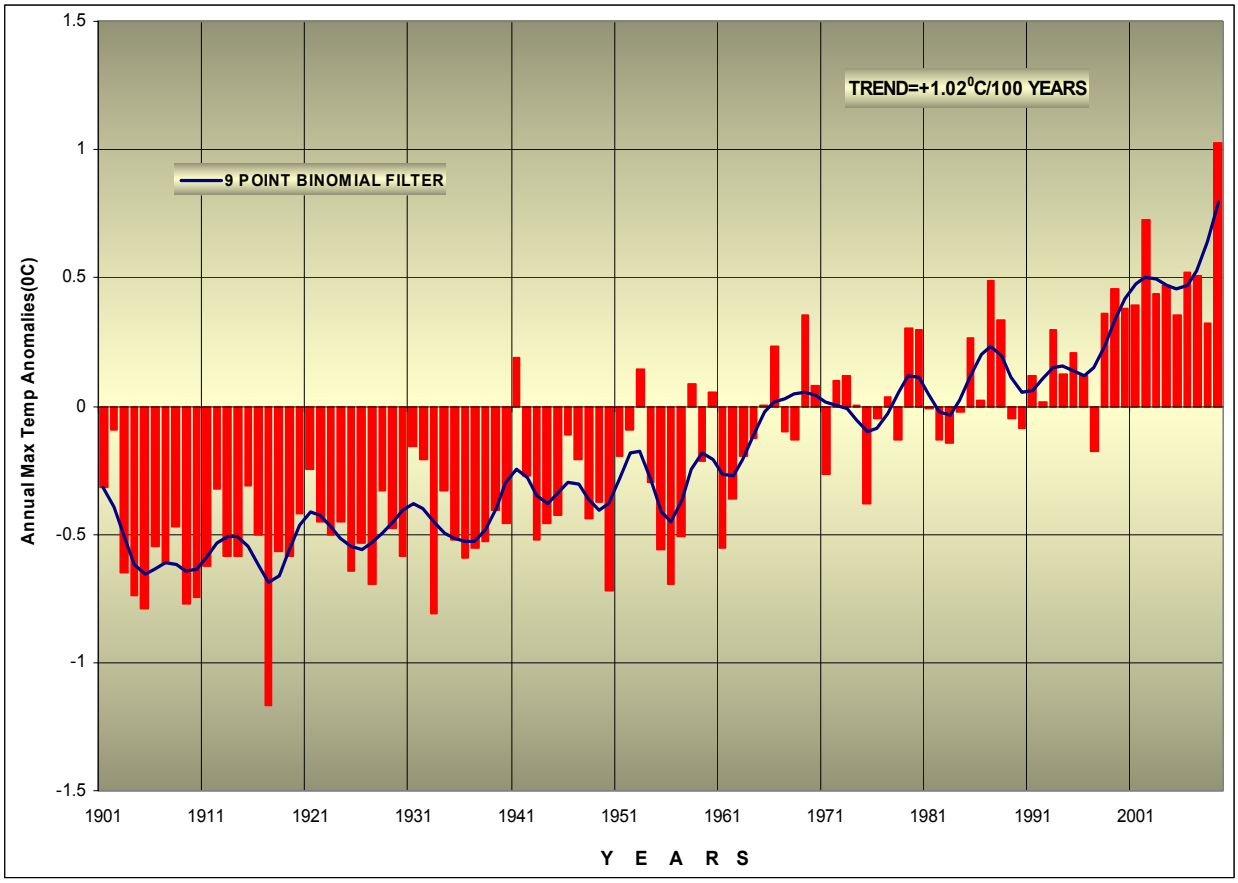


Fig 5: All India annual maximum temperature anomalies for the period 1901-2009 (based on 1961-1990 average) shown as vertical bars

(***The solid blue curve show sub-decadal time scale variations smoothed with a binomial filter)***

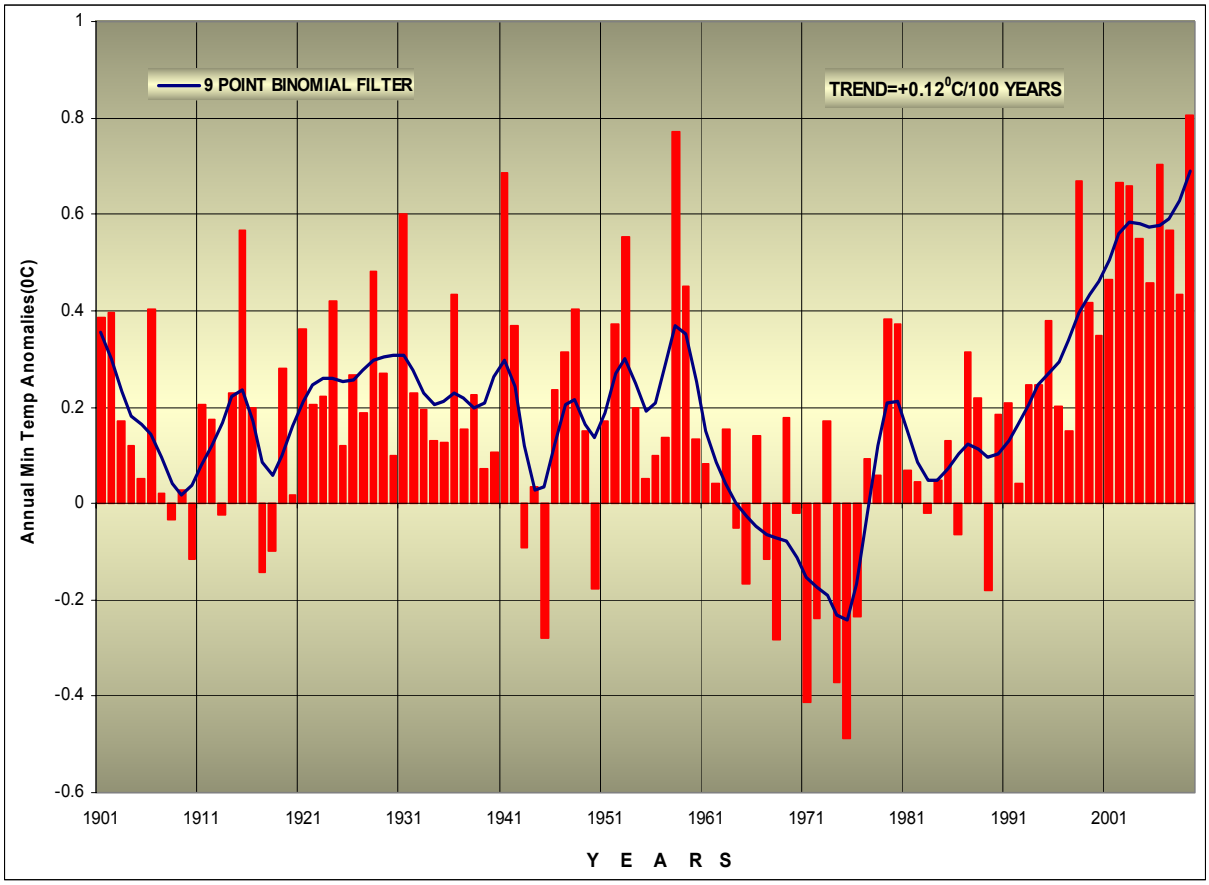


Fig 6: All India annual minimum temperature anomalies for the period 1901-2009 (based on 1961-1990 average) shown as vertical bars

(The solid blue curve show sub-decadal time scale variations smoothed with a binomial filter)