

2012 SWAT INTERNATIONAL CONFERENCE,
NEW DELHI

July 19th 2012

HYDROLOGIC MODELLING OF THE EASTERN CONTRIBUTING BASINS OF VEMBANAD LAKE USING SWAT

Raktim Haldar

Research Scholar

Department of Civil Engineering

Indian Institute of Technology, Delhi

Issues to be addressed



- Introduction to the Vembanad Lake and surrounding scenario of development
- Anthropogenic impacts on lake environment
- Purpose of modelling
- Modelling requirements
- Methodology
- Comparison of results for different scenarios

The Vembanad Lake

- The Vembanad wetland system lies in the Indian state of Kerala, between the latitudes $9^{\circ}5' N$ and $10^{\circ} N$ and the longitudes $76^{\circ}15' E$ and $76^{\circ}45'E$.

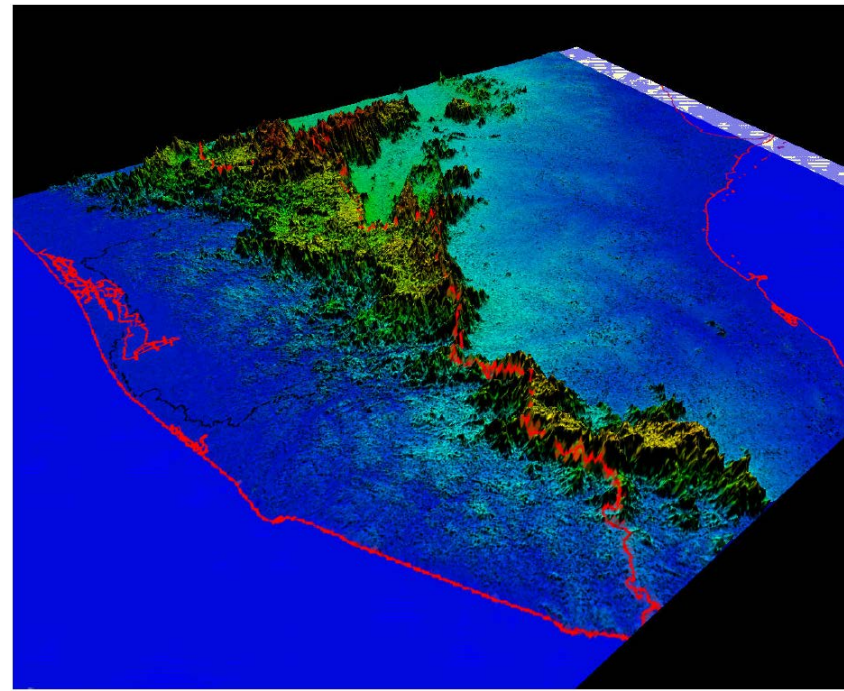
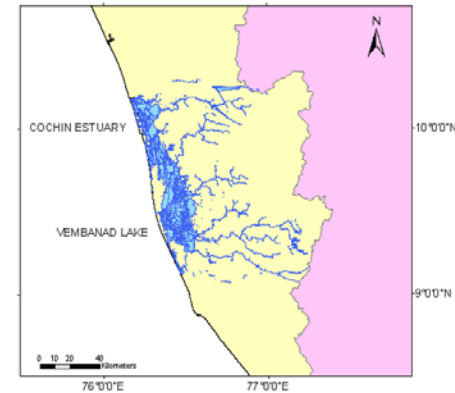
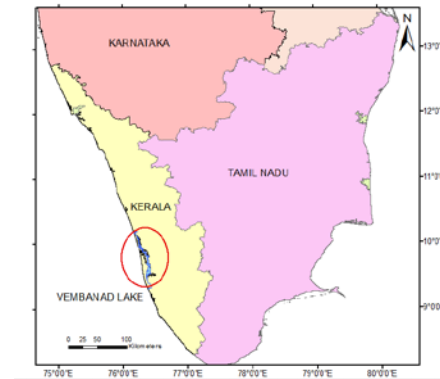
Vembanad Lake was declared as a Ramsar site, a wetland of international importance in November 2002.



Vembanad Lake, along with adjacent kol lands, is the largest Ramsar site in India and supports the third largest wintering waterfowl population of the country.

The Morphologic Background

- The rivers joining the Vembanad Lake form a natural wetland surrounding the main lake body.
- The five major rivers joining the Vembanad Lake are Muvattupuzha, Meenachil, Manimala, Pamba and Achenkovil form the southern network of channels; while Periyar, the largest of the rivers of Kerala joins the northern part of the wetland system.
- The lake lies at the sea level with depths varying from 1 to 13 meters below mean sea level.
- The lake is separated from the Lakshadweep Sea by series of islands and at places by minor sand bar formations.



Sea-connectivities

□ The wetland system has three major connectivities with the sea, at Munambam, at Cochin and at Thottapally.

□ The water from Periyar exits the system mainly at Munambam and has meager influence on the Vembanad Lake flow dynamics, which lies south of the Cochin outlet.

□ Keeping this in view the five rivers have been considered for the study.

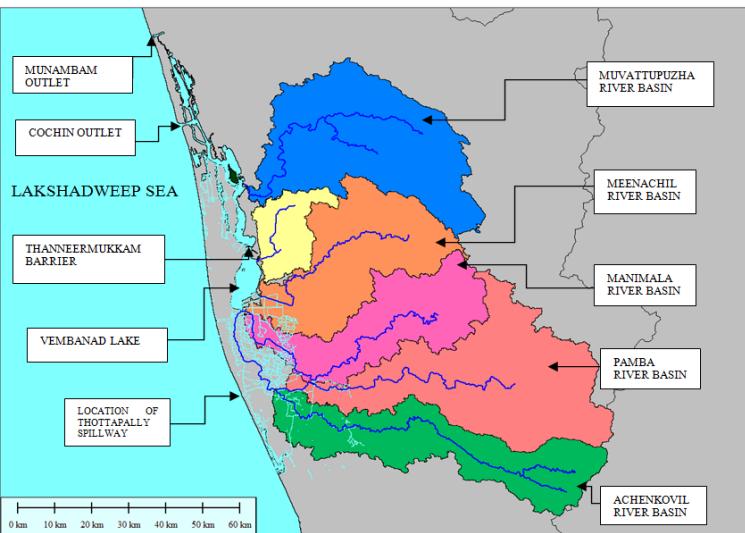
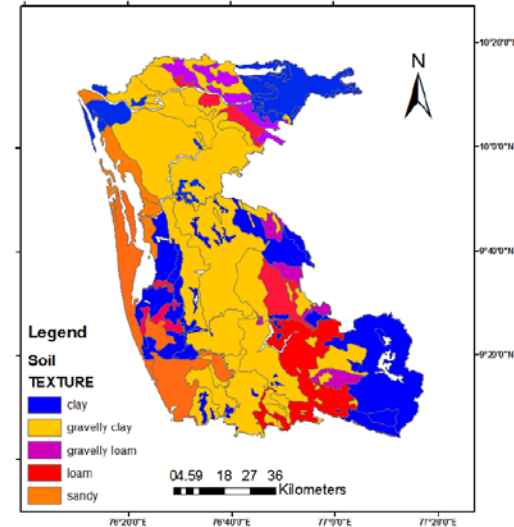
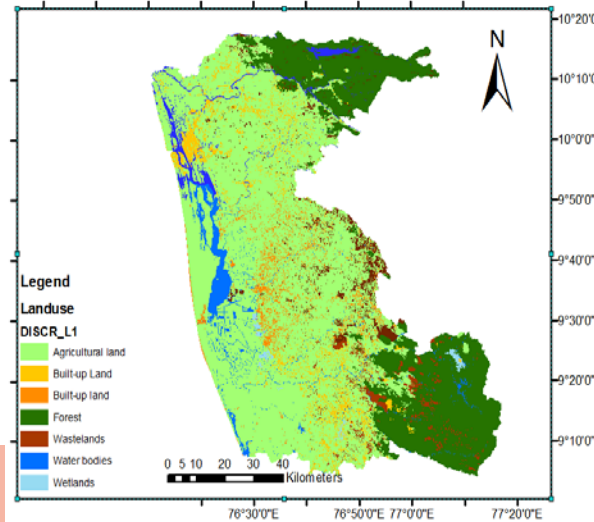
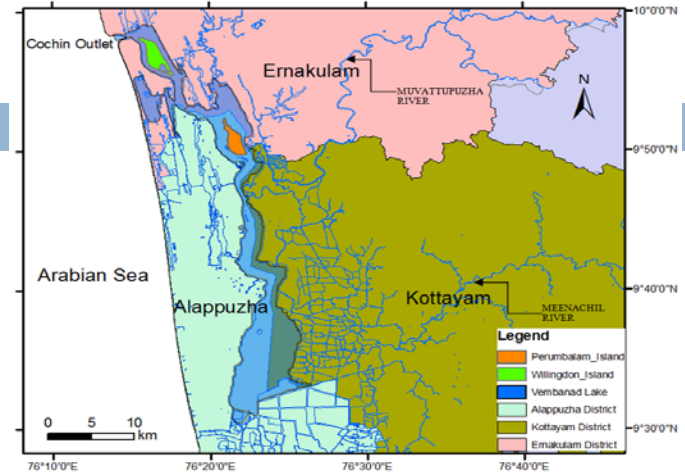


Figure showing the Vembanad Lake and contributing river basins, namely, Muvattupuzha, Meenachil, Manimala, Pamba and Achenkovil

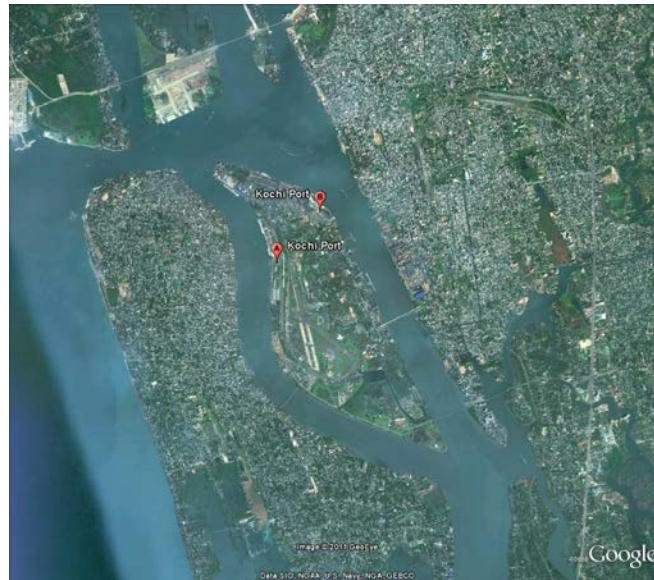
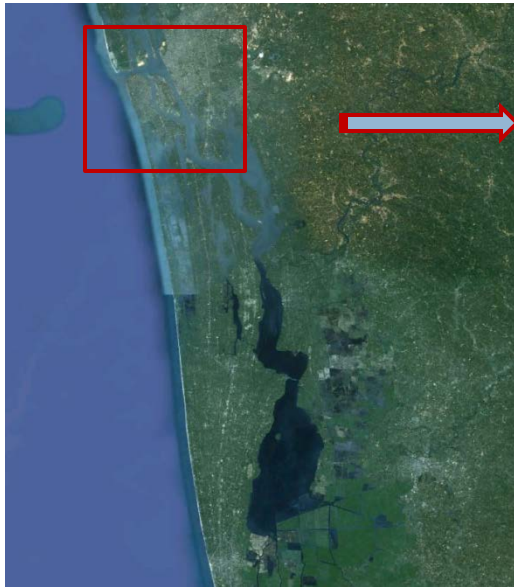
Administrative Boundaries



Land-use and Soil map

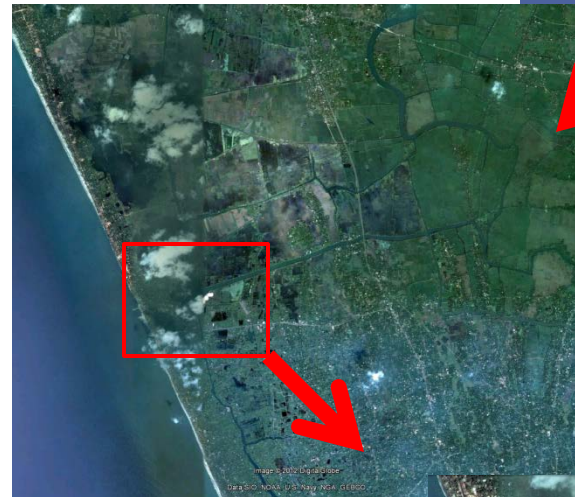
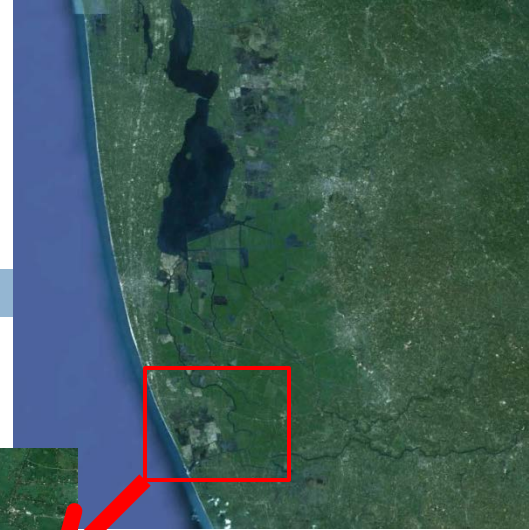
Anthropogenic Influences

1. **Port of Kochi - Wellington Island was created (1838-1845)**
2. Thottapally Spillway (completed in 1955)
3. Thaneermukkom Saltwater barrier (commissioned in 1975)
4. Embankments for paddy cultivation



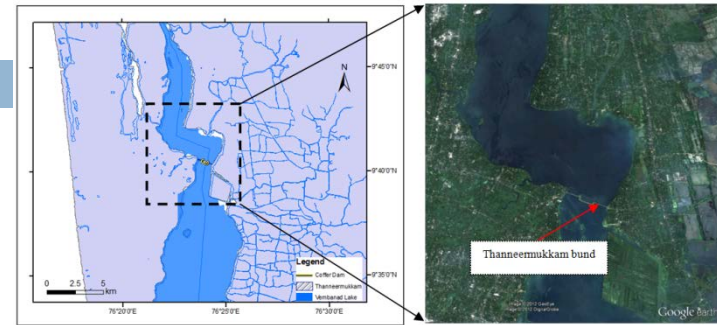
Anthropogenic Influences

1. Port of Kochi - Wellington Island was created (1838-1845)
2. **Thottapally Spillway (completed in 1955)**
3. Thaneermukkom Saltwater barrier (commissioned in 1975)
4. Embankments for paddy cultivation



Anthropogenic Influences

1. Port of Kochi - Wellington Island was created (1838-1845)
2. Thottapally Spillway (completed in 1955)
3. **Thaneermukkom Saltwater barrier (commissioned in 1975)**
4. Embankments for paddy cultivation



Location of Thanneermukkam Bund in the Vembanad Lake



Anthropogenic Influences

1. Port of Kochi - Wellington Island was created (1838-1845)
2. Thottapally Spillway (completed in 1955)
3. Thaneermukkom Saltwater barrier (commissioned in 1975)
4. **Embankments for paddy cultivation**

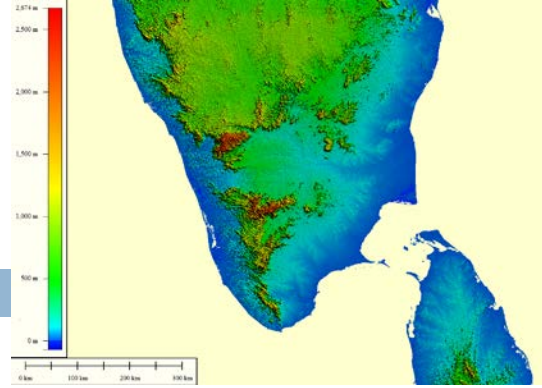
Period	Area reclaimed		Purpose
	(ha)	(%)	
1834-1903	2227	6.1	Agricultural
1912-1931	5253	14.4	Agricultural
1920-1936	364	1.0	Wellington island
1941-1950	1325	3.6	Agricultural
Till 1970s	5100	14.0	Paddy-cum-shrimp culture
1970-1984	800	2.2	Paddy-cum-shrimp culture
1975	6900	18.9	Ecologically severed from backwater as a result of bunding at Thannirmukham
1978	11	0.03	Fishing harbour
1981-1985	142	0.4	Vallarapadam - Ramanthuruthu
1981-1985	142	0.4	Candle island
1981-1985	142	0.4	Southern extension to Wellington island
1981-1985	24	0.06	Foreshore urban development
1981-1985	12	0.03	Cochin Shipyard & tanker berths
1900-1984	1500	4.1	Housing, agricultural & traditional industries



In the Kuttanad region, construction of embankments (bunds) in the shallow parts of the backwaters started at least a century ago. The purpose was to create large tracts of land in which paddy could be grown in the period between the end of the flood season (Nov) and the dry season when water becomes too saline for agriculture. In course of time these tracts have grown to 550 km², even to areas where water depth used to be 2.5m and the people live on the embankments.

Motivation

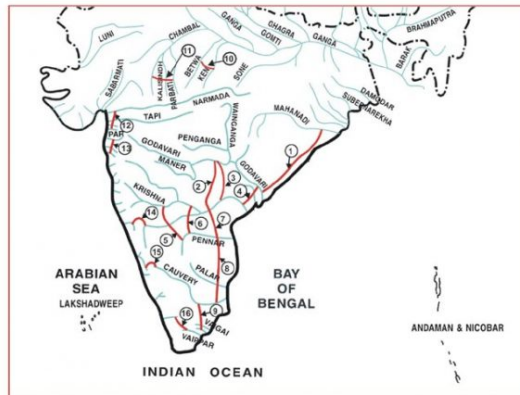
- The occurrence of rainfall in Peninsular India is never uniform owing to several reasons.
- The topography of heavy rainfall regions does not permit utilisation of entire waters.
- This leads to a paradoxical situation; abundant waters and no land to utilise them on western side and vast areas of arable land and no water to irrigate them on eastern side.
- While the areas on the western side of Western Ghats are endowed with abundant rainfall, the areas along the east coast of Tamil Nadu receive scanty rainfall from north east monsoon.
- The areas in the eastern side of Western Ghats sandwiched between Western Ghats and coastal areas of Tamil Nadu do not have the benefit of receiving significant rainfall from either of the two monsoons and is being situated in a rain shadow area and hence affected by chronicle droughts in almost every year.



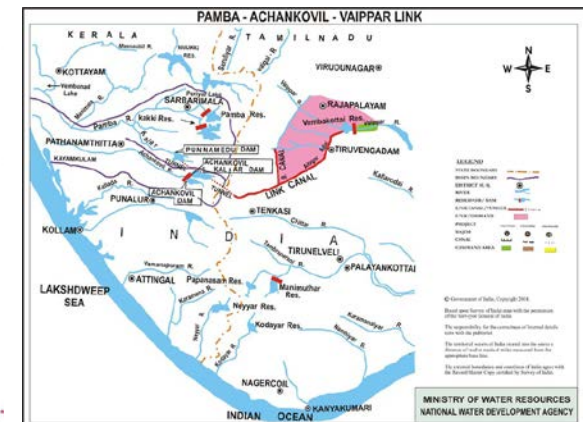
Topography depicting the Western Ghats

The **Pampa - Achankovil - Vaippar Link Project (PAVLP)** is one among the inter-basin water transfer schemes formulated by the NWDA for utilising the surplus water available in the river basin to another river basin facing acute water shortage. The Pampa Achankovil-Vaippar Link Project, proposes a **diversion of 634Mm³ of waters** from Pampa and Achankovil rivers in Kerala to irrigate areas in the Vaippar river basin in Tamil Nadu.

PROPOSED INTER BASIN WATER TRANSFER LINKS PENINSULAR COMPONENT



1. Mahanadi (Manibhadra) – Godavari (Dowlaiswaram) *
 2. Godavari (Inchampalli) – Krishna (Nagarjunasagar) *
 3. Godavari (Inchampalli) – Krishna (Pulichintala) *
 4. Godavari (Potlavarum) – Krishna (Vijayawada) *
 5. Krishna (Almatti) – Pennar *
 6. Krishna (Srisaillam) – Pennar *
 7. Krishna (Nagarjunasagar) – Pennar (Somasila) *
 8. Pennar (Somasila) – Palar- Cauvery (Grand Anicut) *
 9. Cauvery (Kattalai) – Vaigai – Gundar *
 10. Ken – Betwa *
 11. Parbati – Kalisindh – Chambal *
 12. Par – Tapi – Narmada *
 13. Damanganga – Pinjal *
 14. Beeti – Varda *
 15. Netravati – Hemavati *
 16. Pampa – Achankovil – Vaippar *
- * FR Completed

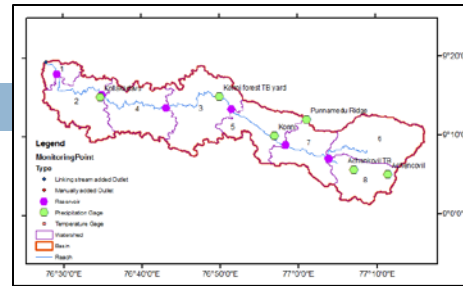


MINISTRY OF WATER RESOURCES
NATIONAL WATER DEVELOPMENT AGENCY

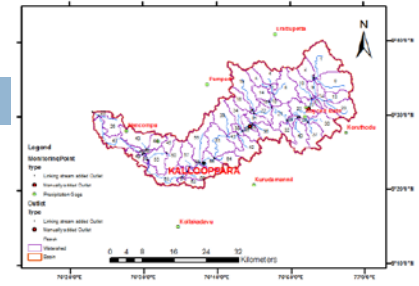
Model Setup

Delimited watershed of

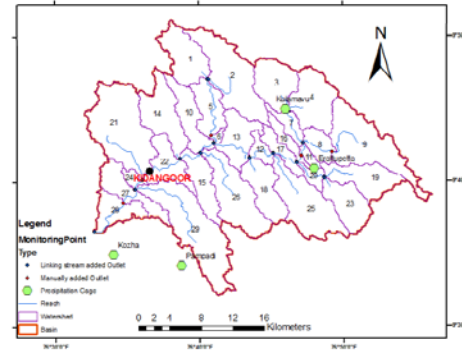
- DEM (SRTM based)
- Stream Network - Digitized from Google Earth and ascertained with that provided by state water resources department maps
- LANDUSE and SOIL
- HRU creation
- Rainfall and Temperature
- Reservoir and Irrigation plus hydel projects information
- Calibration and Validation



The Achenkovil basin



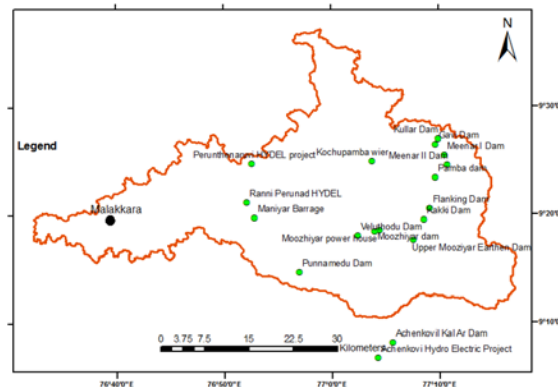
The Manimala basin



The Meenachil basin



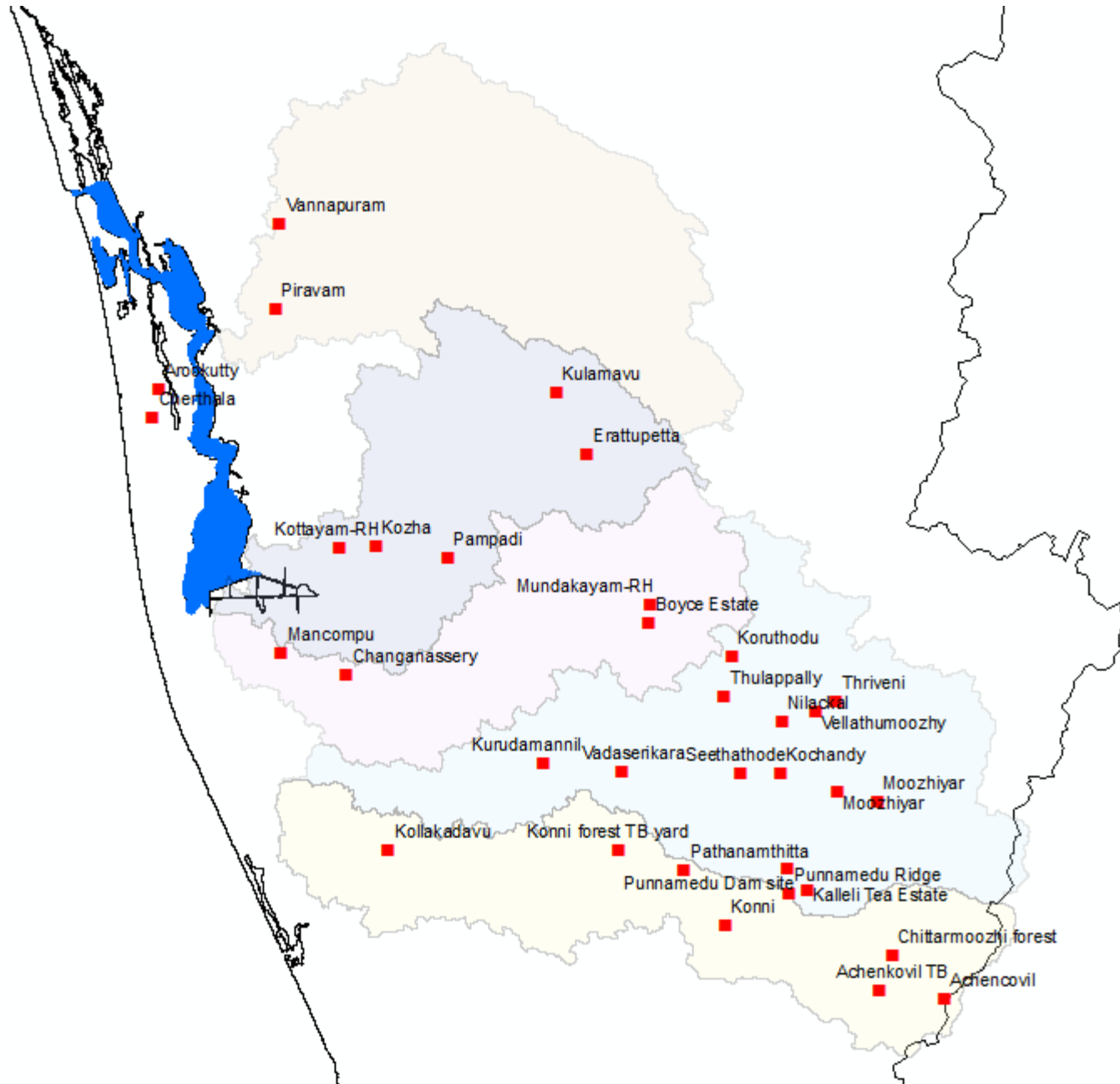
The Muvattupuzha basin



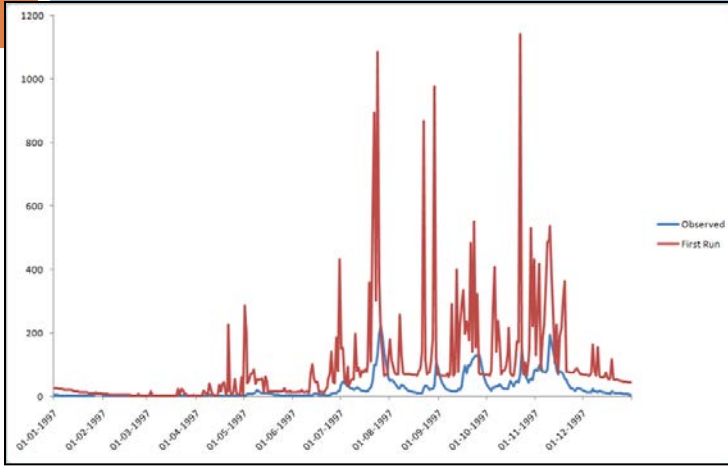
The Pamba basin

Approximate Project Locations

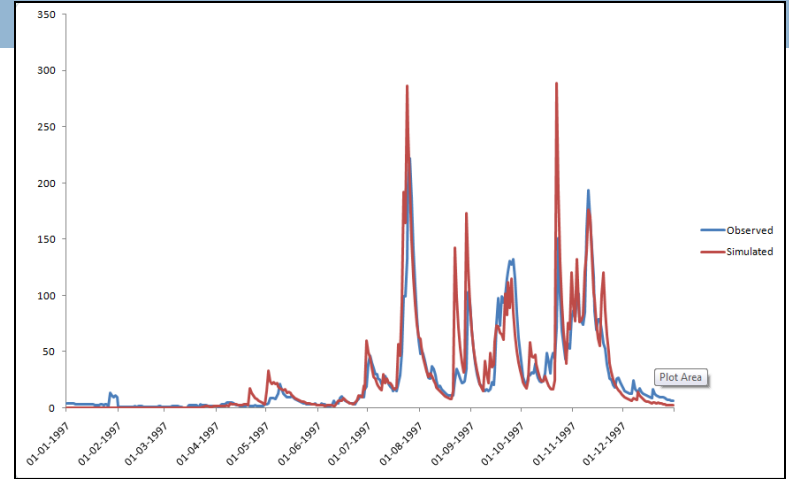
Rainfall Station Locations- Few (1995-2008) & Others (2001-08)



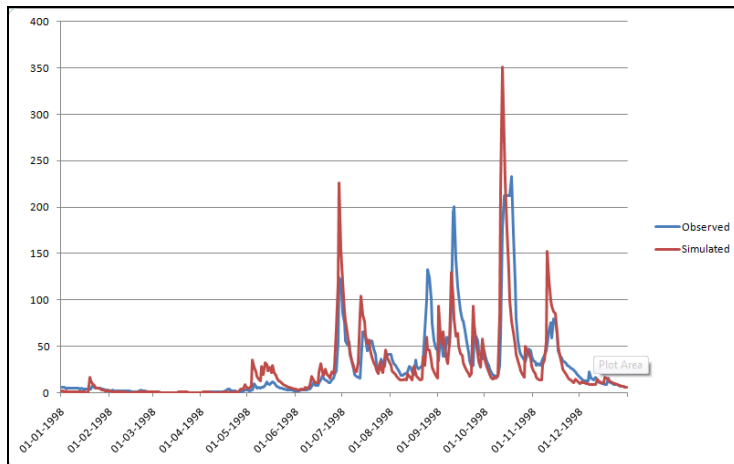
Model Calibration and Validation



Before Calibration □ For Achenkovil Basin



After Calibration

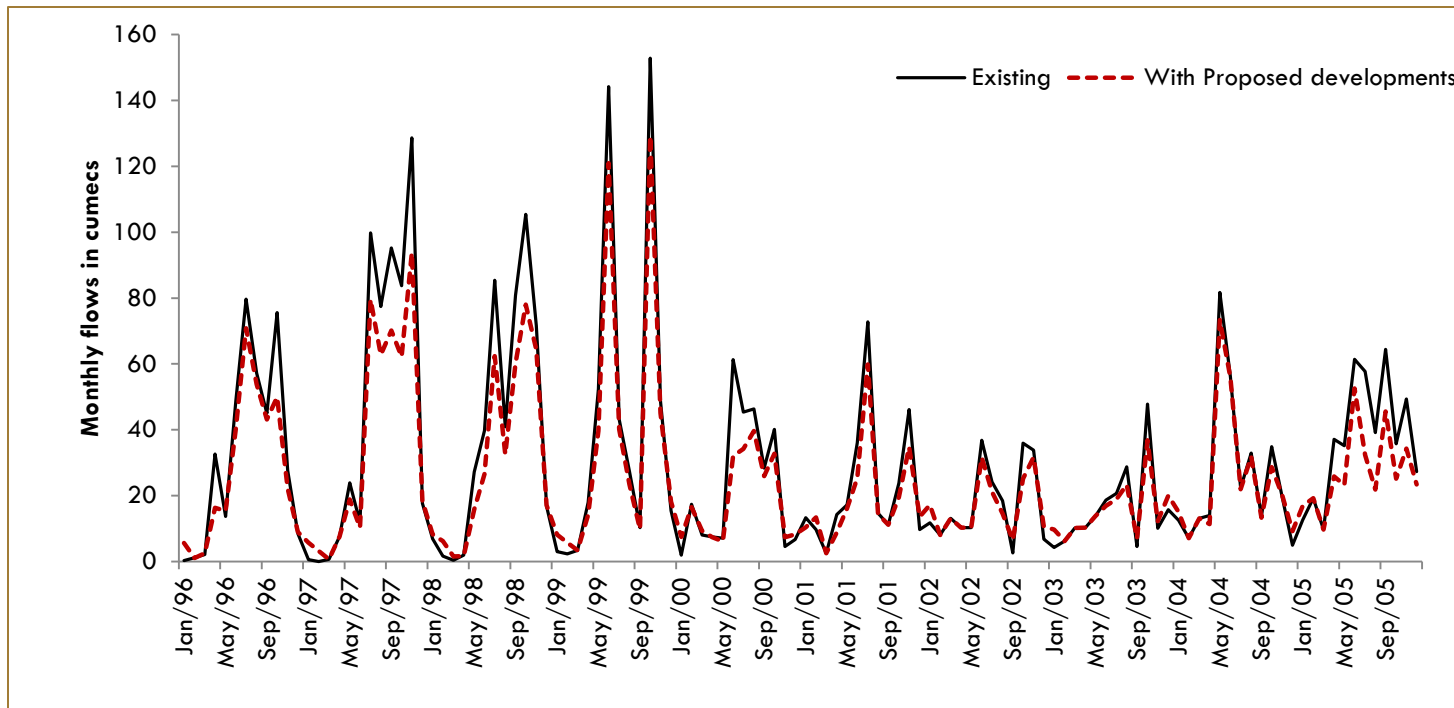


Validation period

Monitoring stations	NSE	R ²	RSR	PBIAS (%)
Acceptable Limits	> 0.5 _a	> 0.5 _b	< 0.7 _a	± 25 _a
Kalampoor (Muvattupuzha)	0.805549	0.817319	0.440966	1.559381
Kidangoor (Meenachil)	0.605457	0.69074	0.628127	0.705749
Kalloopara (Manimala)	0.806507	0.822214	0.439879	6.289268
Malakkara (Pamba)	0.724427	0.727976	0.52495	0.840595
Kollakadavu (Achenkovil)	0.685099	0.811673	0.56116	22.13738

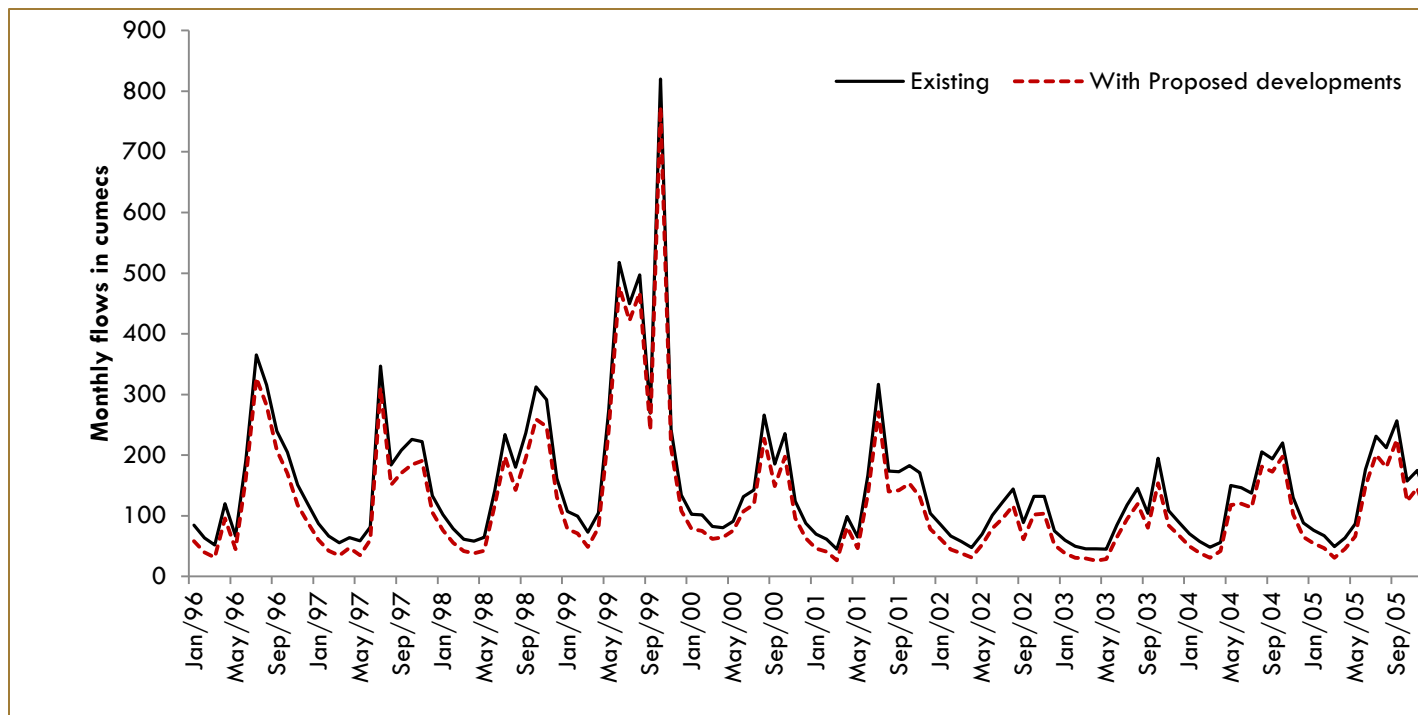
Modelling under future development scenario (Achenkovil)

After the SWAT model was calibrated and validated for the existing scenario of development, proposed changes were included in the model by adding reservoirs to the specific subbasins and changing the water uses of few subbasins where new projects and diversions are proposed.



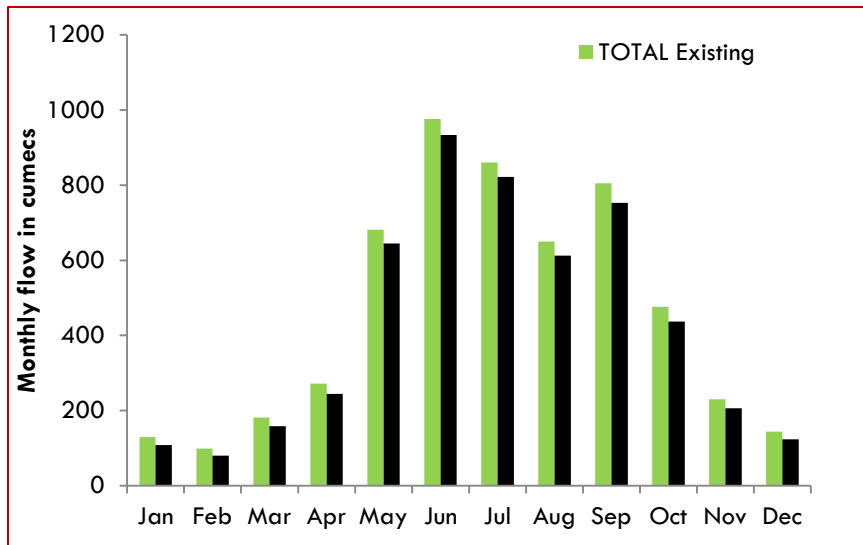
Comparison of simulated monthly flows for Achenkovil River before and after proposed developments

Modelling under future development scenario (Pamba)

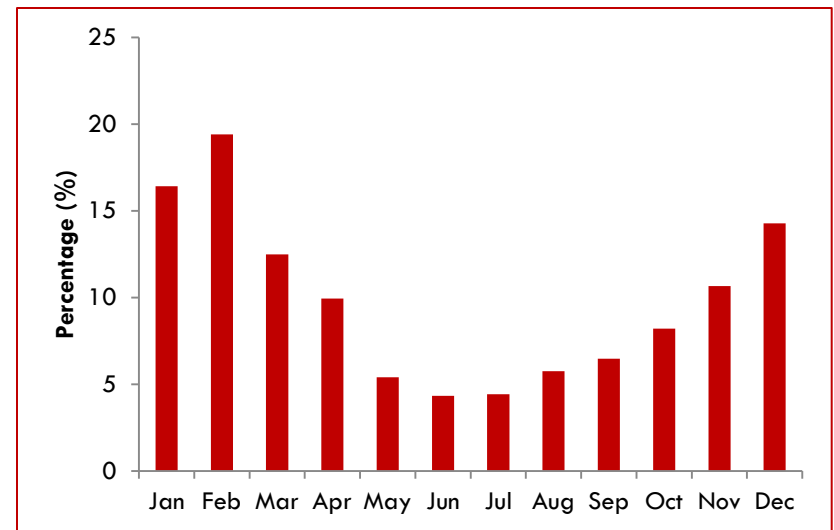


Comparison of simulated monthly flows for Pamba River before and after proposed developments

Comparison of Average Monthly Discharge



Comparison of average (1996-2005) simulated total monthly flows for the five rivers before and after development



Percentage reduction in total flow of five rivers averaged for ten years modeled (1996-2005)

The inferences from the study can be concluded as:

- The alteration of the Pamba and Achenkovil hydro-systems introduce a change of 5 – 20 % in the total flow volumes entering into the Vembanad Wetland system.
- The higher impacts can be seen in the low –flow months during which the rivers have meagre flow and become almost stagnant.
- This can be another serious problem to the already depleted lake environment.

Conclusions from the study

- Impact of these latter initiatives on the natural river regime, both in quantity as well as quality terms is expected to be significant.
- The natural consequence of these impacts is its adverse effect on the connected wetland system along with its resident biota.
- Hence it is very important that the decisions related to water resources development be taken after deliberate research and attention to previously witnessed fate of so many river and wetland systems in the world.

Acknowledgement

First of all, I would like to thank the people who have made it possible for this study to substantiate. First of them is the **Hon'ble Minister for Water Resources, Government of Kerala, Shri P.J. Joseph**. Other officials whose guidance led to the prosperous progress of the work are:

1. Smt. P. Lathika, Chief Engineer, Inter-State Water (ISW), Government of Kerala;
2. Mr. M.K. Parameswaran Nair, Chairman, Mullaperiyar Cell;
3. Mr. Abraham Koshy and Mr. R. Mohanan, Assistant Executive Engineers, Irrigation Department, Government of Kerala



Thanks for your attention!