August 19, 2018
Alappuzha District

APPENDICES

Appendix 1.1

Statement showing list of institutions covered by Audit

(Reference: Paragraph 1.4)

Sl. No.	Name of District	Name of institutions covered by Audit
1.	Alappuzha	District Disaster Management Authority, District Emergency Operations Centre, Chengannur Taluk, Kuttanad Taluk, Major Irrigation Division, Minor Irrigation Division, Mechanical Division, Chief Engineer Kuttanad Package, Kuttanad Development Division Thanneermukkom, Fire Stations at Thakazhi and Chengannur
2.	Ernakulam	District Disaster Management Authority, District Emergency Operations Centre, Aluva Taluk, Paravur Taluk, Office of the Special Tahsildar, Nedumbassery, Village Office, Nedumbassery, Major Irrigation Division, Minor Irrigation Division, Fire stations at Aluva and North Paravur, Idamalayar dam, Bhoothathankettu barrage, Central Water Commission Regional Office
3.	Idukki	District Disaster Management Authority, District Emergency Operations Centre, Idukki Taluk, Devikulam Taluk, Major Irrigation Division, Minor Irrigation Division, Idukki dam, Lower Periyar dam, Madupetty dam, Kallarkutty dam, Fire Stations
4.	Thrissur	District Disaster Management Authority, District Emergency Operations Centre, Chalakkudy Taluk, Thalappilly Taluk, Major Irrigation Division, Minor Irrigation Division, Vazhani Dam, Poringalkuthu Dam, Lower Sholayar Dam, Civil Defence Training Institute, Fire and Rescue Services Academy
5.	Thiruvananthapuram	Revenue Disaster Management Department, Water Resources (Irrigation) Department, Finance Department, Transport Department, Kerala State Disaster Management Authority, State Emergency Operations Centre, India Meteorological Department, Fire and Rescue Headquarters, Chief Engineer Irrigation, Design and Research Board, Chief Engineer Irrigation and Administration, Chief Engineer Mechanical, Chief Engineer Project II, Institute of Land and Disaster Management, Dam Safety Organisation, Kerala State Electricity Board Limited, Land Use Board, Commissionerate of Land Revenue
6.	Dam Safety Organisation of KSEBL, Pallom, Kottayam district	

Appendix 2.1

Details of encroachment of water bodies noticed in the test-checked districts and status of action taken by Departments*

(Reference: Paragraphs 2.1, 2.3, 4.1)

Sl. No.	Location details	Number of encroachments	Extent of land (in Ha)	Whether complaints received or not
1.	**Deviyarpuzha at Adimali-Valara stretch (Survey no. 205 and 206) in Idukki district**	**23**	**0.2221**	**8 nos. from 2013 to 2016**
Performance Audit Party examined 11 files relating to the encroachment of Deviyarpuzha maintained at Taluk Office, Devikulam. All these files pertained to the complaints of local people and departments regarding illegal construction of buildings by encroachment of the river bed and obstructing the free flow of the river. However, no action was taken to identify the extent of encroachment by surveying the area. Superintendent of Police (Intelligence), Special Branch CID, Thiruvananthapuram reported (December 2012) to the District Collector, Idukki about encroachments of Deviyarpuzha by constructing multi-storied buildings and warned that non-eviction of these encroachments would lead to further encroachments of the area. In one case, Village Officer, Mannamkandam Village after conducting preliminary enquiry reported (January 2015) that there were 23 number of encroachments (0.2221 ha) of Deviyarpuzha at Adimali-Valara stretch near Irumbupalam. The encroachers had been occupying the land for more than five years. No further action was taken in this regard. A joint site verification (December 2019) revealed that the riverbank was encroached upon by constructing huge buildings which reduced the width of the river to a narrow stretch and thereby obstructed the free flow of the river which caused inundation of adjacent area in 2018 flood. No survey of the river to demarcate the boundaries was conducted to identify and evict the encroachers. Taluk Officer, Devikulam Taluk replied that out of 53 complaints and KLC cases regarding the encroachment of rivers and water bodies received in Devikulam Taluk upto 2018-19, only one eviction has taken place till date. Other cases were pending in the office either with the surveyor or with the village officer.				
2.	**Kanoli Canal in Thrissur district**	**832**	**17.97**	**Yes in May 2008**
Kanoli Canal is part of west coast canal network of Kerala and the canal was constructed by combining the rivers and streams along the coasts. In Thrissur District Kanoli canal starts from Kodungallur Taluk and passes through Kodungallur, Thrissur, Chavakkad and Mukundapuram Taluks. A complaint regarding encroachment of land in Kanoli Canal was received (May 2008) in the Chief Minister's Public Grievance Cell, Thiruvananthapuram. Chief Minister ordered time bound disposal of the case and stringent action against the encroachers. Deputy Director, Survey, Thrissur reported (January 2011) to the District Collector that there were 832 number of encroachments covering an area of 17.9673 hectares on the sides of Kanoli canal in four taluks in Thrissur District. District Collector, Thrissur (August 2011) informed Revenue Department that details of all encroachments with their sketches were passed on to Additional Irrigation Division, Thrissur for eviction. Executive Engineer, Additional Irrigation Division, Thrissur reported to the District Collector, Thrissur (April 2018) that since Kanoli Canal was declared as National Waterway 3 in 2016, eviction of encroachments would be undertaken by National Waterway Authority of India. But the fact remains that encroachments continued without eviction even after the lapse of nine years from the date of identification of encroachments. A joint site verification of Kanoli Canal (December 2019) at Chavakkad Taluk revealed large scale cultivation of coconut trees on both sides and across the canal obstructing and diverting the free flow of the river. Around six meters of the canal was filled with sand and fenced for private use. Local residents stated that the area adjacent to the canal was flooded in 2018 and they were shifted to relief camps.				
3.	**Bharathapuzha at Nambiar Pallam in Thrissur**	**11**	**0.5136**	**Yes in March 2017**
A complaint was received at District Collectorate, Thrissur regarding the encroachment of Bharathapuzha at Nambiar Pallam in March 2017. Tahsildar (Land Records), Thalappilly reported (June 2017) that encroachment was found in Bharathapuzha at Nambiar Pallam on preliminary enquiry but no natural boundary and survey stones were available to fix the river purambokku. After conducting the survey of the area in December 2018, Tahsildar, Thalappilly identified 11 number of encroachments covering an area of 0.5136 ha at Nambiar Pallam and requested the District Collector to release an amount of ₹28,000 incurred for planting survey stones at the site. Though funds were available in River Management Fund, the amount was not released till date. Encroachers were occupying the land for eight to 40 years. It was observed that though the complaint regarding river encroachment was received in March 2017, the survey to identify the extent of encroachment was carried out in December 2018 and no further action was taken till date.				

Sl. No.	Location details	Number of encroachments	Extent of land (in Ha)	Whether complaints received or not
4.	**Uttarappalliyar river (Alappuzha)**	**47**	**NA****	**Yes in 2007 and 2015**
The original river course through Venmani, Ala, Cheriyanadu, Puliyoor and Ennakkad villages was blocked due to intermittent encroachments. As part of rejuvenation activities, survey and demarcation of boundaries of the river was attempted in April 2017. Though complaints were received in 2007 and 2015, action in this regard was initiated by the Revenue Department only on 17 April 2017 when Uttarappalliyar Rejuvenation Campaign was launched by pooling funds from River Management Fund for survey and demarcation of boundaries of the river. However, survey could not be conducted in three villages, as the resurvey records contained little or no trace of the river route in these villages. Unless a fresh survey is conducted using the Lithomaps and records prior to resurvey, and boundaries of the river demarcated, effective control of encroachment and rejuvenation of river path will not be realised. Though the Land Revenue Commissioner repeatedly sought detailed report from the District Collector on the scope of re-establishing the flow route of the river through the five villages, there was no response in file (December 2019). As the river used to serve as a balancing channel between the water levels in Achencovil river and Pamba river, its stagnancy caused severe floods in the villages during 2018.				
5.	**Kuttamperoor river (Alappuzha)**	**NA****	**NA****	**Yes May 2008**
The river flows through Ennakkad and Mannar Villages in Chengannur Taluk. The river has a length of 7.2 km in Alappuzha district. Continuous encroachment identified on either side of the river causing shrinkage of the width of the river to about 15m to 20m against the actual width of 70m. No survey of the entire stretch of the river was conducted till 2018 floods. The villages through which the river flowed were severely affected during 2018 flood. Irrigation Department took up (March 2019) rejuvenation of the river under NABARD assisted scheme, which is yet to be completed.				
6. District Collector Ernakulam stated that noticeable encroachments were not reported in the District. The justification is not tenable as survey of rivers is to be conducted in order to identify illegal encroachments in rivers. However, Audit observed that no survey of water bodies was conducted in Paravur, one of the selected Taluks. Detection of encroachments is not possible in the absence of survey and demarcation of boundaries of rivers.				

* Based on examination of files at respective field offices. ** Details not available

Appendix 2.2

Statement showing shortage of equipment, vehicles and infrastructural facilities in Kerala Fire and Rescue Services Academy

(Reference: Paragraph 2.6)

Sl. No.	Nature of shortage	Description	Number of items in possession	Number of items in shortage
1.	Equipment	Trailer Pump	5	Nil
2.		Portable Pump (serviceable)	1	Nil
3.		Generator (230 volt)	1	Nil
4.		BA Set (serviceable)	8	50
5.		SCUBA Set (serviceable)	3	20
6.		BA Compressor set (serviceable)	1	2
7.		Float pump	2	Nil
8.		Hydraulic equipment set (serviceable)	1	1
9.		Chain saw (serviceable)	2	10
10.		Concrete cutters (serviceable)	2	3
11.		Rubber Dinghy with OB engine	Nil	2
12.		Fibre Boat	Nil	2
13.		Fire Fighting Suit	Nil	70
14.		Chemical suits	Nil	25
15.		Pneumatic rescue tools	Nil	2 sets
16.		High pressure portable pumps	Nil	3
17.		Rope rescue kit and accessories	Nil	10 sets
18.		Life detectors	Nil	5
19.		Demolition hammers	Nil	3 sets
20.		Thermal imaging cameras	Nil	3
21.		Extinguishers	Nil	50
22.		Rope Launcher	Nil	2
23.		Leak arrest kit	Nil	5
24.		Canister	Nil	20
25.		Inflatable Tent	Nil	2
26.		Inflatable Light	1	3
27.		Portable Water Mist	Nil	5
28.		Exhaust Blower	Nil	2
29.		Basic life support accessories - Mannequins, AED etc. Choking arrester kits Stretchers etc.	 Nil 2	 3 sets each 10
30.		Multi-Purpose Rescue Tools	1	Nil
31.	Vehicles	Fire tender	1	Nil
32.		Mobilising bus (old - proposed for condemnation)	1	1
33.		Excavator	1	Nil
34.		Jeep	2	Nil
35.		Bolero Jeep	2	Nil
36.		Ambulance	Nil	2
37.		Water mist tender	Nil	1
38.		Emergency Rescue tender	1	1
39.		Quick response vehicle	1	1
40.		SCUBA Van	Nil	1
41.		Mess Van	Nil	1

Sl. No.	Nature of shortage	Description	Number of items in possession	Number of items in shortage
42.	Shortage of infrastructure facilities	Fire lab		
43.		Multipurpose rescue tower		
44.		Smart class rooms		
45.		Computer lab		
46.		BA smoke room gallery		
47.		Fire lift		
48.		Fixed firefighting installations models		
49.		Drill grounds - 8 acres additional		
50.		Conference room-under construction		
51.		Barrack-under proposal, design and approval stage		
52.		Library		
53.		Health club		

Appendix 3.1

Salient features of Mullaperiyar, Idukki, Idamalayar, Lower Periyar dams and Bhoothathankettu barrage

(Reference: Chapter 3, Paragraph on Reservoir operation)

Name of Dam/ Barrage and source of data	FRL[128] (m, MSL)	MWL[129] (m, MSL)	MDDL[130] (m, MSL)	Capacity at FRL (MCM)	Live[131] storage capacity (MCM)	Capacity at dead storage[132] level (MCM)	Free board[133] over MWL (m)	Spillway type and discharge design volume (cumecs)	Number, type and size of gates	Extent of catchment area (sq. km)	Discharge capacity (cumecs)
Mullaperiyar Dam (Irrigation Department)	-*	-*	41.45	-*	299.26	144.17	0.91	Vertical and radial shutter type, 3454.65	13 numbers 10.97 x 4.87 m (3 number of vertical gates) 12.19 x 4.87 m (10 number of radial gates)	602.95	59.46
Idukki dam/ Cheruthoni dam (KSEBL)	732.43	734.11	694.94	1996.34	1459.49	536.81	1.79	Chute, 5012	5 numbers of radial gates, 12.19 x 10.36 m	650.00	557.50
Idamalayar dam (KSEBL)	169.00	171.20	115.00	1089.80	1017.80	72.00	0.80	Ogee, 3248	4 number of radial gates, 11.5 x 9.7 m	380.79 (excluding 101 sq. km Nirar catchment)	NA
Lower Periyar dam (KSEBL)	253.00	256.00	237.74	5.30	4.50	0.80	1.00	Ogee, 11200	5 number of radial gates, 13.5 x 15.65 m	584.00	338.94
Bhoothathankettu barrage (Irrigation Department)	34.95			-				Electrically operated framed steel shutters with vertical lifting arrangements of chain pulley blocks equipped with counterweight boxes, 7079	3 numbers 9.14 x 10.36 m 12 numbers 12.19 x 9.14 m	3048.00	

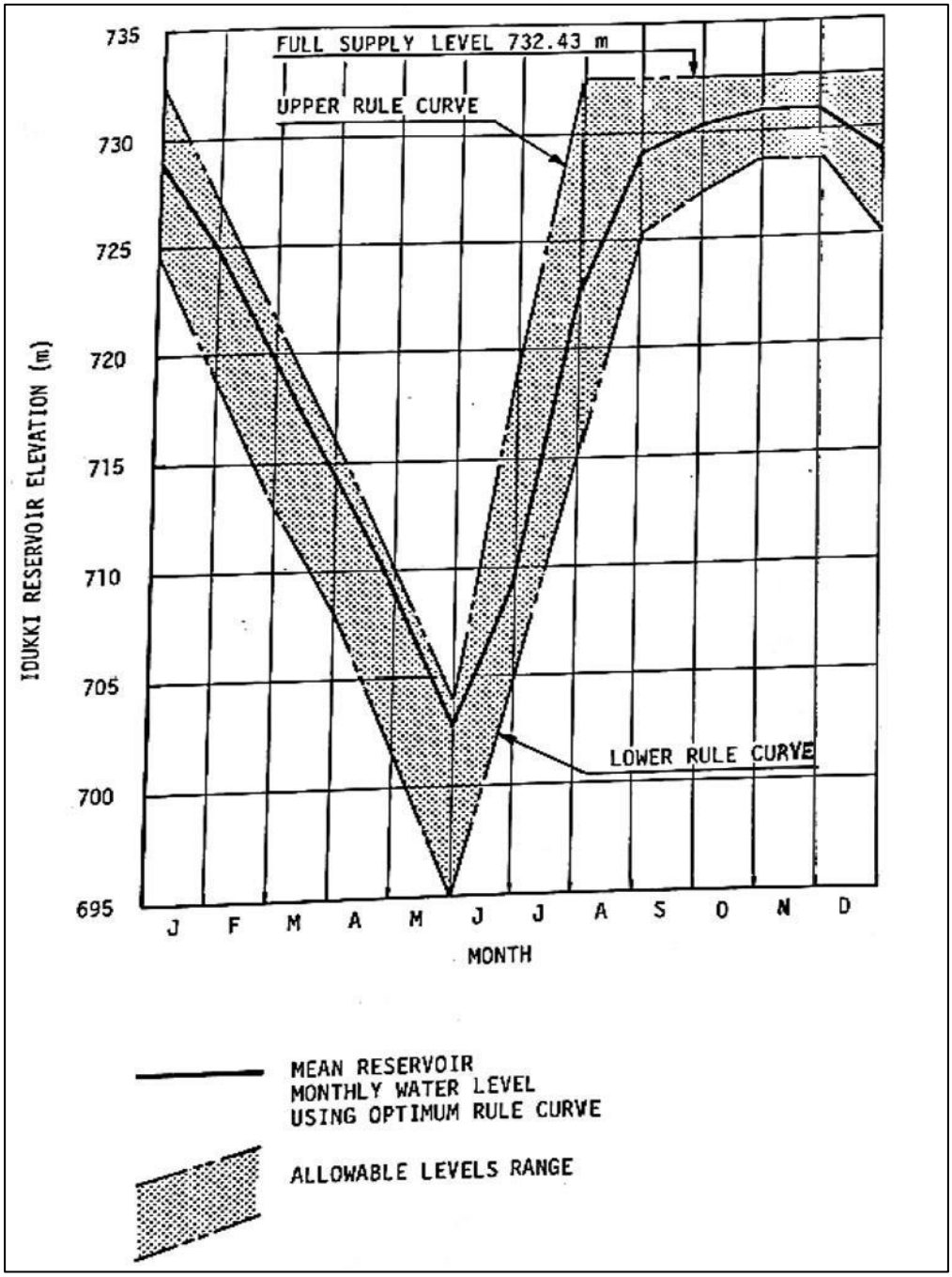
* matter is sub judice

[128] Full Reservoir Level (FRL) corresponds to the water level when the dam is filled to its full capacity.
[129] Maximum Water Level (MWL) corresponds typically to the top level of the gates. At MWL, the flow over spillway will be at design flood discharge.
[130] Minimum Drawn Down Level
[131] Live storage is the storage between FRL and the dead storage level
[132] Dead storage is the minimum amount of water to be maintained in the dam
[133] The storage between MWL and FRL is available as flood cushion.

Appendix 3.2

Rule curve framed in 1983 for Idukki dam

(Reference: Paragraph 3.6.1)



(Source: Records at KSEBL)

Appendix 3.3

Rule curve framed in 2020 for Idukki and Idamalayar dams

(Reference: Paragraph 3.6.1)

Time Step	Reservoir Level in meter	
	Idukki	Idamalayar
June 10th	723.29	161.00
June 20th	723.29	161.00
June 30th	723.29	161.00
July 10th	724.00	161.50
July 20th	724.80	161.75
July 31st	725.60	162.50
August 10th	726.50	163.00
August 20th	727.50	163.50
August 31st	728.50	164.00
September 10th	729.25	165.00
September 20th	730.00	166.00
September 30th	730.59	166.30
October 10th	730.84	166.60
October 20th	731.17	166.80
October 31st	731.31	167.00
November 10th	731.46	168.50
November 20th	731.53	168.50
November 30th	731.53	168.50

Appendix 3.4

Procedure followed for conduct of simulations of reservoir operations using rule curves

(Reference: Paragraph 3.6.1)

The Idukki reservoir operation is analysed with the rule curves developed both in 1983 and 2020 whereas the Idamalayar reservoir operation is analysed with only the rule curve of 2020.
The reservoir operation was simulated by IISc, Bangalore for its study as follows

$$S_{t+1} = S_t + Q_t - R_t - E_t - Spill_t \quad \text{(Eq. A)}$$

where,

$S_{t+1:}$ reservoir storage at the end of the period t

S_t: reservoir storage at the beginning of the period t

Q_t: the inflow to the reservoir during the period t

R_t: release from the reservoir during the period t

E_t: evaporation loss from the water surface in the reservoir during the period t

$Spill_t$: excess water spilled from the reservoir during the period t

Period t is the time interval for which the reservoir operation is simulated. This may be for example a month, a day, an hour etc. All terms are expressed in volume units (MCM). Eq. A uses the principle of continuity. The rule curve analysis is carried out for the entire monsoon period from June to September 2018.

Appendix 3.5

Sample simulations of Idukki reservoir using 1983 rule curve

(Reference: Paragraph 3.6.2)

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
30-06-2018	1315.47	805.58	805.58	705.00	1.83	9.81	0.13	813.44	0.00	813.44
01-07-2018	1337.36	816.83	813.44	705.26	0.00	8.89	0.13	822.20	0.00	822.20
02-07-2018	1359.24	828.08	822.20	705.56	0.00	10.72	0.13	832.78	0.00	832.78
03-07-2018	1381.12	839.32	832.78	705.91	0.00	8.00	0.13	840.66	0.00	840.66
04-07-2018	1403.01	850.57	840.66	706.17	0.00	6.53	0.13	847.05	0.00	847.05
05-07-2018	1424.89	861.81	847.05	706.39	0.00	5.56	0.13	852.48	0.00	852.48
06-07-2018	1446.78	873.06	852.48	706.57	0.00	5.04	0.13	857.39	0.00	857.39
07-07-2018	1468.66	884.31	857.39	706.73	0.00	6.46	0.13	863.72	0.00	863.72
08-07-2018	1490.54	895.55	863.72	706.95	0.00	9.50	0.13	873.09	0.00	873.09
09-07-2018	1512.43	906.80	873.09	707.24	0.00	19.66	0.13	892.62	0.00	892.62
10-07-2018	1534.31	918.05	892.62	707.80	0.00	34.60	0.13	927.09	0.00	927.09
11-07-2018	1556.19	929.29	927.09	708.78	0.00	32.70	0.13	959.66	0.00	959.66
12-07-2018	1578.08	940.54	959.66	709.71	2.06	28.23	0.13	985.69	0.00	985.69
13-07-2018	1599.96	951.78	985.69	710.46	1.94	40.69	0.13	1024.31	0.00	1024.31
14-07-2018	1621.84	963.03	1024.31	711.56	1.85	33.21	0.13	1055.54	0.00	1055.54
15-07-2018	1643.73	974.28	1055.54	712.45	1.39	53.77	0.13	1107.78	0.00	1107.78
16-07-2018	1665.61	985.52	1107.78	713.85	1.59	61.92	0.13	1167.99	0.00	1167.99
17-07-2018	1687.49	996.77	1167.99	715.34	3.27	41.73	0.13	1206.32	0.00	1206.32
18-07-2018	1709.38	1008.02	1206.32	716.29	5.01	38.02	0.13	1239.20	0.00	1239.20
19-07-2018	1731.26	1019.26	1239.20	717.11	5.92	35.83	0.13	1268.98	0.00	1268.98
20-07-2018	1753.14	1030.51	1268.98	717.85	6.74	29.70	0.13	1291.81	0.00	1291.81
21-07-2018	1775.03	1041.75	1291.81	718.41	5.63	22.64	0.13	1308.69	0.00	1308.69
22-07-2018	1796.91	1053.00	1308.69	718.83	5.40	20.09	0.13	1323.25	0.00	1323.25
23-07-2018	1818.79	1064.25	1323.25	719.19	6.83	23.50	0.13	1339.79	0.00	1339.79
24-07-2018	1840.68	1075.49	1339.79	719.57	8.87	39.11	0.13	1369.90	0.00	1369.90

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
25-07-2018	1862.56	1086.74	1369.90	720.21	9.12	39.35	0.13	1399.99	0.00	1399.99
26-07-2018	1884.44	1097.99	1399.99	720.86	9.74	39.98	0.13	1430.10	0.00	1430.10
27-07-2018	1906.33	1109.23	1430.10	721.51	9.82	24.83	0.13	1444.99	0.00	1444.99
28-07-2018	1928.21	1120.48	1444.99	721.83	9.68	24.36	0.13	1459.54	0.00	1459.54
29-07-2018	1950.09	1131.72	1459.54	722.14	10.05	23.41	0.13	1472.78	0.00	1472.78
30-07-2018	1971.98	1142.97	1472.78	722.42	10.04	21.75	0.13	1484.36	0.00	1484.36
31-07-2018	1993.86	1154.22	1484.36	722.67	10.07	19.14	0.13	1493.29	0.00	1493.29
01-08-2018	1993.86	1168.36	1493.29	722.86	10.07	14.83	0.13	1497.92	0.00	1497.92
02-08-2018	1993.86	1182.51	1497.92	722.96	10.09	12.53	0.13	1500.23	0.00	1500.23
03-08-2018	1993.86	1196.66	1500.23	723.01	9.59	11.37	0.13	1501.89	0.00	1501.89
04-08-2018	1993.86	1210.81	1501.89	723.05	9.30	9.10	0.13	1501.55	0.00	1501.55
05-08-2018	1993.86	1224.96	1501.55	723.04	9.50	7.97	0.13	1499.89	0.00	1499.89
06-08-2018	1993.86	1239.11	1499.89	723.00	9.00	8.46	0.13	1499.23	0.00	1499.23
07-08-2018	1993.86	1253.26	1499.23	722.99	9.05	16.46	0.13	1506.50	0.00	1506.50
08-08-2018	1993.86	1267.40	1506.50	723.15	9.99	39.58	0.13	1535.96	0.00	1535.96
09-08-2018	1993.86	1281.55	1535.96	723.78	9.95	57.45	0.13	1583.33	0.00	1583.33
10-08-2018	1993.86	1295.70	1583.33	724.80	9.98	61.03	0.13	1634.26	0.00	1634.26
11-08-2018	1993.86	1309.85	1634.26	725.82	9.96	45.44	0.13	1669.62	0.00	1669.62
12-08-2018	1993.86	1324.00	1669.62	726.48	9.99	48.44	0.13	1707.94	0.00	1707.94
13-08-2018	1993.86	1338.15	1707.94	727.18	10.00	45.99	0.13	1743.80	0.00	1743.80
14-08-2018	1993.86	1352.30	1743.80	727.84	9.99	84.18	0.13	1817.86	0.00	1817.86
15-08-2018	1993.86	1366.44	1817.86	729.21	9.99	165.06	0.13	1972.80	0.00	1972.80
16-08-2018	1993.86	1380.59	1972.80	732.03	9.95	154.96	0.13	2117.68	123.82	1993.86
17-08-2018	1993.86	1394.74	1993.86	732.40	9.98	111.70	0.13	2095.45	101.59	1993.86
18-08-2018	1993.86	1408.89	1993.86	732.40	9.66	92.51	0.13	2076.58	82.72	1993.86
19-08-2018	1993.86	1423.04	1993.86	732.40	9.98	62.88	0.13	2046.63	52.77	1993.86
20-08-2018	1993.86	1437.19	1993.86	732.40	9.95	37.54	0.13	2021.33	27.46	1993.86
21-08-2018	1993.86	1451.34	1993.86	732.40	9.68	29.95	0.13	2014.00	20.14	1993.86
22-08-2018	1993.86	1465.48	1993.86	732.40	9.98	24.60	0.13	2008.35	14.49	1993.86
23-08-2018	1993.86	1479.63	1993.86	732.40	9.96	20.39	0.13	2004.16	10.30	1993.86

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
24-08-2018	1993.86	1493.78	1993.86	732.40	9.96	18.96	0.13	2002.72	8.86	1993.86
25-08-2018	1993.86	1507.93	1993.86	732.40	9.96	17.77	0.13	2001.55	7.68	1993.86
26-08-2018	1993.86	1522.08	1993.86	732.40	9.93	16.42	0.13	2000.22	6.35	1993.86
27-08-2018	1993.86	1536.23	1993.86	732.40	9.97	18.44	0.13	2002.20	8.34	1993.86
28-08-2018	1993.86	1550.38	1993.86	732.40	9.91	18.71	0.13	2002.53	8.67	1993.86
29-08-2018	1993.86	1564.52	1993.86	732.40	9.97	15.79	0.13	1999.55	5.69	1993.86
30-08-2018	1993.86	1578.67	1993.86	732.40	8.69	15.17	0.13	2000.21	6.35	1993.86
31-08-2018	1993.86	1592.82	1993.86	732.40	10.01	15.83	0.13	1999.56	5.69	1993.86
01-09-2018	1993.86	1596.33	1993.86	732.40	10.01	14.17	0.13	1997.89	4.03	1993.86
02-09-2018	1993.86	1599.84	1993.86	732.40	9.96	8.49	0.13	1992.26	0.00	1992.26
03-09-2018	1993.86	1603.35	1992.26	732.37	9.74	7.58	0.13	1989.98	0.00	1989.98
04-09-2018	1993.86	1606.86	1989.98	732.33	9.20	7.38	0.13	1988.03	0.00	1988.03
05-09-2018	1993.86	1610.36	1988.03	732.30	9.14	6.99	0.13	1985.74	0.00	1985.74
06-09-2018	1993.86	1613.87	1985.74	732.26	10.03	6.88	0.13	1982.47	0.00	1982.47
07-09-2018	1993.86	1617.38	1982.47	732.20	9.89	4.57	0.13	1977.01	0.00	1977.01
08-09-2018	1993.86	1620.89	1977.01	732.11	9.55	3.39	0.13	1970.72	0.00	1970.72
09-09-2018	1993.86	1624.40	1970.72	732.00	9.31	3.82	0.13	1965.09	0.00	1965.09
10-09-2018	1993.86	1627.91	1965.09	731.90	9.76	3.61	0.13	1958.81	0.00	1958.81
11-09-2018	1993.86	1631.42	1958.81	731.79	8.51	3.68	0.13	1953.85	0.00	1953.85
12-09-2018	1993.86	1634.93	1953.85	731.70	7.73	2.89	0.13	1948.89	0.00	1948.89
13-09-2018	1993.86	1638.43	1948.89	731.61	6.89	4.70	0.13	1946.57	0.00	1946.57
14-09-2018	1993.86	1641.94	1946.57	731.57	6.49	0.99	0.13	1940.94	0.00	1940.94
15-09-2018	1993.86	1645.45	1940.94	731.47	7.14	2.64	0.13	1936.31	0.00	1936.31
16-09-2018	1993.86	1648.96	1936.31	731.39	5.89	3.04	0.13	1933.33	0.00	1933.33
17-09-2018	1993.86	1652.47	1933.33	731.33	5.28	2.76	0.13	1930.68	0.00	1930.68
18-09-2018	1993.86	1655.98	1930.68	731.28	5.11	2.93	0.13	1928.37	0.00	1928.37
19-09-2018	1993.86	1659.49	1928.37	731.24	4.96	3.77	0.13	1927.04	0.00	1927.04
20-09-2018	1993.86	1662.99	1927.04	731.22	6.40	3.55	0.13	1924.06	0.00	1924.06
21-09-2018	1993.86	1666.50	1924.06	731.16	7.30	2.46	0.13	1919.10	0.00	1919.10
22-09-2018	1993.86	1670.01	1919.10	731.07	7.05	2.22	0.13	1914.13	0.00	1914.13

Day	Storage for upper levels (MCM)	Storage for lower rule levels (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6)	Spills (MCM)	Storage after spills (MCM)
	1a	1b	2	3	4	5	6	7	8	9
23-09-2018	1993.86	1673.52	1914.13	730.98	4.16	3.96	0.13	1913.80	0.00	1913.80
24-09-2018	1993.86	1677.03	1913.80	730.97	6.13	7.58	0.13	1915.12	0.00	1915.12
25-09-2018	1993.86	1680.54	1915.12	731.00	5.20	4.34	0.13	1914.13	0.00	1914.13
26-09-2018	1993.86	1684.05	1914.13	730.98	6.14	5.61	0.13	1913.47	0.00	1913.47
27-09-2018	1993.86	1687.56	1913.47	730.97	5.02	5.81	0.13	1914.13	0.00	1914.13
28-09-2018	1993.86	1691.06	1914.13	730.98	5.77	9.54	0.13	1917.77	0.00	1917.77
29-09-2018	1993.86	1694.57	1917.77	731.05	5.32	10.42	0.13	1922.74	0.00	1922.74

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 3.6

Sample simulations of Idukki reservoir using 2020 rule curve

(Reference: Paragraph 3.6.2)

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
10-06-2018	1513.98	1513.98	723.30	2.38	43.53	0.13	1555.00	41.02	1513.98
11-06-2018	1513.98	1513.98	723.30	3.52	52.36	0.13	1562.69	48.71	1513.98
12-06-2018	1513.98	1513.98	723.30	4.26	34.28	0.13	1543.87	29.89	1513.98
13-06-2018	1513.98	1513.98	723.30	2.18	25.39	0.13	1537.07	23.09	1513.98
14-06-2018	1513.98	1513.98	723.30	2.13	16.99	0.13	1528.71	14.73	1513.98
15-06-2018	1513.98	1513.98	723.30	1.33	12.95	0.13	1525.47	11.49	1513.98
16-06-2018	1513.98	1513.98	723.30	1.67	13.84	0.13	1526.02	12.04	1513.98
17-06-2018	1513.98	1513.98	723.30	2.10	7.62	0.13	1519.38	5.40	1513.98
18-06-2018	1513.98	1513.98	723.30	2.90	8.42	0.13	1519.38	5.39	1513.98
19-06-2018	1513.98	1513.98	723.30	1.63	9.86	0.13	1522.08	8.10	1513.98
20-06-2018	1513.98	1513.98	723.30	2.55	12.27	0.13	1523.57	9.58	1513.98
21-06-2018	1513.98	1513.98	723.30	2.27	13.21	0.13	1524.79	10.81	1513.98
22-06-2018	1513.98	1513.98	723.30	2.21	12.42	0.13	1524.06	10.08	1513.98
23-06-2018	1513.98	1513.98	723.30	3.88	12.61	0.13	1522.58	8.60	1513.98
24-06-2018	1513.98	1513.98	723.30	2.49	9.00	0.13	1520.37	6.39	1513.98
25-06-2018	1513.98	1513.98	723.30	2.43	10.90	0.13	1522.32	8.34	1513.98
26-06-2018	1513.98	1513.98	723.30	1.96	9.22	0.13	1521.10	7.12	1513.98
27-06-2018	1513.98	1513.98	723.30	1.40	10.37	0.13	1522.83	8.85	1513.98
28-06-2018	1513.98	1513.98	723.30	1.62	10.35	0.13	1522.58	8.60	1513.98
29-06-2018	1513.98	1513.98	723.30	1.37	8.87	0.13	1521.35	7.37	1513.98
30-06-2018	1513.98	1513.98	723.30	1.83	9.81	0.13	1521.83	4.59	1517.24
01-07-2018	1517.24	1517.24	723.37	1.40	8.89	0.13	1524.60	4.10	1520.50

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
02-07-2018	1520.50	1520.50	723.44	2.49	10.72	0.13	1528.60	4.84	1523.76
03-07-2018	1523.76	1523.76	723.51	2.23	8.00	0.13	1529.41	2.38	1527.03
04-07-2018	1527.03	1527.03	723.58	2.72	6.53	0.13	1530.70	0.41	1530.29
05-07-2018	1530.29	1530.29	723.65	2.99	5.56	0.13	1532.73	0.00	1532.73
06-07-2018	1533.55	1532.73	723.70	2.71	5.04	0.13	1534.92	0.00	1534.92
07-07-2018	1536.81	1534.92	723.75	2.66	6.46	0.13	1538.59	0.00	1538.59
08-07-2018	1540.07	1538.59	723.83	1.03	9.50	0.13	1546.93	3.59	1543.33
09-07-2018	1543.33	1543.33	723.93	1.85	19.66	0.13	1561.02	14.42	1546.59
10-07-2018	1546.59	1546.59	724.00	3.05	34.60	0.13	1578.01	27.60	1550.41
11-07-2018	1550.41	1550.41	724.08	1.16	32.70	0.13	1581.82	27.59	1554.23
12-07-2018	1554.23	1554.23	724.17	2.06	28.23	0.13	1580.26	22.22	1558.05
13-07-2018	1558.05	1558.05	724.25	1.94	40.69	0.13	1596.66	34.80	1561.86
14-07-2018	1561.86	1561.86	724.33	1.85	33.21	0.13	1593.10	27.42	1565.68
15-07-2018	1565.68	1565.68	724.42	1.39	53.77	0.13	1617.92	48.42	1569.50
16-07-2018	1569.50	1569.50	724.50	1.59	61.92	0.13	1629.70	56.39	1573.32
17-07-2018	1573.32	1573.32	724.57	3.27	41.73	0.13	1611.65	34.52	1577.13
18-07-2018	1577.13	1577.13	724.65	5.01	38.02	0.13	1610.01	29.06	1580.95
19-07-2018	1580.95	1580.95	724.72	5.92	35.83	0.13	1610.73	25.96	1584.77
20-07-2018	1584.77	1584.77	724.80	6.74	29.70	0.13	1607.60	19.13	1588.47
21-07-2018	1588.47	1588.47	724.87	5.63	22.64	0.13	1605.35	13.18	1592.16
22-07-2018	1592.16	1592.16	724.95	5.40	20.09	0.13	1606.72	10.86	1595.86
23-07-2018	1595.86	1595.86	725.02	6.83	23.50	0.13	1612.40	12.84	1599.56
24-07-2018	1599.56	1599.56	725.09	8.87	39.11	0.13	1629.67	26.41	1603.26
25-07-2018	1603.26	1603.26	725.16	9.12	39.35	0.13	1633.36	26.40	1606.96
26-07-2018	1606.96	1606.96	725.24	9.74	39.98	0.13	1637.07	26.41	1610.66
27-07-2018	1610.66	1610.66	725.31	9.82	24.83	0.13	1625.54	11.19	1614.35
28-07-2018	1614.35	1614.35	725.38	9.68	24.36	0.13	1628.91	10.85	1618.05
29-07-2018	1618.05	1618.05	725.45	10.05	23.41	0.13	1631.29	9.54	1621.75

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
30-07-2018	1621.75	1621.75	725.53	10.04	21.75	0.13	1633.33	7.88	1625.45
31-07-2018	1625.45	1625.45	725.60	10.07	19.14	0.13	1634.38	4.30	1630.08
01-08-2018	1630.08	1630.08	725.69	10.07	14.83	0.13	1634.71	0.00	1634.71
02-08-2018	1634.71	1634.71	725.78	10.09	12.53	0.13	1637.02	0.00	1637.02
03-08-2018	1639.34	1637.02	725.83	9.59	11.37	0.13	1638.67	0.00	1638.67
04-08-2018	1643.97	1638.67	725.86	9.30	9.10	0.13	1638.34	0.00	1638.34
05-08-2018	1648.60	1638.34	725.85	9.50	7.97	0.13	1636.68	0.00	1636.68
06-08-2018	1653.23	1636.68	725.82	9.00	8.46	0.13	1636.01	0.00	1636.01
07-08-2018	1657.86	1636.01	725.81	9.05	16.46	0.13	1643.29	0.00	1643.29
08-08-2018	1662.49	1643.29	725.95	9.99	39.58	0.13	1672.75	5.63	1667.12
09-08-2018	1667.12	1667.12	726.41	9.95	57.45	0.13	1714.49	42.74	1671.75
10-08-2018	1671.75	1671.75	726.50	9.98	61.03	0.13	1722.68	45.50	1677.18
11-08-2018	1677.18	1677.18	726.60	9.96	45.44	0.13	1712.54	29.92	1682.61
12-08-2018	1682.61	1682.61	726.70	9.99	48.44	0.13	1720.93	32.89	1688.04
13-08-2018	1688.04	1688.04	726.80	10.00	45.99	0.13	1723.90	30.43	1693.47
14-08-2018	1693.47	1693.47	726.90	9.99	84.18	0.13	1767.54	68.63	1698.91
15-08-2018	1698.91	1698.91	727.00	9.99	165.06	0.13	1853.85	149.51	1704.34
16-08-2018	1704.34	1704.34	727.10	9.95	154.96	0.13	1849.22	139.45	1709.77
17-08-2018	1709.77	1709.77	727.20	9.98	111.70	0.13	1811.36	96.16	1715.20
18-08-2018	1715.20	1715.20	727.30	9.66	92.51	0.13	1797.92	77.29	1720.63
19-08-2018	1720.63	1720.63	727.40	9.98	62.88	0.13	1773.40	47.34	1726.06
20-08-2018	1726.06	1726.06	727.50	9.95	37.54	0.13	1753.53	22.51	1731.01
21-08-2018	1731.01	1731.01	727.59	9.68	29.95	0.13	1751.16	15.19	1735.96
22-08-2018	1735.96	1735.96	727.68	9.98	24.60	0.13	1750.45	9.53	1740.91
23-08-2018	1740.91	1740.91	727.77	9.96	20.39	0.13	1751.21	5.35	1745.86
24-08-2018	1745.86	1745.86	727.86	9.96	18.96	0.13	1754.73	3.91	1750.81
25-08-2018	1750.81	1750.81	727.95	9.96	17.77	0.13	1758.50	2.73	1755.76
26-08-2018	1755.76	1755.76	728.05	9.93	16.42	0.13	1762.12	1.40	1760.71
27-08-2018	1760.71	1760.71	728.14	9.97	18.44	0.13	1769.05	3.39	1765.66

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
28-08-2018	1765.66	1765.66	728.23	9.91	18.71	0.13	1774.33	3.72	1770.62
29-08-2018	1770.62	1770.62	728.32	9.97	15.79	0.13	1776.31	0.74	1775.57
30-08-2018	1775.57	1775.57	728.41	8.69	15.17	0.13	1781.92	1.40	1780.52
31-08-2018	1780.52	1780.52	728.50	10.01	15.83	0.13	1786.21	1.66	1784.55
01-09-2018	1784.55	1784.55	728.57	10.01	14.17	0.13	1788.58	0.00	1788.58
02-09-2018	1788.58	1788.58	728.65	9.96	8.49	0.13	1786.98	0.00	1786.98
03-09-2018	1792.61	1786.98	728.62	9.74	7.58	0.13	1784.70	0.00	1784.70
04-09-2018	1796.65	1784.70	728.58	9.20	7.38	0.13	1782.74	0.00	1782.74
05-09-2018	1800.68	1782.74	728.54	9.14	6.99	0.13	1780.46	0.00	1780.46
06-09-2018	1804.71	1780.46	728.50	10.03	6.88	0.13	1777.18	0.00	1777.18
07-09-2018	1808.74	1777.18	728.44	9.89	4.57	0.13	1771.73	0.00	1771.73
08-09-2018	1812.78	1771.73	728.34	9.55	3.39	0.13	1765.44	0.00	1765.44
09-09-2018	1816.81	1765.44	728.22	9.31	3.82	0.13	1759.81	0.00	1759.81
10-09-2018	1820.84	1759.81	728.12	9.76	3.61	0.13	1753.53	0.00	1753.53
11-09-2018	1824.88	1753.53	728.00	8.51	3.68	0.13	1748.57	0.00	1748.57
12-09-2018	1828.92	1748.57	727.91	7.73	2.89	0.13	1743.61	0.00	1743.61
13-09-2018	1832.95	1743.61	727.82	6.89	4.70	0.13	1741.29	0.00	1741.29
14-09-2018	1836.99	1741.29	727.78	6.49	0.99	0.13	1735.66	0.00	1735.66
15-09-2018	1841.03	1735.66	727.68	7.14	2.64	0.13	1731.03	0.00	1731.03
16-09-2018	1845.07	1731.03	727.59	5.89	3.04	0.13	1728.05	0.00	1728.05
17-09-2018	1849.10	1728.05	727.54	5.28	2.76	0.13	1725.40	0.00	1725.40
18-09-2018	1853.14	1725.40	727.49	5.11	2.93	0.13	1723.08	0.00	1723.08
19-09-2018	1857.18	1723.08	727.45	4.96	3.77	0.13	1721.76	0.00	1721.76
20-09-2018	1861.22	1721.76	727.42	6.40	3.55	0.13	1718.78	0.00	1718.78
21-09-2018	1864.41	1718.78	727.37	7.30	2.46	0.13	1713.82	0.00	1713.82
22-09-2018	1867.60	1713.82	727.28	7.05	2.22	0.13	1708.85	0.00	1708.85
23-09-2018	1870.80	1708.85	727.18	4.16	3.96	0.13	1708.52	0.00	1708.52
24-09-2018	1873.99	1708.52	727.18	6.13	7.58	0.13	1709.84	0.00	1709.84
25-09-2018	1877.19	1709.84	727.20	5.20	4.34	0.13	1708.85	0.00	1708.85

Day	Storage for rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation Loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
26-09-2018	1880.38	1708.85	727.18	6.14	5.61	0.13	1708.19	0.00	1708.19
27-09-2018	1883.57	1708.19	727.17	5.02	5.81	0.13	1708.85	0.00	1708.85
28-09-2018	1886.77	1708.85	727.18	5.77	9.54	0.13	1712.49	0.00	1712.49
29-09-2018	1889.96	1712.49	727.25	5.32	10.42	0.13	1717.46	0.00	1717.46

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 3.7

Sample simulations of Idamalayar reservoir using 2020 rule curve

(Reference: Paragraph 3.6.3)

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
10-06-2018	860.00	860.00	161.00	1.77	28.30	0.00	886.53	26.53	860.00
11-06-2018	860.00	860.00	161.00	1.12	23.16	0.00	882.04	22.04	860.00
12-06-2018	860.00	860.00	161.00	1.38	26.34	0.00	884.96	24.96	860.00
13-06-2018	860.00	860.00	161.00	1.30	22.60	0.00	881.30	21.30	860.00
14-06-2018	860.00	860.00	161.00	2.16	24.18	0.05	881.96	21.96	860.00
15-06-2018	860.00	860.00	161.00	0.32	16.33	0.04	875.98	15.98	860.00
16-06-2018	860.00	860.00	161.00	0.56	10.58	0.02	869.99	9.99	860.00
17-06-2018	860.00	860.00	161.00	1.15	11.14	0.00	869.99	9.99	860.00
18-06-2018	860.00	860.00	161.00	0.81	8.28	0.02	867.46	7.46	860.00
19-06-2018	860.00	860.00	161.00	1.95	8.46	0.05	866.46	6.46	860.00
20-06-2018	860.00	860.00	161.00	0.76	10.68	0.04	869.88	9.88	860.00
21-06-2018	860.00	860.00	161.00	0.59	13.29	0.00	872.70	12.70	860.00
22-06-2018	860.00	860.00	161.00	0.61	13.66	0.02	873.04	13.04	860.00
23-06-2018	860.00	860.00	161.00	0.53	12.93	0.02	872.38	12.38	860.00
24-06-2018	860.00	860.00	161.00	0.54	7.53	0.03	866.97	6.97	860.00
25-06-2018	860.00	860.00	161.00	0.62	7.62	0.03	866.97	6.97	860.00
26-06-2018	860.00	860.00	161.00	0.34	8.85	0.00	868.51	8.51	860.00
27-06-2018	860.00	860.00	161.00	0.68	7.30	0.03	866.58	6.58	860.00
28-06-2018	860.00	860.00	161.00	1.49	10.02	0.01	868.51	8.51	860.00
29-06-2018	860.00	860.00	161.00	0.54	10.21	0.00	869.67	9.67	860.00
30-06-2018	860.00	860.00	161.00	0.44	9.86	0.03	869.38	7.97	861.41
01-07-2018	861.41	861.41	161.05	0.36	7.63	0.02	868.66	5.83	862.83
02-07-2018	862.83	862.83	161.10	0.28	7.25	0.04	869.76	5.51	864.25

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
03-07-2018	864.25	864.25	161.15	0.73	7.87	0.00	871.39	5.73	865.66
04-07-2018	865.66	865.66	161.20	0.75	5.83	0.04	870.70	3.62	867.08
05-07-2018	867.08	867.08	161.25	0.61	4.03	0.06	870.44	1.95	868.49
06-07-2018	868.49	868.49	161.30	1.20	3.74	0.02	871.01	1.10	869.90
07-07-2018	869.90	869.90	161.35	1.63	4.21	0.06	872.42	1.10	871.32
08-07-2018	871.32	871.32	161.40	1.26	6.72	0.00	876.78	4.05	872.73
09-07-2018	872.73	872.73	161.45	0.29	9.49	0.00	881.93	7.78	874.15
10-07-2018	874.15	874.15	161.50	0.29	17.45	0.00	891.31	16.45	874.86
11-07-2018	874.86	874.86	161.53	0.45	39.76	0.00	914.18	38.61	875.56
12-07-2018	875.56	875.56	161.55	0.35	29.87	0.00	905.08	28.81	876.27
13-07-2018	876.27	876.27	161.58	0.56	21.40	0.00	897.12	20.14	876.98
14-07-2018	876.98	876.98	161.60	0.53	28.63	0.02	905.06	27.38	877.69
15-07-2018	877.69	877.69	161.63	0.34	27.81	0.00	905.16	26.77	878.39
16-07-2018	878.39	878.39	161.65	0.42	40.34	0.00	918.31	39.21	879.10
17-07-2018	879.10	879.10	161.68	0.18	37.63	0.00	916.55	36.74	879.81
18-07-2018	879.81	879.81	161.70	0.61	32.01	0.00	911.21	30.69	880.52
19-07-2018	880.52	880.52	161.73	0.49	28.81	0.06	908.78	27.55	881.23
20-07-2018	881.23	881.23	161.75	0.82	24.34	0.00	904.75	21.58	883.17
21-07-2018	883.17	883.17	161.82	1.64	24.18	0.03	905.68	20.56	885.11
22-07-2018	885.11	885.11	161.89	0.98	19.46	0.08	903.51	16.45	887.05
23-07-2018	887.05	887.05	161.95	2.30	15.41	0.00	900.16	11.17	889.00
24-07-2018	889.00	889.00	162.02	4.02	23.14	0.00	908.12	17.18	890.94
25-07-2018	890.94	890.94	162.09	4.90	39.95	0.00	925.99	33.11	892.88
26-07-2018	892.88	892.88	162.16	5.93	21.48	0.00	908.44	13.61	894.83
27-07-2018	894.83	894.83	162.23	5.76	19.60	0.02	908.65	11.88	896.77
28-07-2018	896.77	896.77	162.30	5.19	12.42	0.03	903.97	5.26	898.71
29-07-2018	898.71	898.71	162.36	5.84	16.78	0.00	909.66	9.00	900.66

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
30-07-2018	900.66	900.66	162.43	5.73	13.83	0.03	908.72	6.12	902.60
31-07-2018	902.60	902.60	162.50	5.84	19.96	0.00	916.72	12.69	904.03
01-08-2018	904.03	904.03	162.55	5.81	10.74	0.02	908.94	3.48	905.46
02-08-2018	905.46	905.46	162.60	5.82	9.03	0.03	908.64	1.75	906.89
03-08-2018	906.89	906.89	162.65	5.81	9.62	0.05	910.65	2.33	908.32
04-08-2018	908.32	908.32	162.70	5.77	7.61	0.11	910.05	0.30	909.75
05-08-2018	909.75	909.75	162.75	5.77	6.72	0.08	910.62	0.00	910.62
06-08-2018	911.18	910.62	162.78	5.78	7.83	0.03	912.64	0.03	912.61
07-08-2018	912.61	912.61	162.85	5.77	19.07	0.00	925.91	11.87	914.04
08-08-2018	914.04	914.04	162.90	5.71	61.93	0.00	970.27	54.80	915.47
09-08-2018	915.47	915.47	162.95	5.67	46.37	0.00	956.18	39.28	916.90
10-08-2018	916.90	916.90	163.00	5.67	33.92	0.00	945.15	26.82	918.33
11-08-2018	918.33	918.33	163.05	5.69	17.28	0.00	929.92	10.16	919.76
12-08-2018	919.76	919.76	163.10	5.69	31.81	0.07	945.80	24.61	921.19
13-08-2018	921.19	921.19	163.15	5.47	37.08	0.00	952.80	30.18	922.62
14-08-2018	922.62	922.62	163.20	5.40	62.96	0.00	980.18	56.13	924.05
15-08-2018	924.05	924.05	163.25	1.96	100.59	0.00	1022.68	97.20	925.48
16-08-2018	925.48	925.48	163.30	0.00	86.97	0.00	1012.45	85.54	926.91
17-08-2018	926.91	926.91	163.35	0.00	52.67	0.00	979.58	51.24	928.34
18-08-2018	928.34	928.34	163.40	0.00	34.81	0.00	963.15	33.38	929.77
19-08-2018	929.77	929.77	163.45	0.01	28.17	0.00	957.92	26.72	931.20
20-08-2018	931.20	931.20	163.50	3.91	21.94	0.00	949.23	16.73	932.50
21-08-2018	932.50	932.50	163.55	4.48	15.16	0.00	943.17	9.37	933.80
22-08-2018	933.80	933.80	163.59	5.82	12.41	0.03	940.36	5.26	935.10
23-08-2018	935.10	935.10	163.64	5.26	10.39	0.00	940.23	3.83	936.40
24-08-2018	936.40	936.40	163.68	4.93	8.57	0.04	940.01	2.31	937.70
25-08-2018	937.70	937.70	163.73	5.70	6.89	0.06	938.83	0.00	938.83

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
26-08-2018	939.00	938.83	163.77	5.77	7.14	0.04	940.17	0.00	940.17
27-08-2018	940.30	940.17	163.81	5.77	7.57	0.06	941.90	0.30	941.60
28-08-2018	941.60	941.60	163.86	5.72	7.43	0.02	943.29	0.39	942.90
29-08-2018	942.90	942.90	163.91	5.84	7.11	0.05	944.12	0.00	944.12
30-08-2018	944.20	944.12	163.95	5.85	5.80	0.03	944.05	0.00	944.05
31-08-2018	945.50	944.05	163.95	5.84	6.71	0.02	944.90	0.00	944.90
01-09-2018	948.38	944.90	163.98	5.85	6.71	0.01	945.75	0.00	945.75
02-09-2018	951.26	945.75	164.01	5.84	6.42	0.06	946.27	0.00	946.27
03-09-2018	954.14	946.27	164.03	5.84	6.42	0.05	946.79	0.00	946.79
04-09-2018	957.02	946.79	164.04	5.87	5.87	0.08	946.71	0.00	946.71
05-09-2018	959.90	946.71	164.04	5.88	5.88	0.05	946.66	0.00	946.66
06-09-2018	962.78	946.66	164.04	5.92	5.64	0.14	946.24	0.00	946.24
07-09-2018	965.66	946.24	164.03	5.99	5.71	0.10	945.87	0.00	945.87
08-09-2018	968.54	945.87	164.01	6.01	5.76	0.06	945.55	0.00	945.55
09-09-2018	971.42	945.55	164.00	6.01	6.19	0.09	945.64	0.00	945.64
10-09-2018	974.30	945.64	164.00	5.99	4.54	0.11	944.08	0.00	944.08
11-09-2018	977.18	944.08	163.95	6.00	0.00	0.11	937.98	0.00	937.98
12-09-2018	980.06	937.98	163.74	6.00	1.53	0.09	933.42	0.00	933.42
13-09-2018	982.94	933.42	163.58	6.00	0.98	0.11	928.29	0.00	928.29
14-09-2018	985.82	928.29	163.40	5.36	0.93	0.14	923.73	0.00	923.73
15-09-2018	988.70	923.73	163.24	5.94	1.14	0.05	918.88	0.00	918.88
16-09-2018	991.58	918.88	163.07	5.55	0.79	0.09	914.04	0.00	914.04
17-09-2018	994.46	914.04	162.90	5.46	0.95	0.05	909.48	0.00	909.48
18-09-2018	997.34	909.48	162.74	5.75	1.84	0.05	905.51	0.00	905.51
19-09-2018	1000.22	905.51	162.60	5.45	0.00	0.04	900.03	0.00	900.03
20-09-2018	1003.10	900.03	162.41	4.53	1.43	0.02	896.91	0.00	896.91
21-09-2018	1003.96	896.91	162.30	5.43	0.10	0.05	891.54	0.00	891.54

Day	Storage for the rule level (MCM)	Storage at the beginning of the day (MCM)	Reservoir level (m, MSL)	PH discharge (MCM)	Inflows to reservoir (MCM)	Evaporation loss (MCM)	Storage at the end of the day before spills (2)+(5)-(4)-(6) (MCM)	Spills (MCM)	Storage after spills (MCM)
	1	2	3	4	5	6	7	8	9
22-09-2018	1004.83	891.54	162.11	5.65	0.63	0.07	886.44	0.00	886.44
23-09-2018	1005.69	886.44	161.93	5.89	1.18	0.10	881.63	0.00	881.63
24-09-2018	1006.56	881.63	161.76	4.67	2.81	0.10	879.67	0.00	879.67
25-09-2018	1007.42	879.67	161.69	5.89	3.09	0.00	876.87	0.00	876.87
26-09-2018	1008.28	876.87	161.60	5.38	0.65	0.03	872.11	0.00	872.11
27-09-2018	1009.15	872.11	161.43	5.94	1.26	0.08	867.35	0.00	867.35
28-09-2018	1010.01	867.35	161.26	5.70	0.73	0.07	862.31	0.00	862.31
29-09-2018	1010.88	862.31	161.08	5.68	2.42	0.10	858.95	0.00	858.95

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 4.1

LULC analysis for Idukki district

(Reference: Paragraph 4.1.1)

Land Use	Area 1985 (from NASA)	Area 1995 (from NASA)	Area 2005 (from KSREC)	Area 2015 (from KSREC)	Areal change from 2005 to 2015	Change from 2005 to 2015 (%)*	Areal change from 1985 to 2015	Change from 1985 to 2015 (%)*
	sq. km	sq. km	sq. km	sq. km	sq. km		sq. km	
Forest land	1966.78	1955.22	2196.35	2124.99	-71.35	-3.25	158.21	8.04
Agricultural land	1589.22	1601.99	1416.15	1598.35	182.20	12.87	9.13	0.57
Built-up (Cities/ Towns/ Villages)	11.39	11.40	20.40	154.57	134.16	657.56	143.18	1257.02
Wasteland	99.73	96.80	142.33	142.81	0.48	0.34	43.08	43.20
Grassland	591.01	592.33	478.58	231.64	-246.94	-51.60	-359.37	-60.81
Water bodies	120.26	120.65	109.02	113.24	4.22	3.87	-7.02	-5.84
Total	**4378.39**	**4378.39**	**4362.82[$]**	**4365.59[$]**				

*Negative sign indicates a decrease in area for a particular class and positive sign indicates an increase in area.

[$]The difference in the total areas is due to a slight inconsistency in the data for the two years obtained from KSREC. However, this difference is negligible.

LULC transition matrix for Idukki district (2005-2015)

(in *per cent*)

		2015					
		Forest land	**Agricultural land**	**Grassland**	**Wasteland**	**Water bodies**	**Built-up (Cities/Towns/ Villages)**
2005	**Forest land**	88.12	8.39	1.78	0.49	0.18	1.04
	Agricultural land	0.60	91.00	0.48	0.33	0.29	7.30
	Grassland	32.67	21.52	35.22	7.91	1.23	1.45
	Wasteland	12.98	10.61	11.51	63.03	0.05	1.82
	Water bodies	3.69	3.72	0.26	0.03	90.96	1.34
	Built-up (Cities/ Towns/ Villages)	2.05	11.19	0.02	0.30	0.50	85.94

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 4.2

LULC analysis for Ernakulam district

(Reference: Paragraph 4.1.2)

Land Use	Area 1985 (from NASA)	Area 1995 (from NASA)	Area 2005 (from KSREC)	Area 2015 (from KSREC)	Areal change from 2005 to 2015	Change from 2005 to 2015 (%)*	Areal change from 1985 to 2015	Change from 1985 to 2015 (%)*
	sq. km	sq. km	sq. km	sq. km	sq. km		sq. km	
Forest land	654.78	624.79	830.58	837.21	6.63	0.80	182.43	27.86
Agricultural land	1961.04	1916.65	1737.86	1555.66	-182.2	-10.48	-405.38	-20.67
Built-up (Cities/Towns/ Villages)	140.65	182.26	253.93	439.14	185.21	72.94	298.49	212.22
Wasteland	2.73	2.73	15.83	26.12	10.29	65.00	23.39	856.78
Grassland	86.53	116.49	39.63	21.32	-18.31	-46.20	-65.21	-75.36
Water bodies	219.51	222.32	190.70	188.81	-1.89	-0.99	-30.7	-13.99
Total	**3065.24**	**3065.24**	**3068.54[$]**	**3068.26[$]**				

*Negative sign indicates a decrease in area for a particular class and positive sign indicates an increase in area.

[$]The difference in the total areas is due to a slight inconsistency in the data for the two years obtained from KSREC. However, this difference is negligible.

LULC transition matrix for Ernakulam district (2005-2015)

(in *per cent*)

		2015					
		Forest land	**Agricultural land**	**Grassland**	**Wasteland**	**Water bodies**	**Built-up (Cities/Towns/ Villages)**
2005	**Forest land**	97.29	1.06	0.73	0.63	0.21	0.08
	Agricultural land	1.31	85.56	0.06	0.33	0.74	12.00
	Grassland	7.82	44.58	30.71	6.59	0.13	10.17
	Wasteland	11.12	6.51	1.23	73.32	6.44	1.38
	Water bodies	1.11	7.12	1.00	0.01	89.66	1.10
	Built-up (Cities/ Towns/Villages)	0.11	10.83	0.01	0.39	0.58	88.08

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 4.3

LULC analysis for flood prone region of Ernakulam district

(Reference: Paragraph 4.1.3)

Land Use	Area 1985 (from NASA)	Area 1995 (from NASA)	Area 2005 (from KSREC)	Area 2015 (from KSREC)	Areal change from 2005 to 2015	Change from 2005 to 2015 (%)*	Areal change from 1985 to 2015	Change from 1985 to 2015 (%)*
	sq. km	sq. km	sq. km	sq. km	sq. km		sq. km	
Forest land	27.44	27.38	38.26	49.56	11.30	29.53	22.12	80.63
Agricultural land	613.15	588.99	566.34	489.68	-76.66	-13.54	-123.47	-20.14
Built-up (Cities/Towns/ Villages)	48.44	72.02	104.26	182.59	78.33	75.13	134.15	276.94
Wasteland	0.59	0.59	1.47	3.76	2.29	155.53	3.17	538.08
Grassland	7.65	7.65	11.50	2.22	-9.28	-80.69	-5.43	-70.98
Water bodies	92.90	93.54	69.62	63.50	-6.12	-8.79	-29.40	-31.64
Total	**790.17**	**790.17**	**791.46[$]**	**791.32[$]**				

*Negative sign indicates a decrease in area for a particular class and positive sign indicates an increase in area.

[$]The difference in the total areas is due to a slight inconsistency in the data for the two years obtained from KSREC. However, this difference is negligible.

LULC transition matrix for flood prone region of Ernakulam district (2005-2015)

(in *per cent*)

		2015					
		Forest land	Agricultural land	Grassland	Wasteland	Water bodies	Built-up (Cities/ Towns/ Villages)
2005	**Forest land**	90.75	6.85	0.00	1.52	0.39	0.49
	Agricultural land	2.49	81.01	0.04	0.27	0.87	15.32
	Grassland	6.84	60.90	17.16	5.05	0.00	10.05
	Wasteland	0.24	28.71	0.18	62.07	0.00	8.80
	Water bodies	0.04	15.21	0.00	0.00	83.18	1.57
	Built-up (Cities/ Towns/ Villages)	0.02	9.74	0.00	0.12	0.52	89.60

(Source: IISc, Bangalore's Report on Kerala Floods 2018)

Appendix 5.1

Statement showing name of LSGI, Taluk and number of respondents covered by Audit in selected districts while conducting survey of affected persons

(Reference: Chapter 5, Paragraph on Results of survey)

Sl. No.	Name of District	Name of Taluk Office	Name of LSGI	Number of persons surveyed
1.	Alappuzha	Chengannur	Chengannur Municipality	25
2.			Pandanad Grama Panchayat	25
3.			Thiruvanvandoor Grama Panchayat	25
4.			Ala Grama Panchayat	25
5.		Kuttanad	Champakkulam Grama Panchayat	25
6.			Muttar Grama Panchayat	25
7.			Nedumudi Grama Panchayat	27
8.			Neelamperoor Grama Panchayat	25
9.	Ernakulam	Aluva	Aluva Municipality	26
10.			Kalady Grama Panchayat	26
11.			Parakkadavu Grama Panchayat	31
12.			Sreemoolanagaram Grama Panchayat	28
13.		Paravur	Alangad Grama Panchayat	30
14.			Chendamangalam Grama Panchayat	30
15.			Karumalloor Grama Panchayat	22
16.			Puthenvelikkara Grama Panchayat	26
17.	Idukki	Idukki	Kanjikuzhy Grama Panchayat	15
18.			Konnathady Grama Panchayat	20
19.			Vathikudy Grama Panchayat	20
20.			Vazhathope Grama Panchayat	24
21.		Devikulam	Adimaly Grama Panchayat	20
22.			Mankulam Grama Panchayat	25
23.			Munnar Grama Panchayat	19
24.			Vellathooval Grama Panchayat	17
25.	Thrissur	Chalakkudy	Chalakkudy Municipality	19
26.			Kadukutty Grama Panchayat	28
27.			Koratty Grama Panchayat	24
28.			Melur Grama Panchayat	34
29.		Thalappilly	Chelakkara Grama Panchayat	32
30.			Pazhayannur Grama Panchayat	22
31.			Vallathol Nagar Grama Panchayat	32
32.			Wadakkancherry Municipality	28