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ADAPTATION TO EXTREME FLOODS UNDER FUTURE CLIMATE CHANGE SCENARIOS FOR COLOMBO, SRI LANKA

1. INTRODUCTION

❖ Flooding is one of the major disasters in Sri Lanka. Every year, thousands of people loss their properties due to floods.
❖ Colombo is the commercial capital of the country. Since major part of Colombo is located in the flood plains of Kelani River, Colombo undergoes frequent floods.
❖ Colombo has undergone the effects of climate change for the past years and literature suggests that Colombo will have more extreme flood events in the future .
❖ Though there is a flood protection system, many improvements should be done to minimize damages due to floods.


A flood in Kelani River, 1989


A flood in Kelani River, 2005


During a flood in Kelani River


Flood aftermath in Kelani River, 1989

2. OBJECTIVES

❖ To analyze future climate conditions in the Kelani basin with different Global Circulation Model (GCM) data
❖ To define extreme rainfall scenarios for the Kelani basin taking climate change into account
❖ To model and simulate flood inundations in Colombo area under extreme rainfall scenarios
❖ To propose adaptation measures to reduce the impacts in Colombo area

3. METHODOLOGY

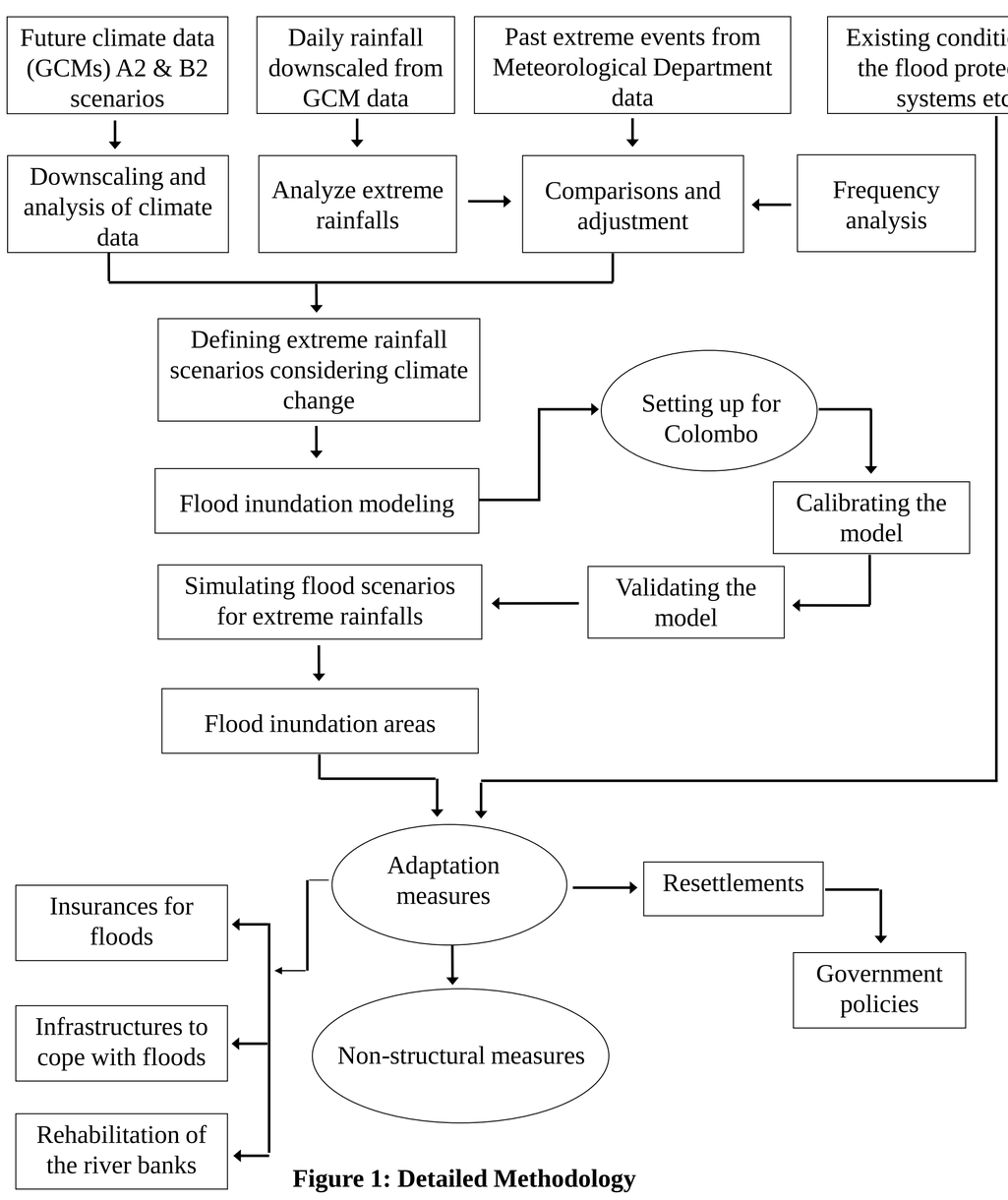
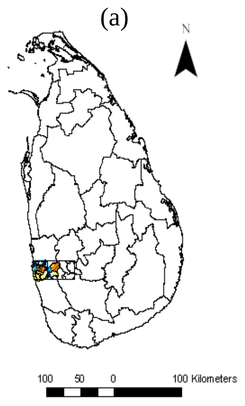


Figure 1: Detailed Methodology

4. STUDY AREA

(a)



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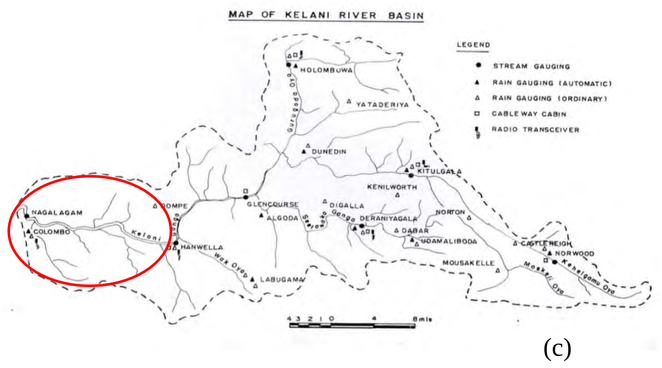

(c)

Figure 2: (a) Sri Lanka in Asia, (b) Map of Kelani basin in Sri Lanka and (c) Map of Kelani basin

Table 1: Historical major extreme events in Kelani basin

Flood date			6/6/89	5/6/92	21/4/99	22/11/05	29/4/08	1/6/08
Water level (mMSL)		Nagalagam	2.80	1.54	2.01	1.72	1.75	1.80
		Hanwella	11.56	8.27	9.39	9.07	9.91	9.51
Daily rainfall (mm)	Colombo	Day earlier	12	494	285	270	13	35
		Flood day	3	16	29	49	1	56
	Hanwella	Day earlier	10	260	198	271	24	57
		Flood day	9	12	32	38	1	98
	Digalla	Day earlier	N/A	99	61	162	169	131
		Flood day	N/A	3	79	28	0	140
	Dunedin	Day earlier	54	132	103	N/A	247	0
		Flood day	4	3	24	N/A	0	20
Discharge (m^3/s)		Nagalagam	1822	1164	1280	1210	1408	1500
		Hanwella	2745	1076	1282	1209	1408	1308

5. RESULTS AND DISCUSSIONS

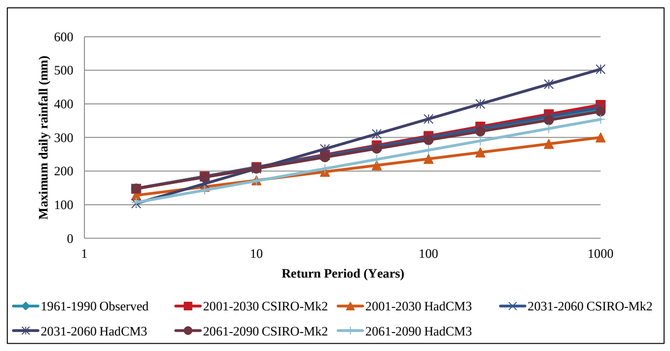

Figure 3: Predicted future extreme events for Colombo under climate change conditions (A2 scenario)

◆ CSIRO-Mk2 model predicts extreme events very close to those of the past years.
◆ HadCM3 tend to reduce extreme events of low return periods and increase extreme events of high return periods.

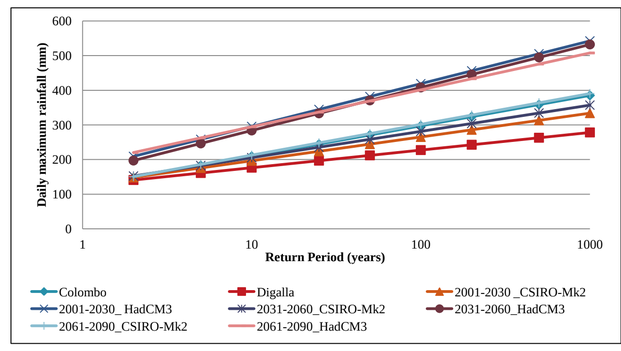

Figure 4: Predicted future extreme events for Digalla under climate change conditions (A2 scenario)

◆ HadCM3 predicts larger extreme events for all the durations than CSIRO-Mk2.
◆ CSIRO-MK2 also shows increase in extreme events.
◆ Compared to extreme events at Colombo for the baseline, extreme events at Digalla showed lower rainfalls from CSIRO-Mk2 for the past.

Table 2: Extreme event summery for Colombo under A2 scenario

Return period (Years)	Daily rainfall (mm)				
	1960 - 1990	Average of ensembles		Preferred model (CSIRO-MK2)	
		Future value 2001-2030	% increment over the baseline	Future value 2001-2030	% increment over the baseline
2	148	130	-11.9	147	-0.7
5	183	168	-8.2	184	0.5
10	209	197	-5.9	212	1.4
25	244	235	-3.9	249	2.0
50	271	263	-2.8	277	2.2
100	297	292	-1.9	304	2.4
200	324	320	-1.1	332	2.5
500	359	358	-0.2	369	2.8
1000	385	387	0.4	397	3.1

Table 3: Extreme event summery for Digalla under A2 scenario

Return period (Years)	Daily rainfall (mm)				
	1985 - 2000	Average of ensembles		Preferred model (CSIRO-MK2)	
		Future value 2001-2030	% increment over the baseline	Future value 2001-2030	% increment over the baseline
2	141	180	27.3	148	5.0
5	161	219	35.9	176	9.3
10	176	248	40.9	196	11.4
25	197	287	45.8	224	13.7
50	212	317	49.3	244	15.1
100	227	346	52.4	265	16.7
200	243	376	54.5	286	17.7
500	263	415	57.6	313	19.0
1000	278	444	59.7	334	20.1

Table 4: Water levels at Nagalagam street for different future and past flood scenarios

Scenario		Water level at Nagalagam Street (mMSL)
Rainfall return period (Years)	Upstream inflow increment (%)	
10		1.69
25	10	2.05
50	20	2.44
100	30	2.85
10 yr rainfall with 0.5m increment in tide		1.94
1989 event		2.81
2005 event		1.72
2008 event		1.81

Table 5: Comparison of past extreme flood events with future scenarios

Category	Return period (Years)	Past floods	Future floods	
		Water level at Nagalagam (mMSL)	Water level at Nagalagam (mMSL)	Inundated areas (km^2)
HR DS*	500	1.94	1.69	94
HR US**	100	2.80	3.28	230
	80	1.75	2.85	208
HR US & DS***	20	2.01	3.28	235
	15	1.72	2.85	219

(Note: *Heavy Rains Down Stream, **Heavy Rains Up Stream ,***Heavy Rains both Up Stream and Down Stream)


Illegal low land filling


Encroachment to flood plains


Improper maintenance of river branches


Destruction of river banks


Destruction of river banks


Improper maintenance of flood gates

Some of the major flood-inducing problems in Kelani River

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

◆ Changes in seasonal rainfalls were observed due to climate changes.
◆ Future extreme rainfall events in Colombo will remain closer to past data though upstream station seems to have higher values than the past data.
◆ Flood inundation areas will increase due to climate change conditions.

Recommendations

◆ GCM data should be analyzed for few more stations in the basin with longer durations of observed records
◆ Since Sri Lanka is an island, regional climate models (RCM) need to be developed for the area.
◆ The extreme events obtained and rainfall trends should be compared with dynamical downscaled GCM data as well.

Non-structural measures

◆ Maintenance and improvement of existing flood protection systems
◆ Proper coordination between all the relevant authorities
◆ Improvement of efficiency of the flood warning system
◆ Improvement of the data base of historical data
◆ Implementation of a flood insurance scheme
◆ Implementation of rainwater harvesting systems
◆ Awareness program for people regarding increments of flood events

Structural measures

◆ Rehabilitation of river banks and flood gates