Center for Urban Water, Sri Lanka

Metro Colombo Urban Development Project

Ministry of Urban Development, Water Supply and Housing Facilities

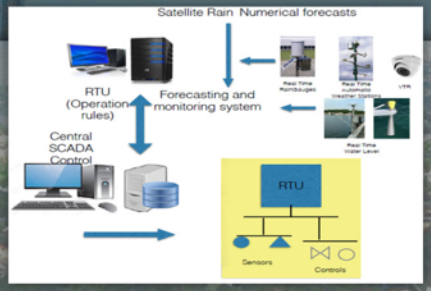
Government of Sri Lanka

STATE OF WATER

A combination of hydrological and hydro-dynamic models are used to forecast the state of water in the Colombo System with rainfall inputs from numerical weather forecasts, satellite data and rain gauge observations. Current and future canal water levels, interaction with river and the lake water levels are forecast in 15 min time intervals at present.

RISK MANAGEMENT

The impact of urbanization on urban water as well as impacts of floods on population and properties are modeled. Pre-disaster loss estimations based on vulnerability functions for different building categories are carried out to clarify flood control investment needed. Various urban water management strategies including improving conveyance as well as retention, including green infrastructure are studied.



MONITORING AND CONTROL

A dense network of rainfgauges and water level sensors are planned to be installed in the basin. A scada control system will be employed to control 3 pumping stations and 3 gate structures. In addition future developments in retention storage units will also be monitored and control through the center.

CUrW BUILDING

Six stories of a new building will house a state-of-the-art center for data integration, modelling, control and dissemination. The first two floors are planned for public outreach, the 3rd floor for data integration and flood control, 4th floor for environmental services, 5th floor for R&D and the 6th floor for administration.

Mission

Develop an integrated flood control and water management information system for flood risk reduction through optimal operational use of flood control facilities such as pumps, storages facilities, surface storages and flood early warning system for Metro Colombo. Center will also assess current and evolving future water related risks to Megapolis from urban development as well as climate change.

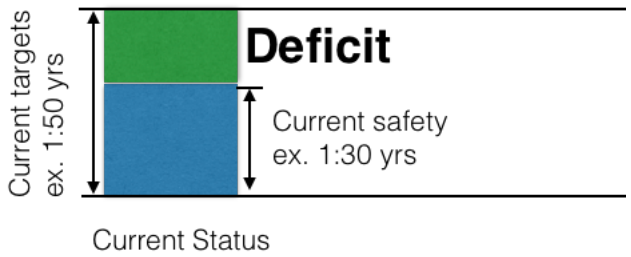
Srikantha Herath (Team Leader)

Session -1: Sharing Experiences

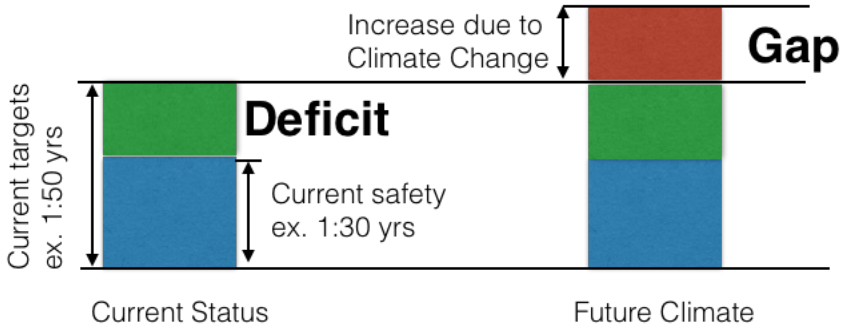
ADBI-ICHARM Policy Dialogue on Water-related Disaster Resilience under Climate Change

Outline

- Addressing Current Safety Deficit
  - Desired safety levels are not yet achieved in many developing countries. Flood control measures are implemented to close this deficit

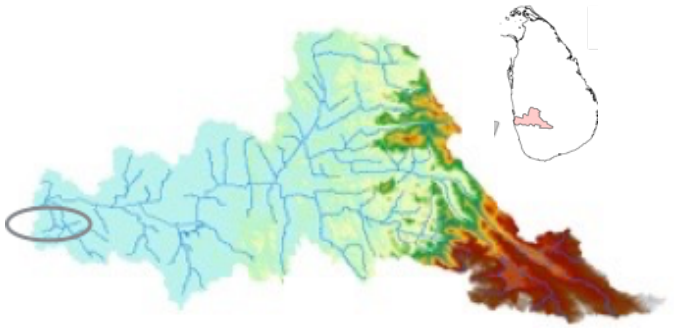


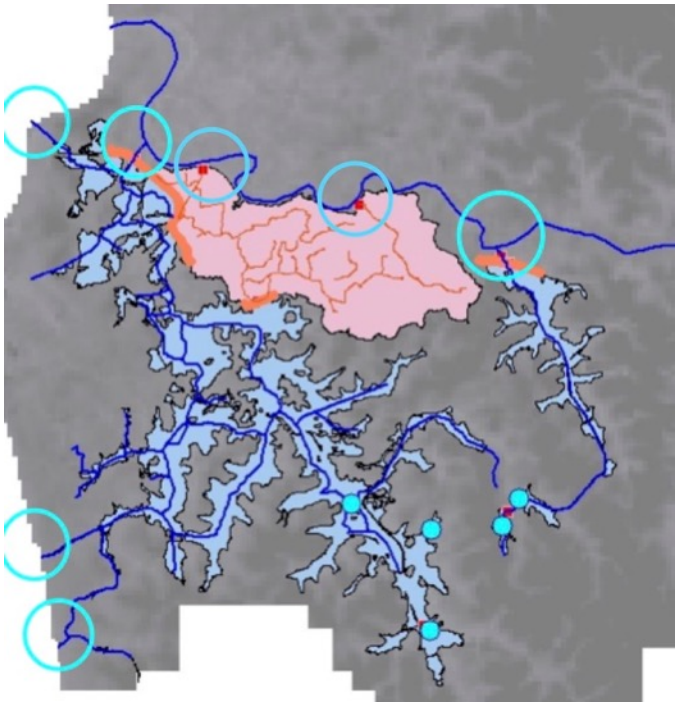
- Case Study of Flood Control component of Metro Colombo Urban Development Project to address deficit
- Addressing future Safety Gap
  - Global Changes will create a gap in safety levels in future due to increasing hazard and vulnerabilities due to global change.



- System Resilience: Addressing Safety Gap under global Change – Climate Change and Urbanization
- System Sustainability

Flood types affecting Colombo

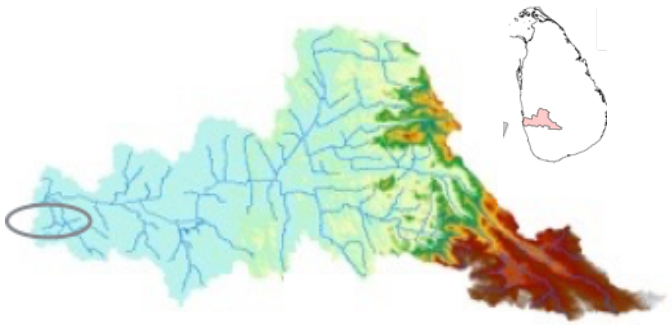


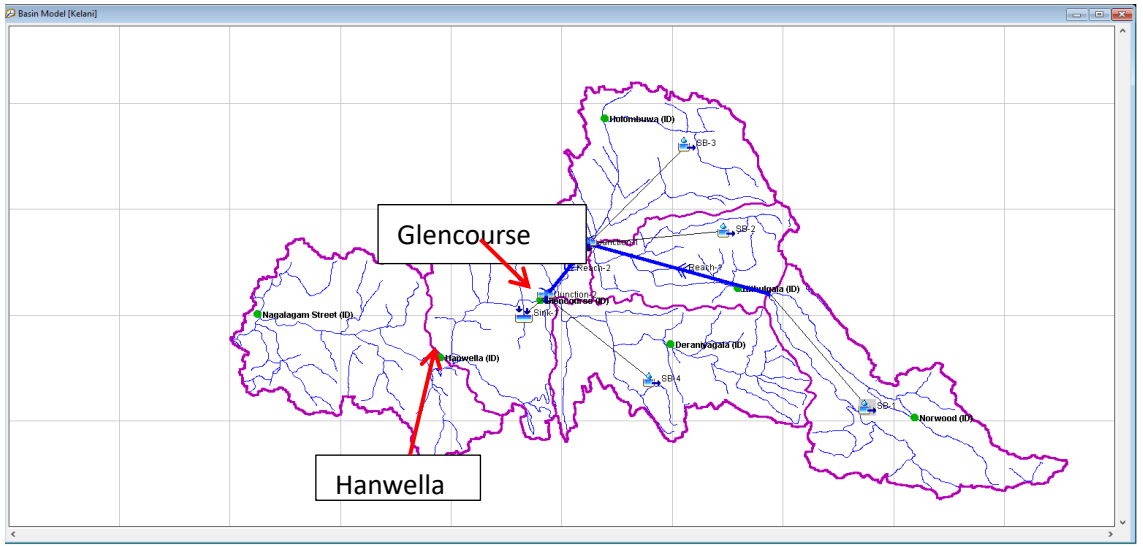


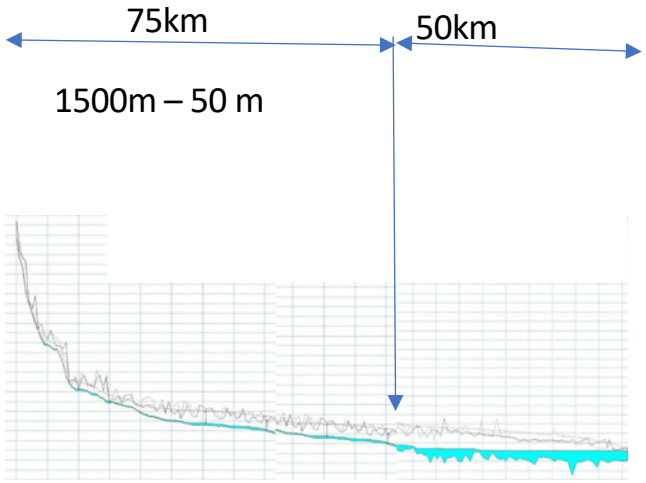
- Flood due to overflowing of Kelani River (eg. 2016 May)
- Flood due to overflowing of Colombo Canals (eg. 2010 Nov)
- Flash Flooding / Urban Flooding

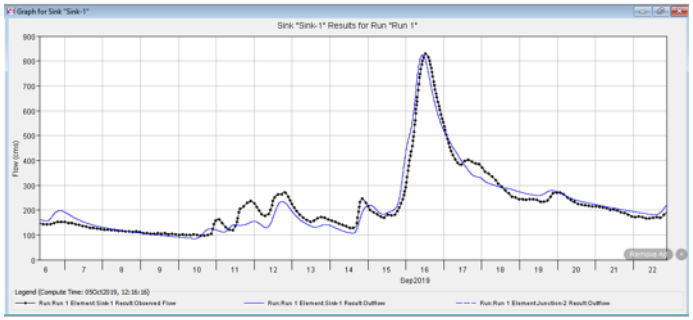
Date	Rainfall
17th May 1981	*194*
4th June 1992	*494*
20th April 1999	*285*
21st November 2005	*270*
17th November 2009	*207*
12th to 18th of May 2010	*503*
10th November 2010	*440*
16th May 2016	*260*

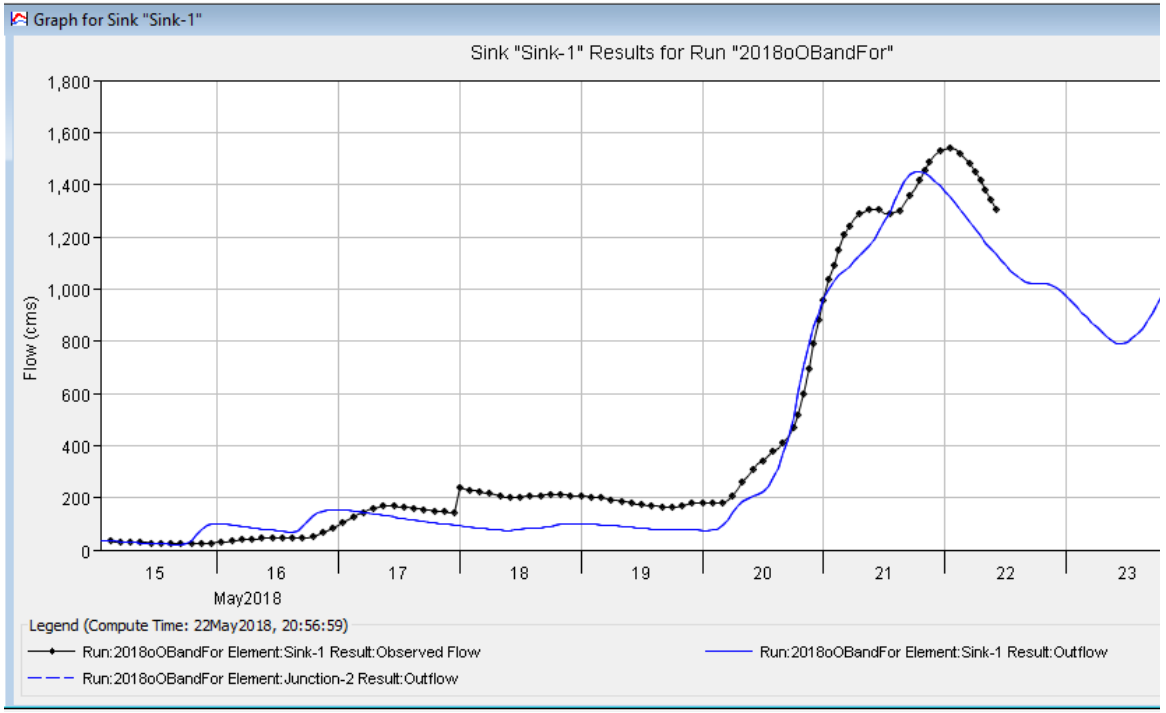
Forecasting Kelani River Floods



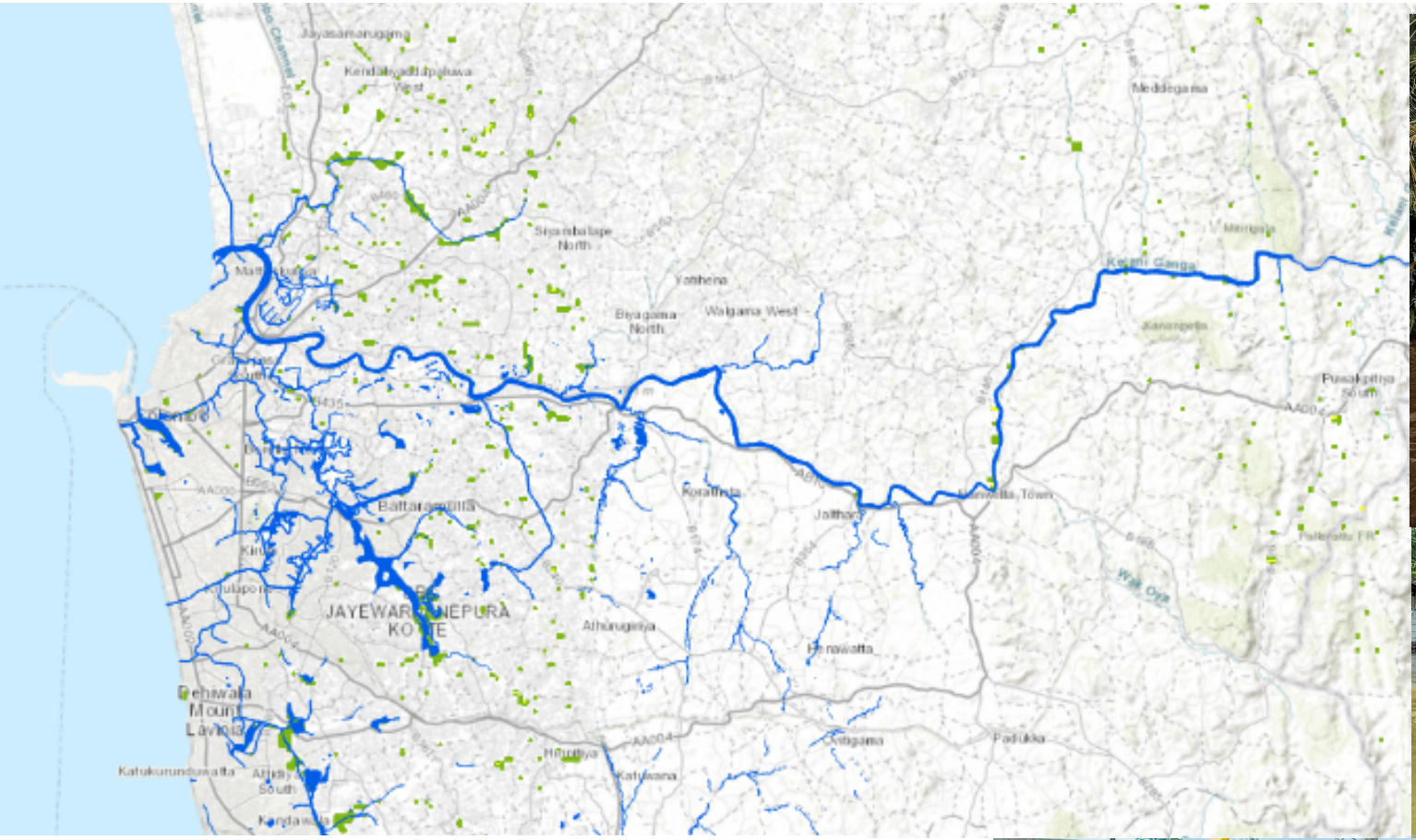


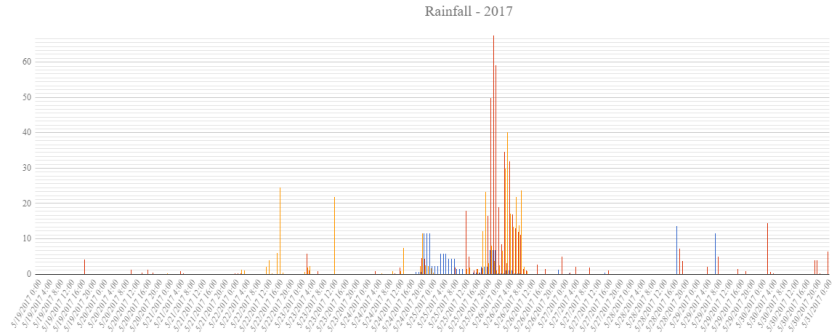


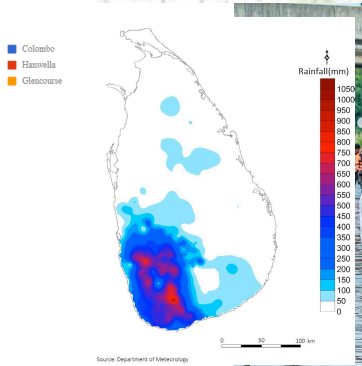




Overflow of Kelani River (2017)







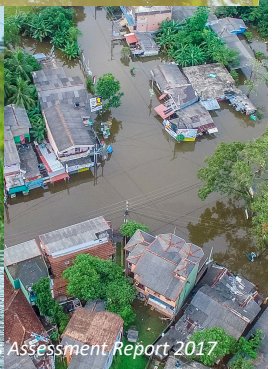
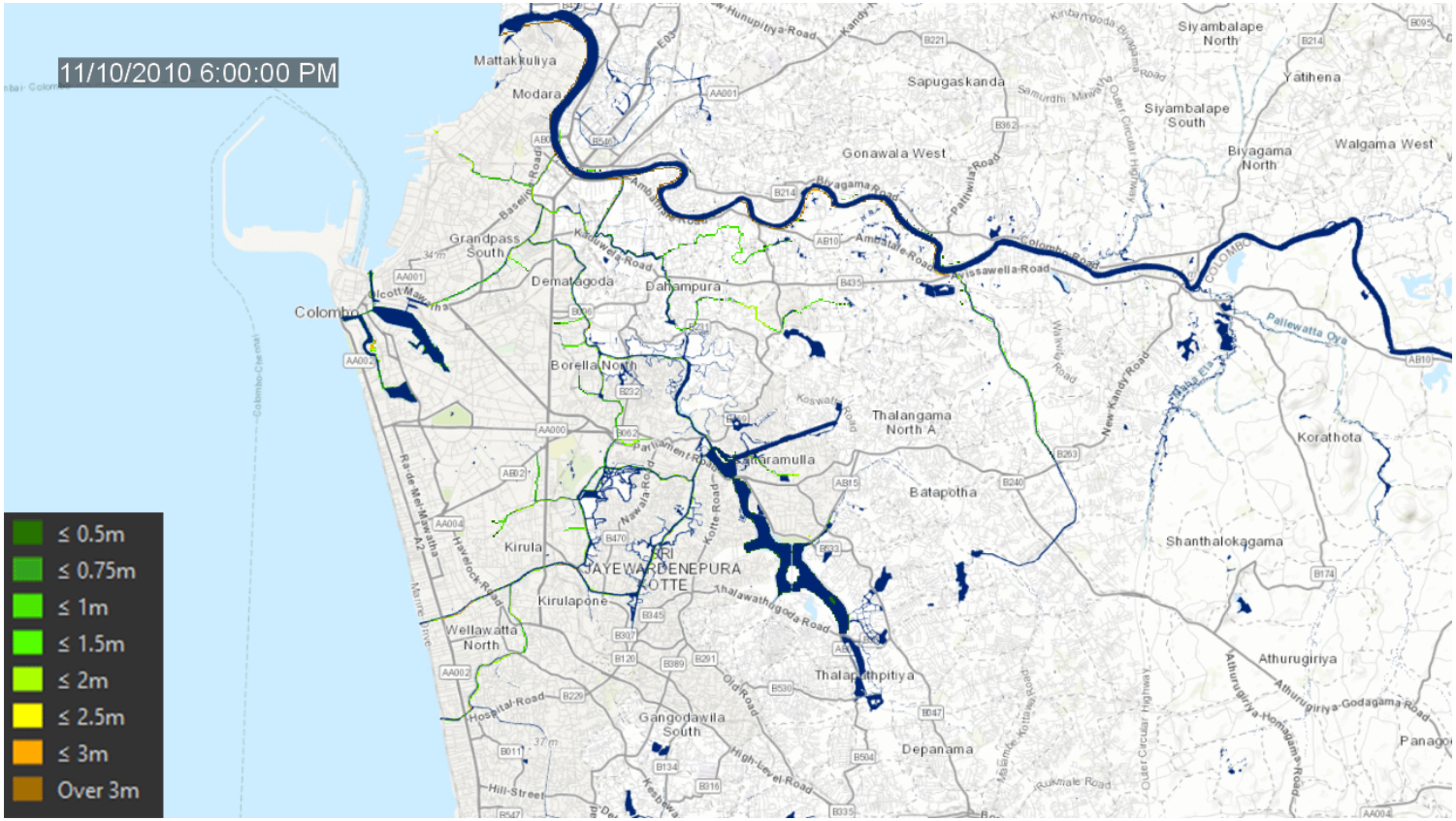
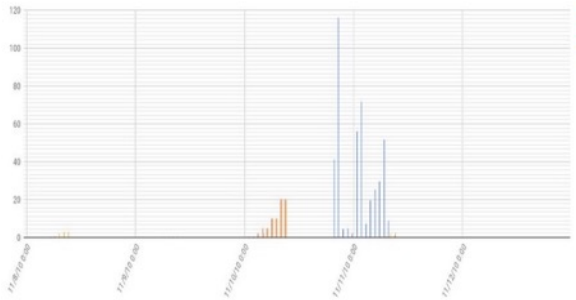


Image Source: Sri Lanka Rapid Post Disaster Needs Assessment Report 2017

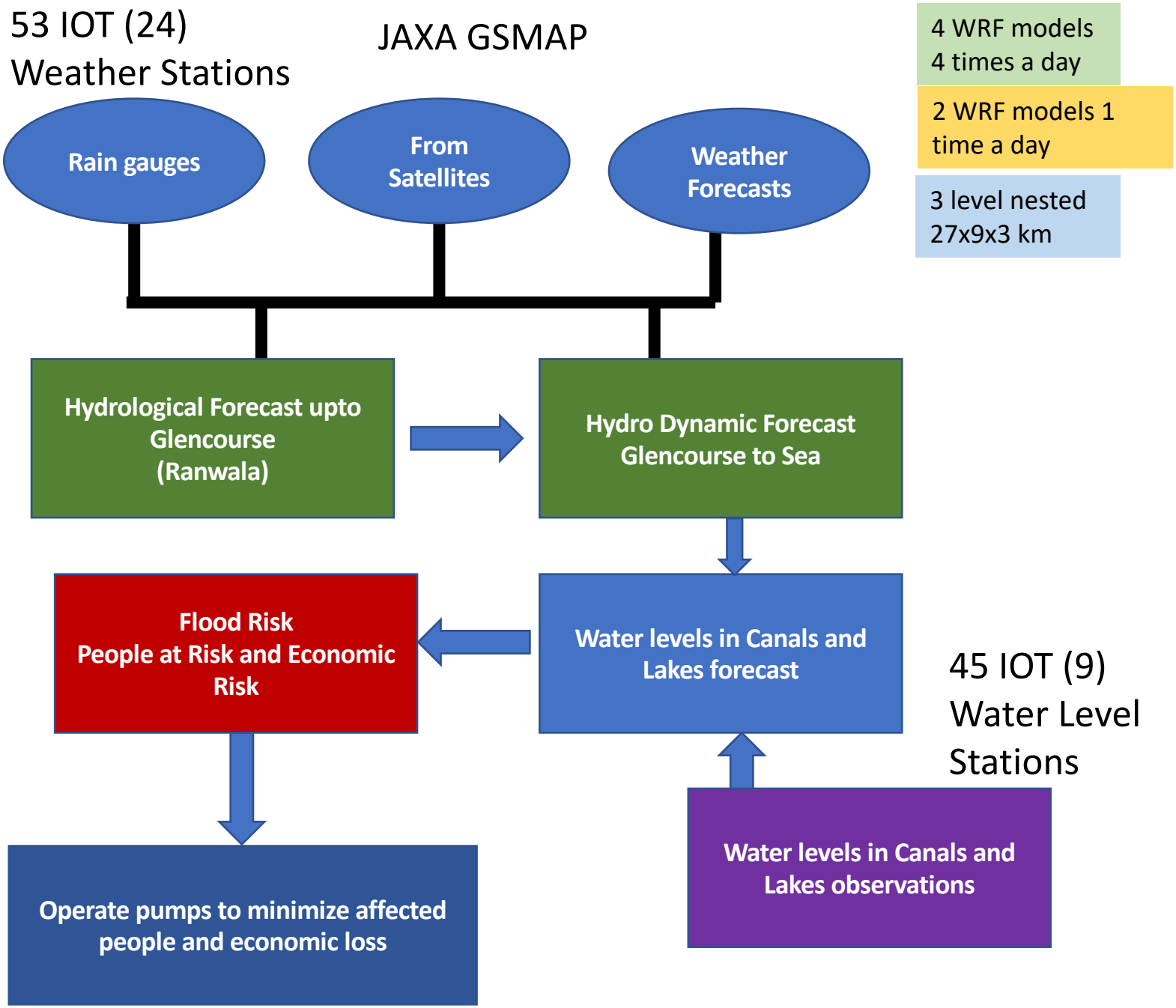
Urban Floods (2010)





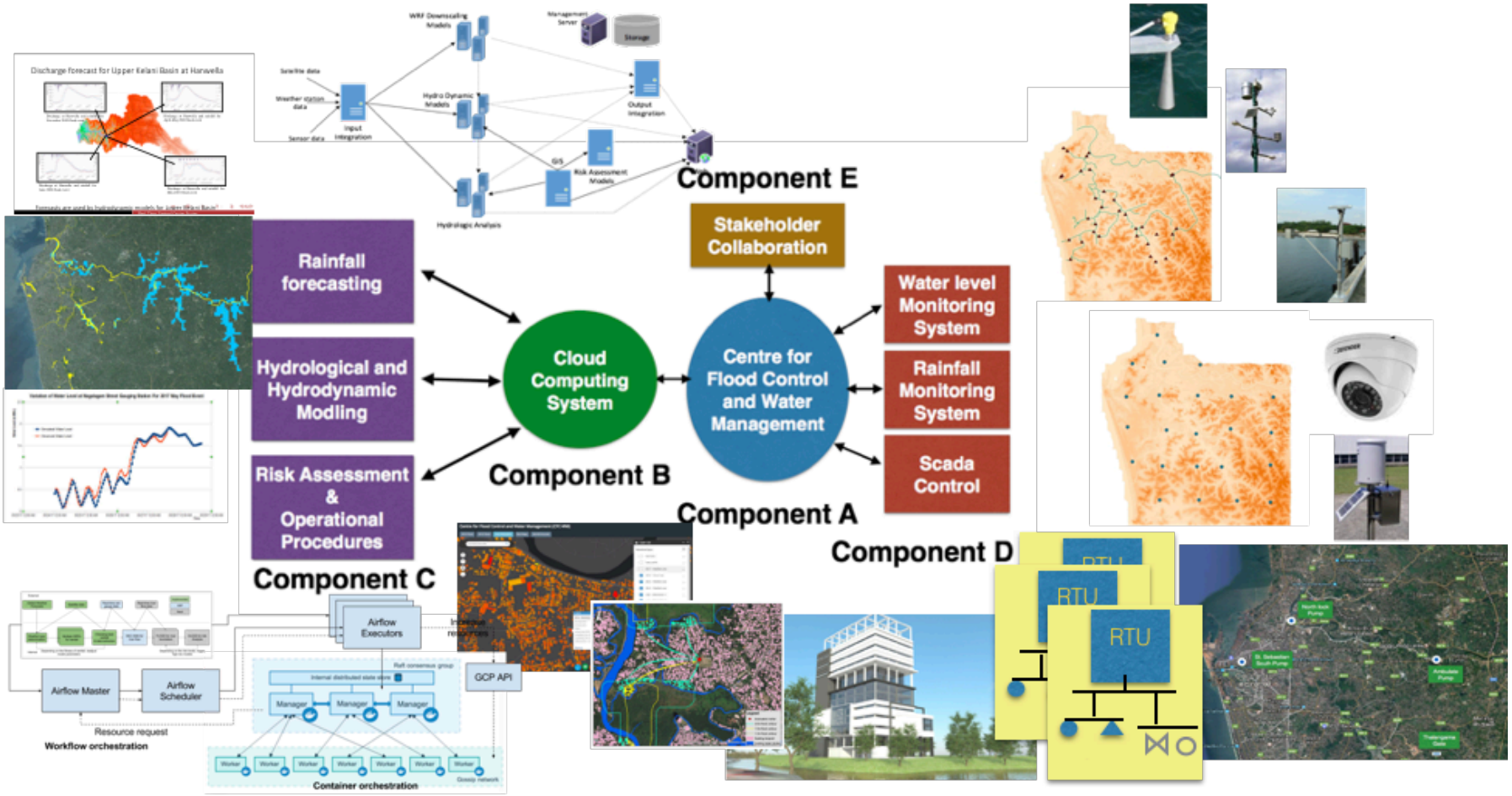
List of major interventions

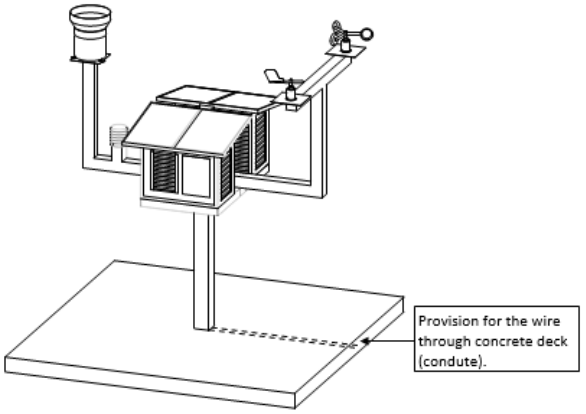
1. Improvements to Madiwela East Diversion Scheme
   - Bank protection, Dredging, Construction of O & M road
   - Rehabilitation of existing flap gates
2. Ambathale pumping station
   - Replacing vertical gates
   - 20 m^3/s pumping station
3. St. Sebastian North Lock Gates and Pumping St
   - Installation of new vertical gates and construction of 30 m^3/s pumping station
4. St. Sebastian South Lock Pumping St
   - Rehabilitation of existing gates
   - 10 m^3/s pumping station
5. Torrington Tunnel
   - 32 m^3/s capacity
   - 3m diameter 1100m main tunnel
   - Network of spine and lateral canal network of 2500m length
6. New Mutwal Tunnel
   - 15 m^3/s capacity
   - 3m diameter 700m tunnel
7. Kolonnawa Canal diversion
   - Bank protection, Dredging, Construction of O & M road
   - Installation of vertical gates


53 IOT (24)
Weather Stations
JAXA GSMAP
4 WRF models
4 times a day
2 WRF models 1
time a day
3 level nested
27x9x3 km
Rain gauges
From
Satellites
Weather
Forecasts
Hydrological Forecast upto
Glencourse
(Ranwala)
Hydro Dynamic Forecast
Glencourse to Sea
Flood Risk
People at Risk and Economic
Risk
Water levels in Canals and
Lakes forecast
45 IOT (9)
Water Level
Stations
Operate pumps to minimize affected
people and economic loss
Water levels in Canals and
Lakes observations

Center for Urban Water, Sri Lanka

System Implementation





Weather Stations

Sensor types:

- Tipping Bucket

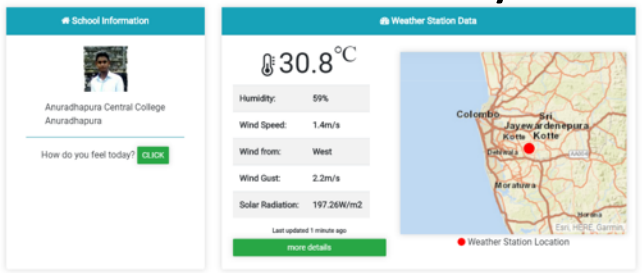
Transmission:

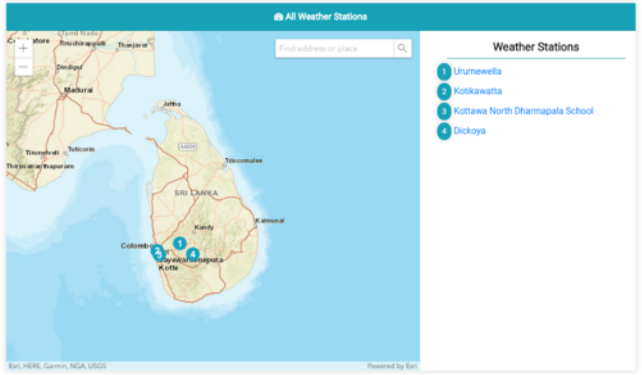
- Radio + Wi-Fi
- **GSM**
- **Fiber Optic**
- **Things Network**

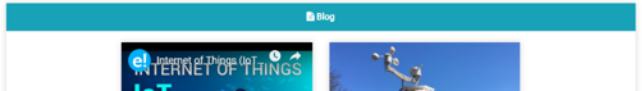
Resolution:

- 0.1mm, and 0.2mm

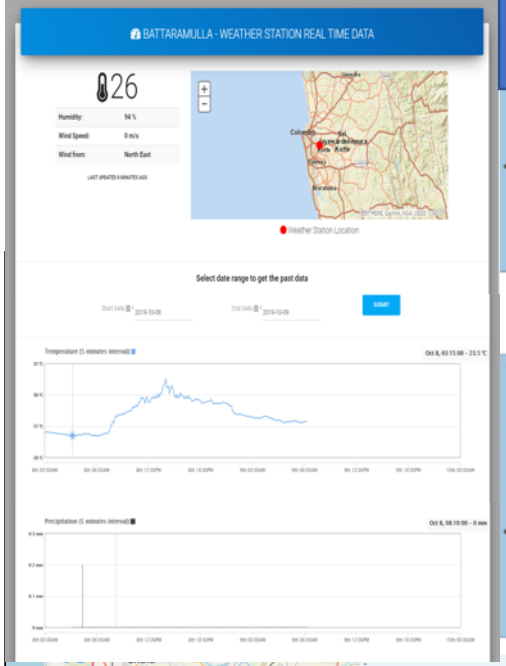
Schools Community

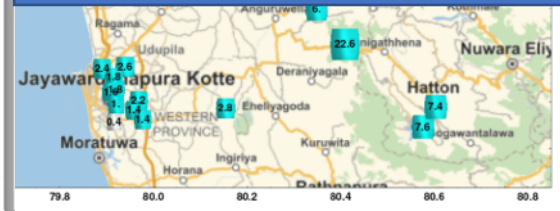




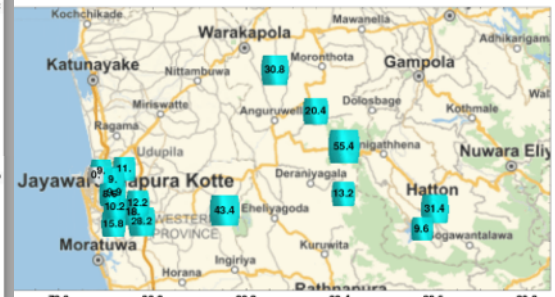


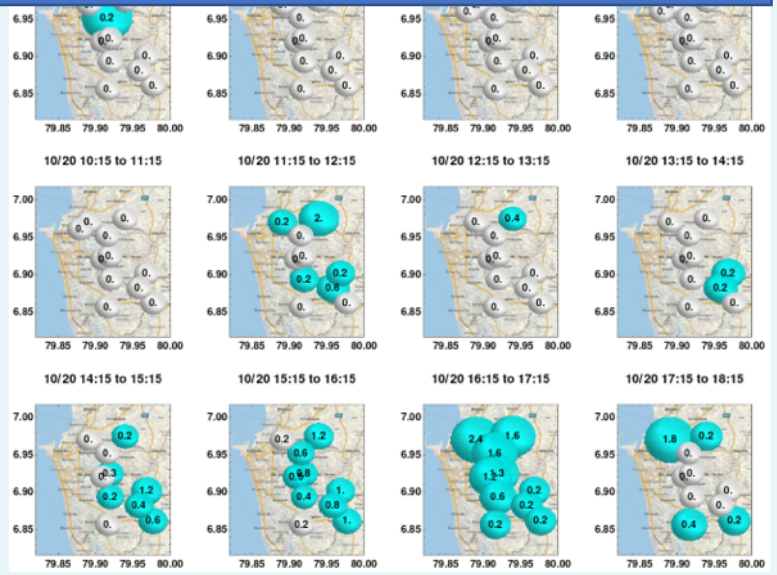
Monitoring Systems and Information Sharing

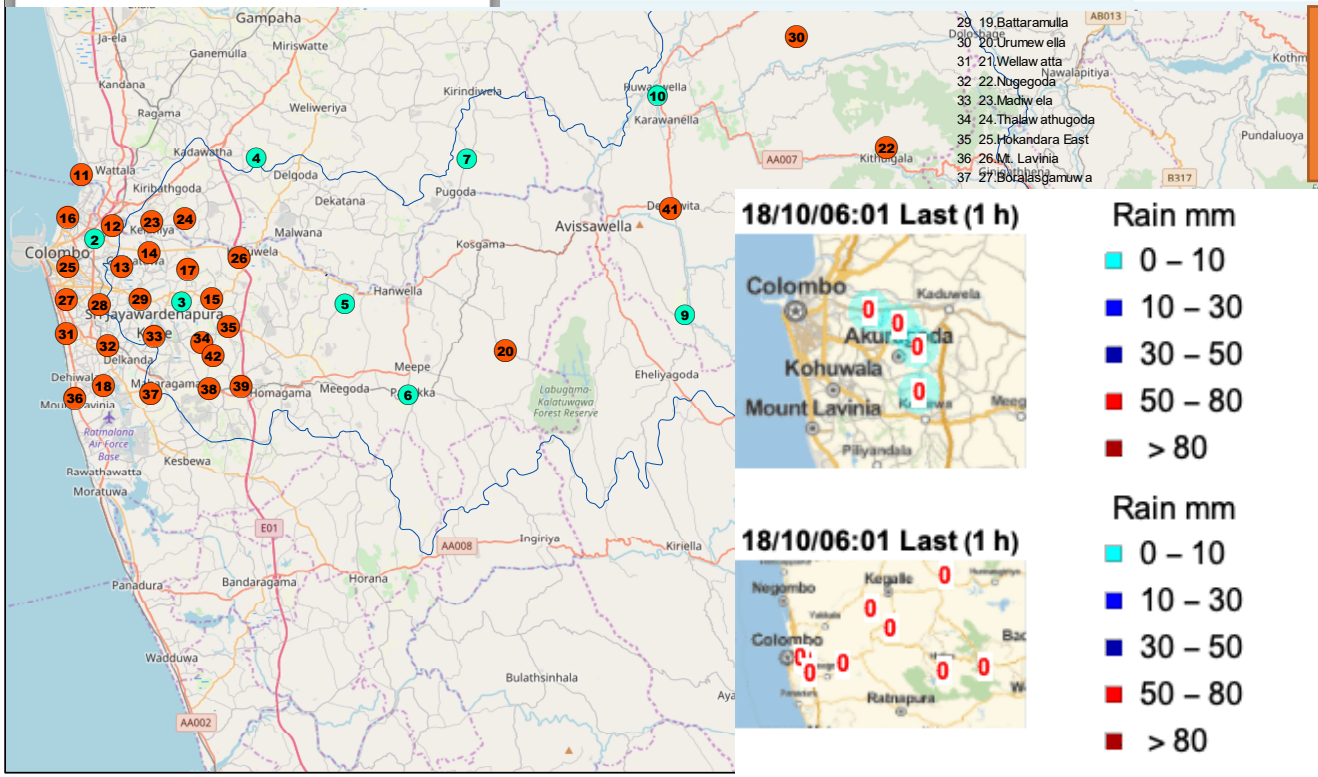




Last 1. day Rain from: 2019-10-20 17:00:00

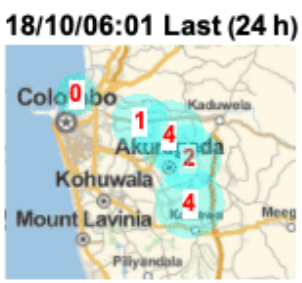






Past 1,3 and 24 Hour summaries, Hourly summaries and past data at stations

Rain mm
- 0 – 10
- 10 – 30
- 30 – 50
- 50 – 80
- > 80



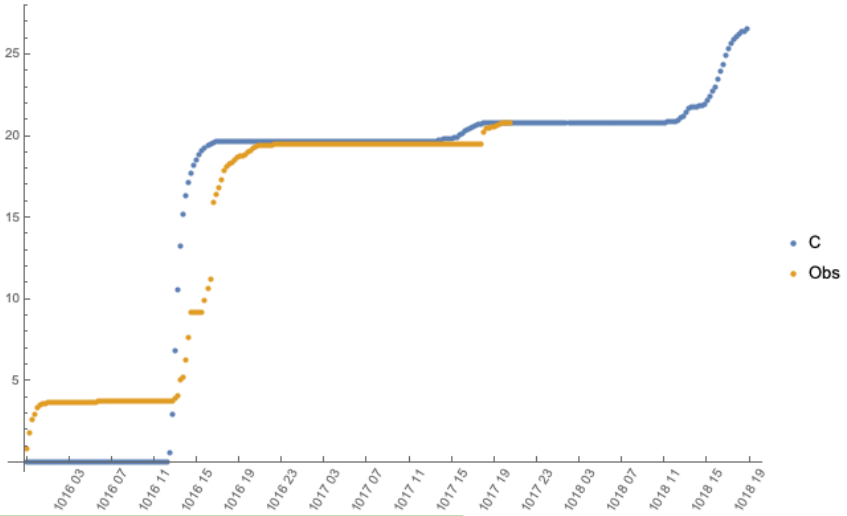
Rain mm
- 0 – 80
- 80 – 100
- 100 – 200
- 200 – 400
- > 400

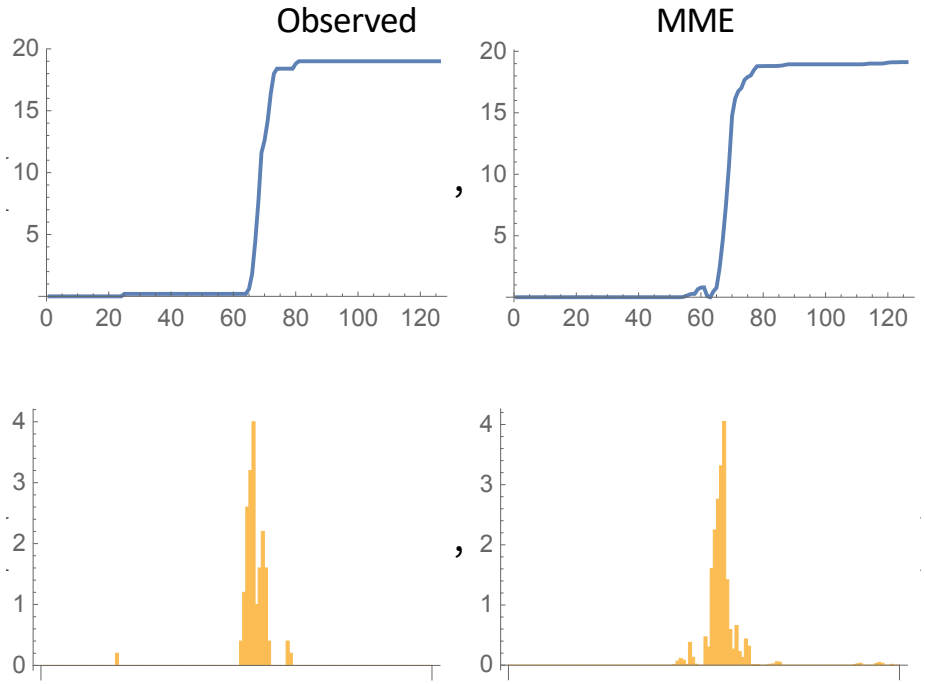
Rain mm
- 0 – 10
- 10 – 30
- 30 – 50
- 50 – 80
- > 80

Rain mm
- 0 – 80
- 80 – 100
- 100 – 200
- 200 – 400
- > 400

Rainfall Forecasts

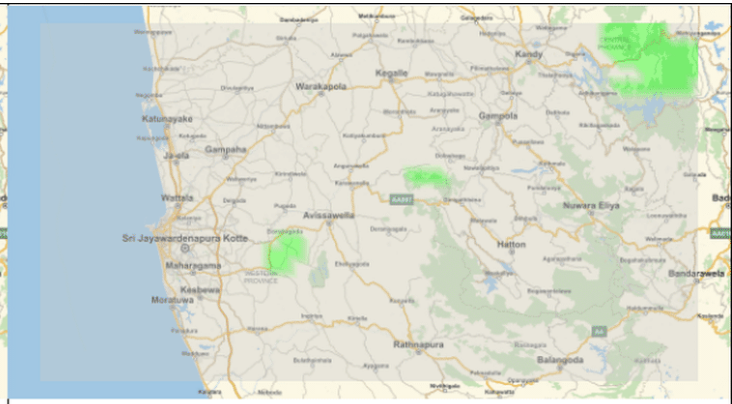
Basin mean rain – forecast and observed



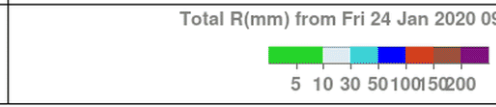


- 4 weather models are run twice or 4 times a day for a 3 day forecast.
- We select the model based on closeness to observations
- Forecast is corrected using past observed data until present time.

WRF SE @ Fri 24 Jan 2020 09:45:00



Total Rain Fri 24 Jan 2020 09:45:00
– Fri 24 Jan 2020 09:45:00



Water Level Stations

Sensor types:

- Ultrasonic
- Radar

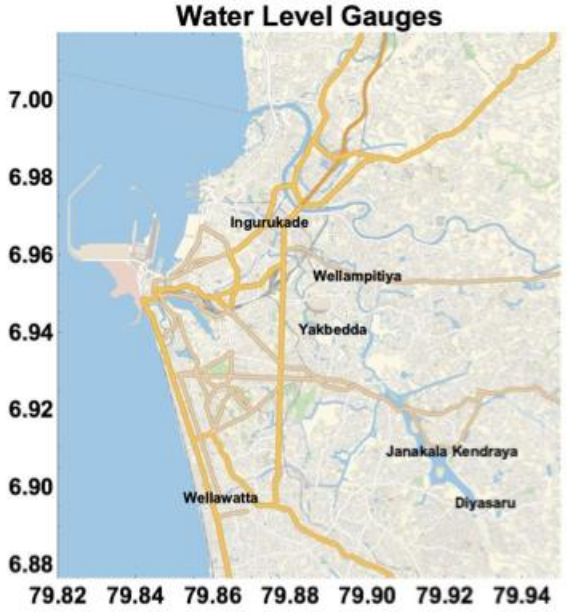
Transmission:

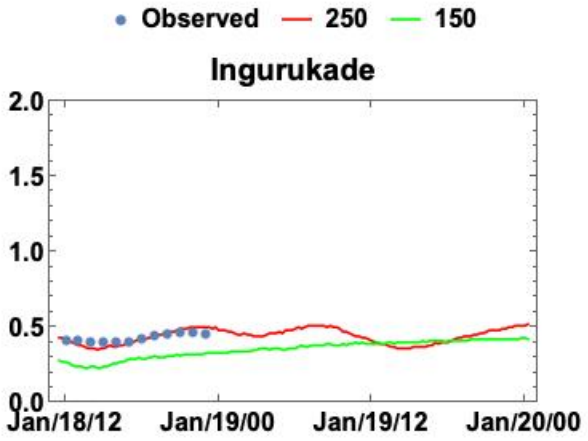
- GSM

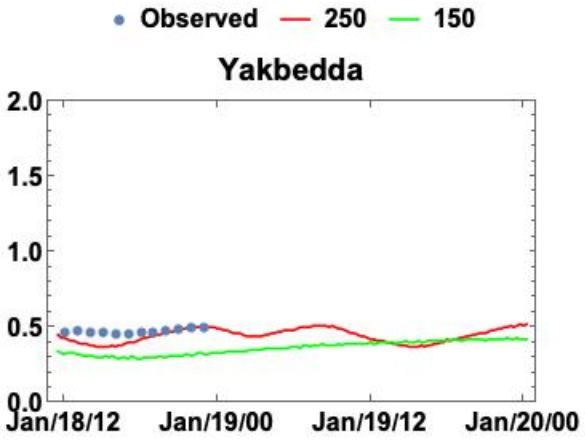
:

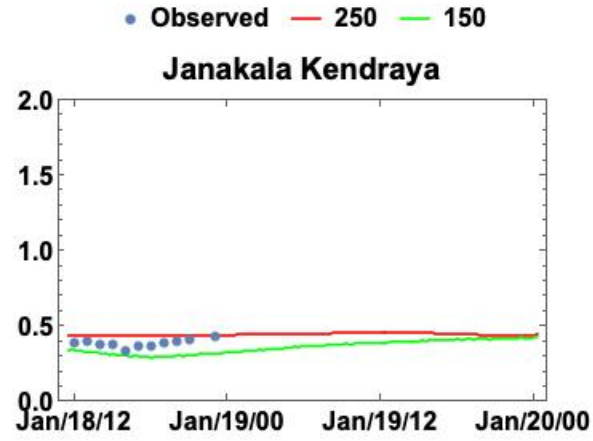
- 2mm and 3mm

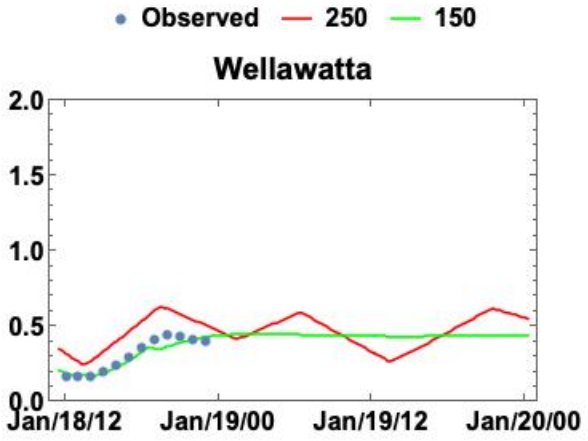
Canal Water Level Forecasts

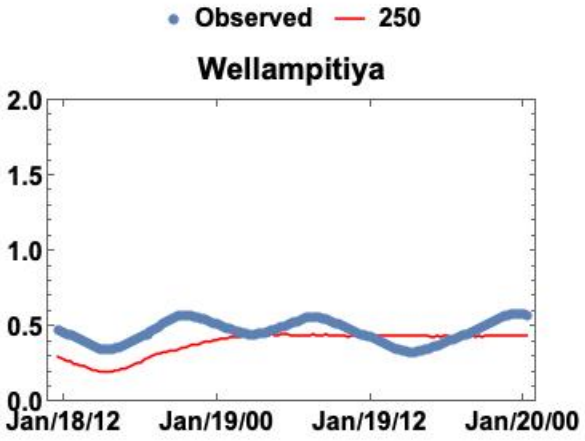






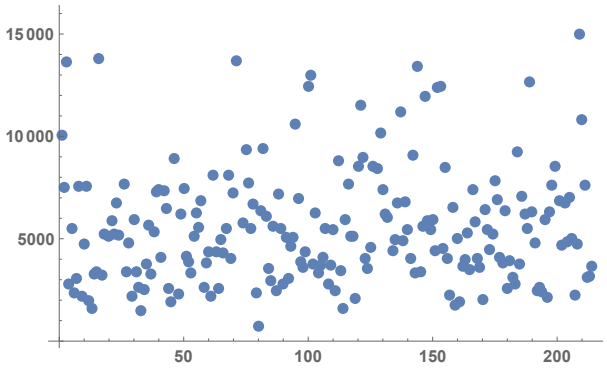




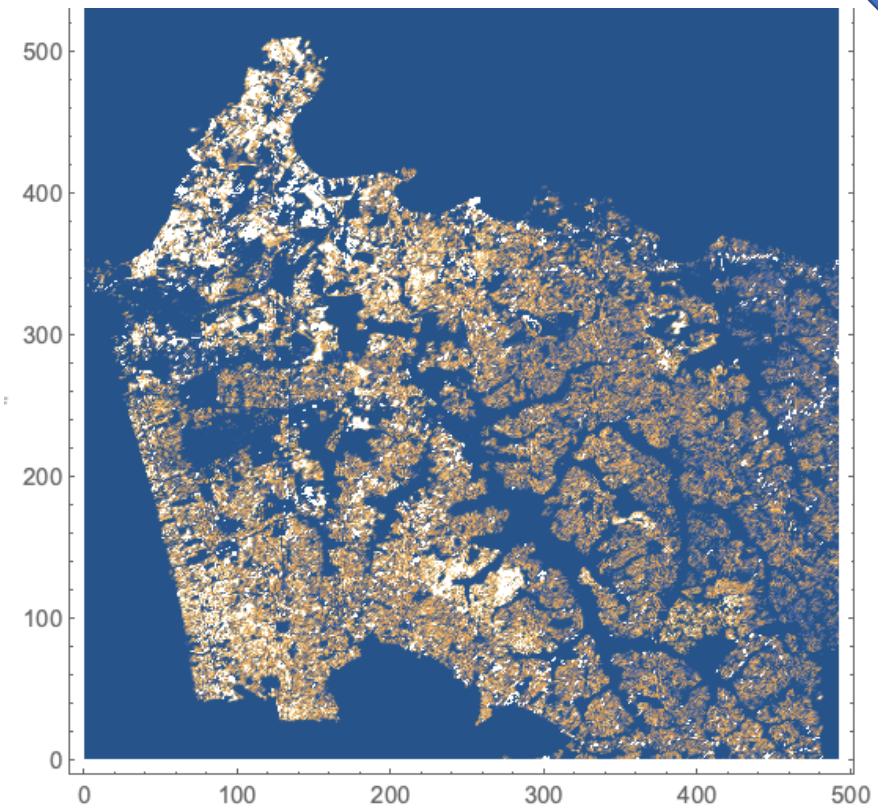


RISK BASED FLOOD MANAGEMENT

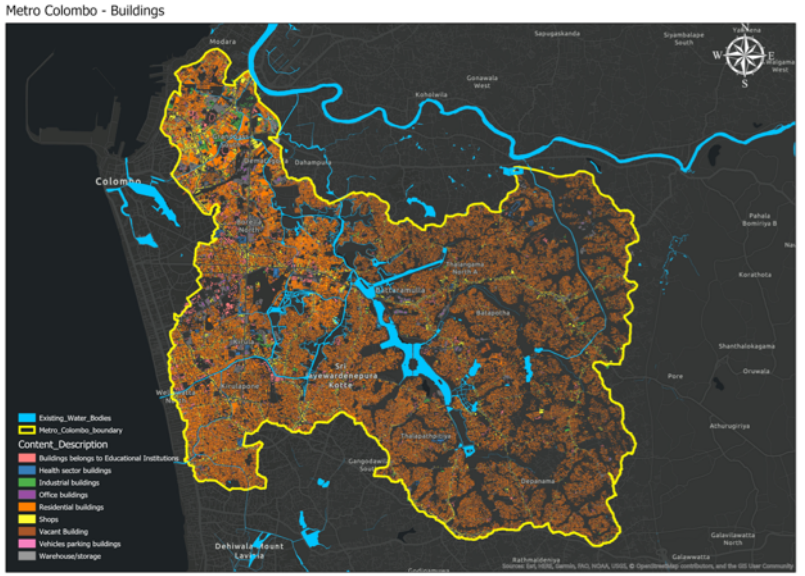
Population and Buildings



214 GN divisions, 1.3m population



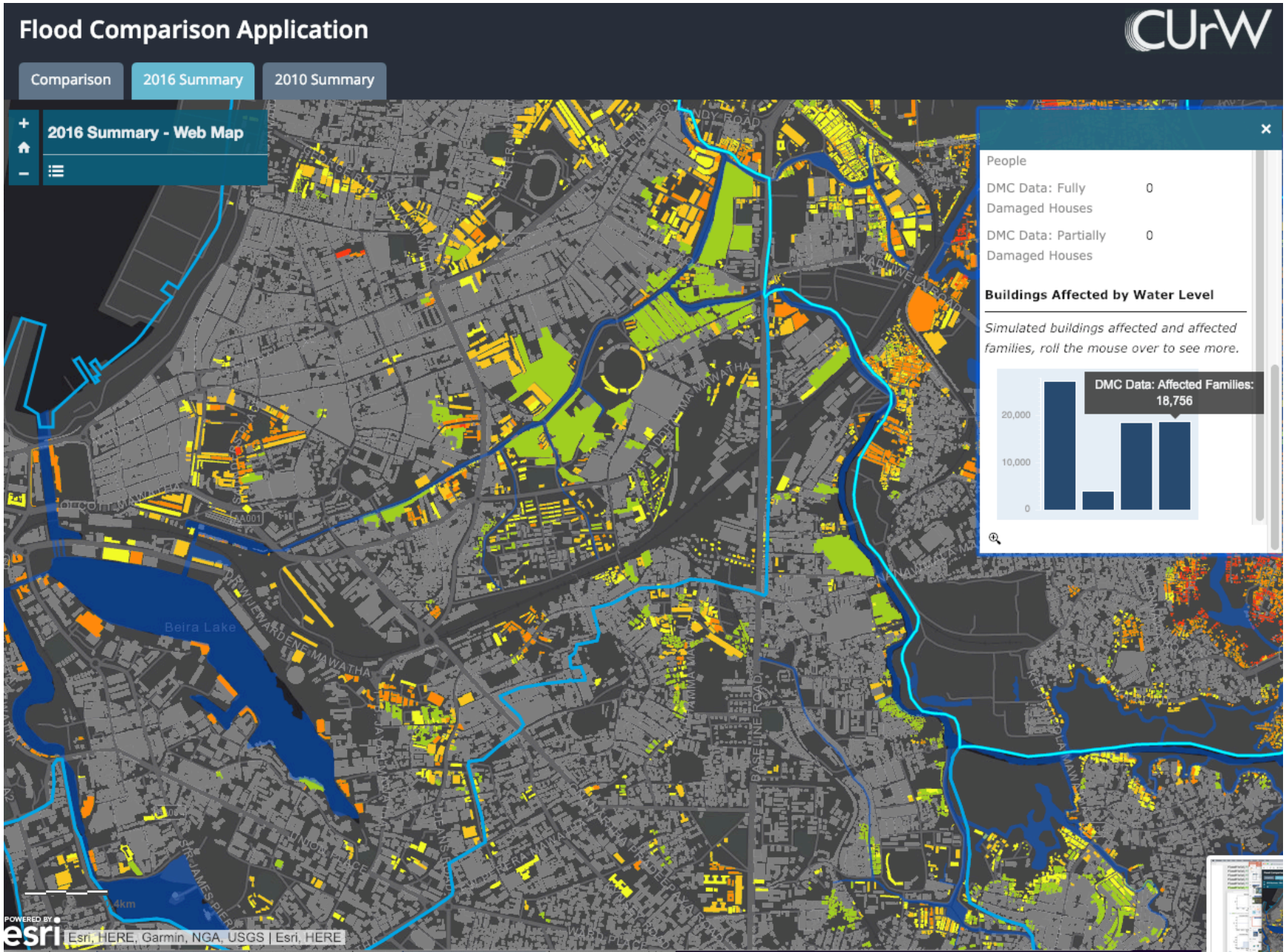
Population Density: Persons per 30m grid, distributed according to building type



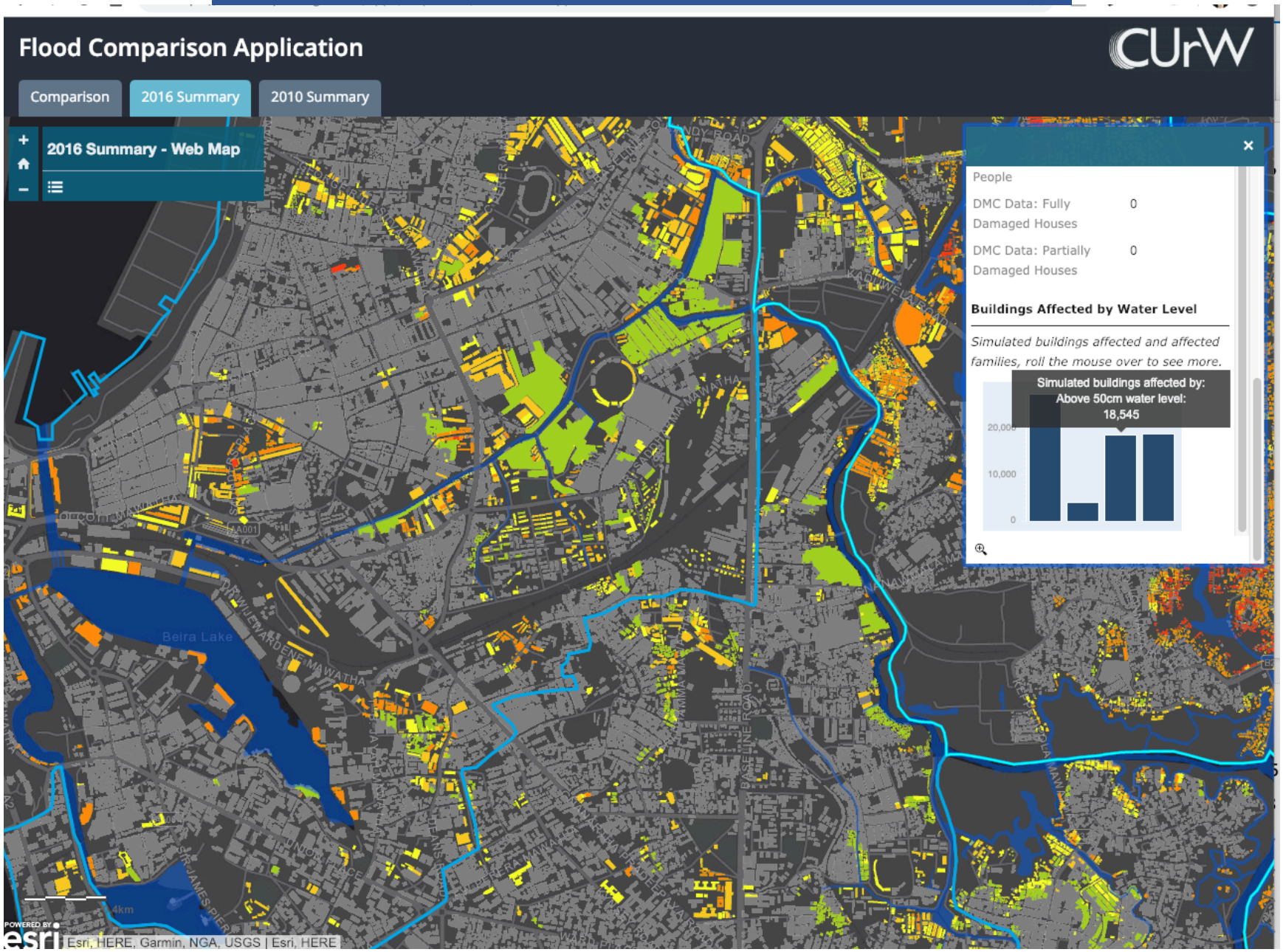
Ten types of building categories → 3 categories for commercial loss estimation

Four structural categories for damage estimation

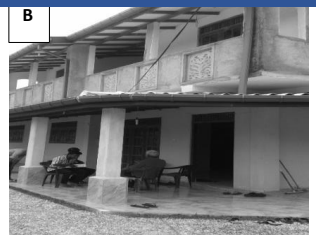
Impact Comparison

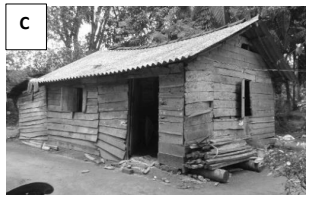


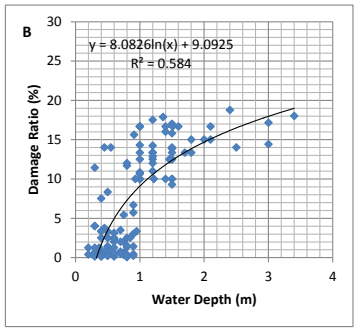
Impact Comparison

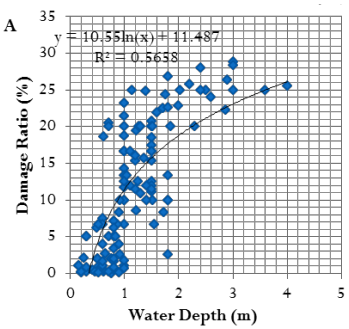


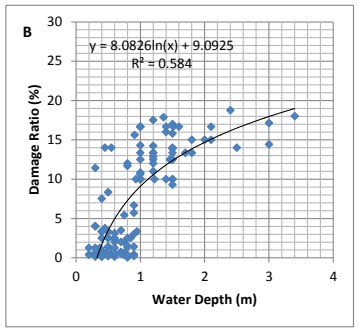
Risk Based Flood Management





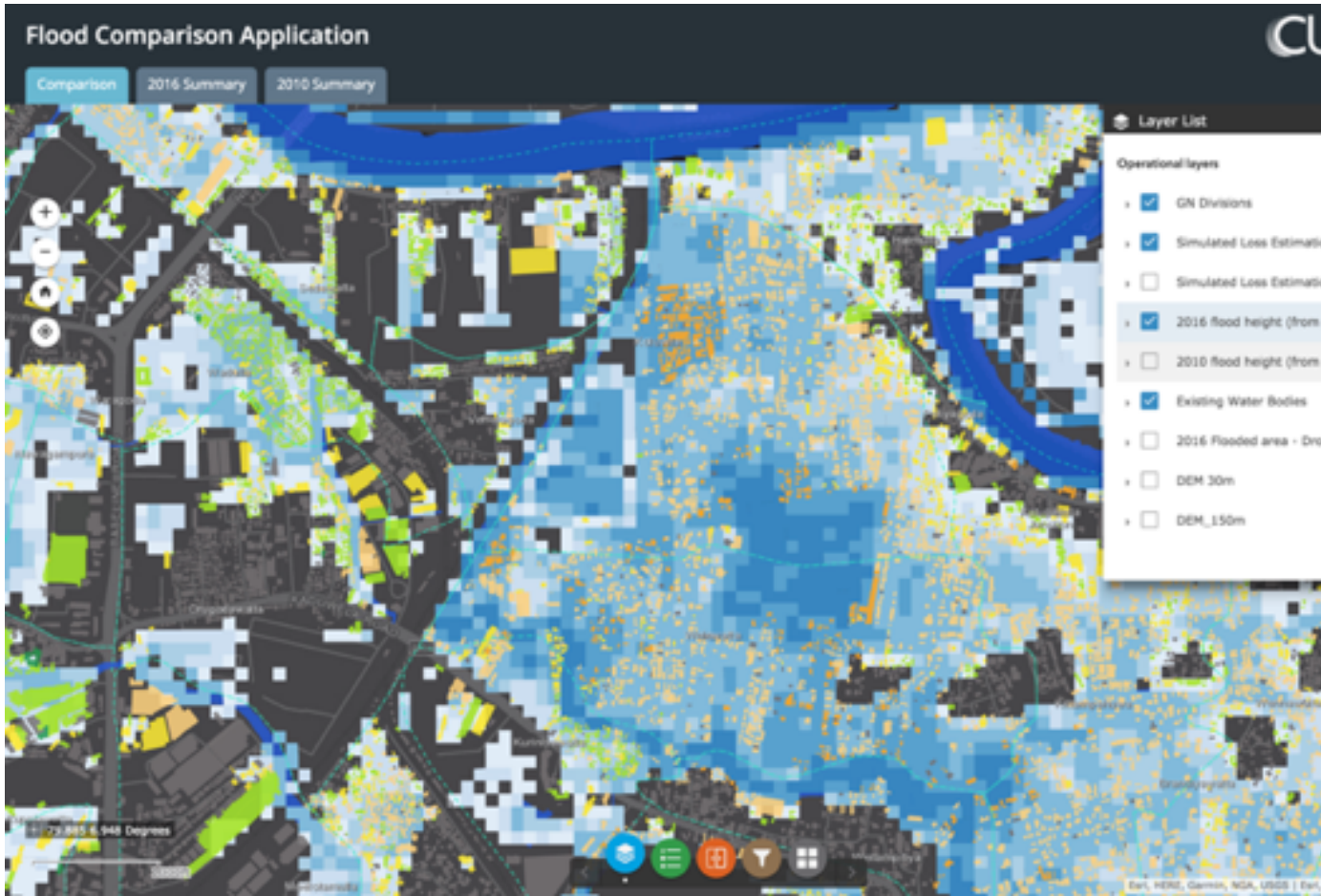






Present Status

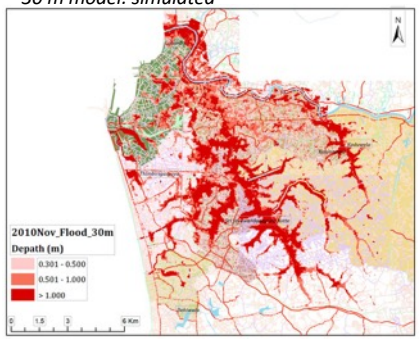
- All buildings are classified to 10 categories
- Damage functions developed for 4 building categories
- All building mapped to one of the 4 DF.
- Total potential damage from a future flood past flood can be estimated from DF + Inundation Simulation



Business/Industry Loss Estimation

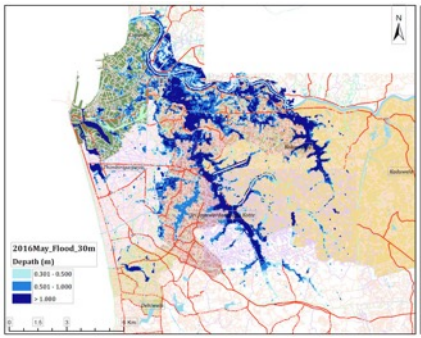
2010 November floods

30 m model: simulated



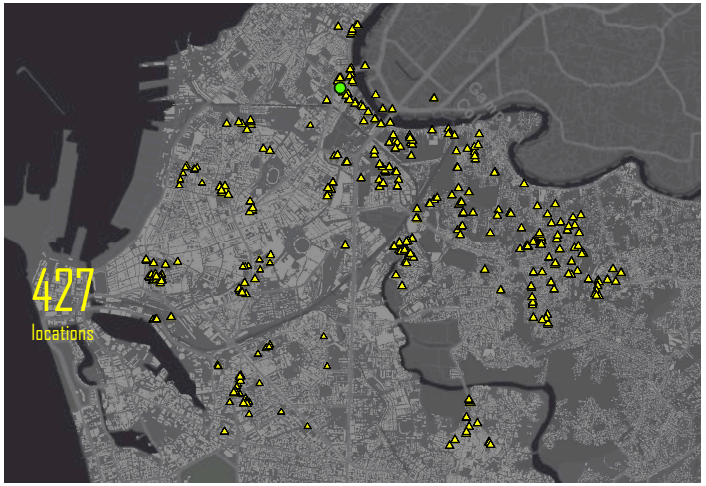
2016 May floods

30 m model: simulated



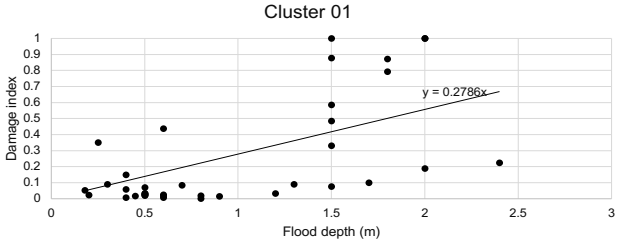
Flash floods (CMC)

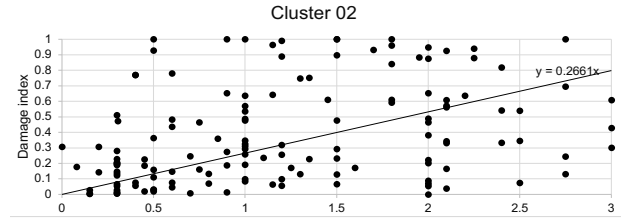
10 year return periods simulated

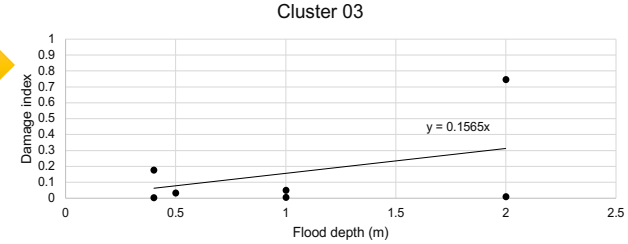


- **Collected attributes on affected buildings**
  - GPS coordinates (using the mobile phones)
  - Name of the institution
  - Address of the institution
  - Type of the industry
  - Name of the owner and contact details (tel/email)
  - Number of employees
  - Approximate floor area used by the institution ….

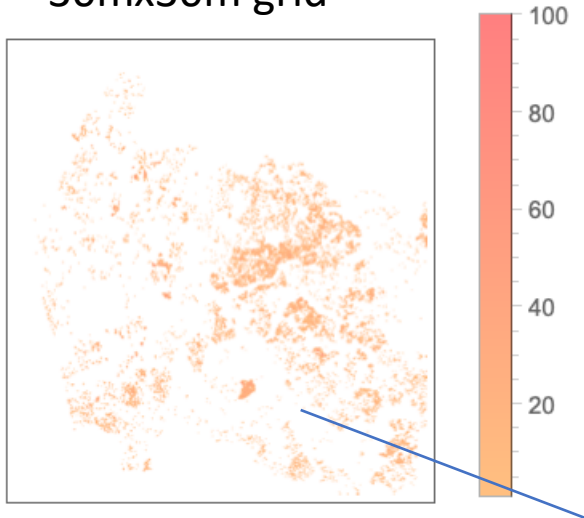
Cluster	Building category
01	Hardware
	Mechanical
	Textile
02	Garages
	SpareParts and Service
	ComResGrocery
	Communnication
	Grocery
	Medicine
	Restaurent
	Misc
03	Offices



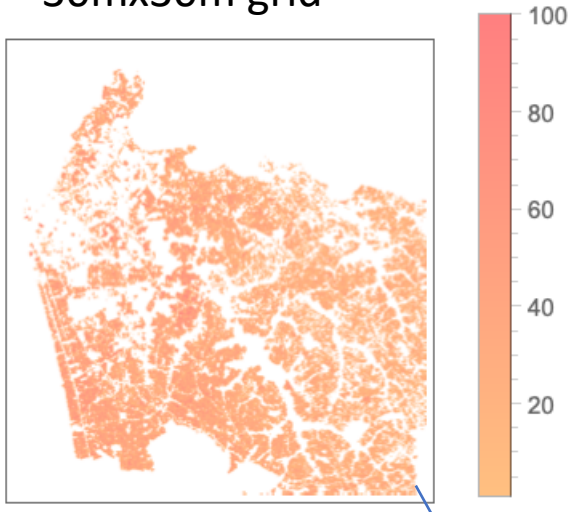




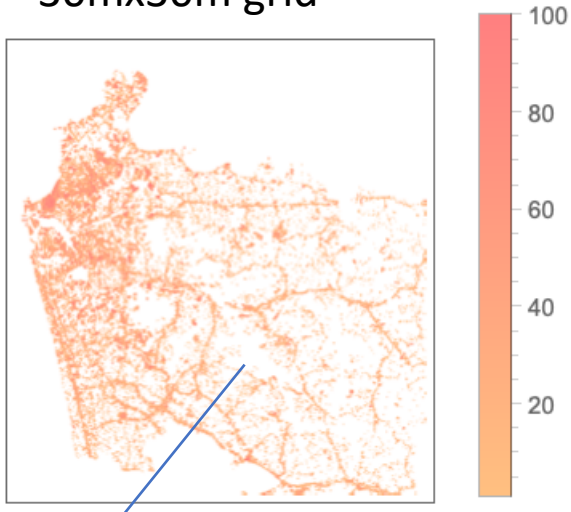
30mx30m grid

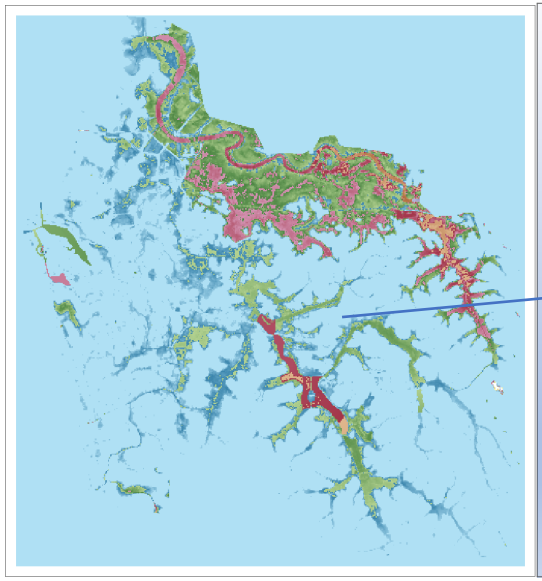


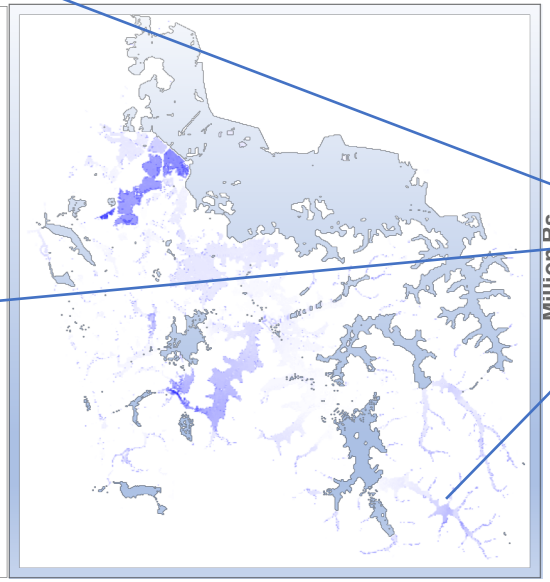
30mx30m grid

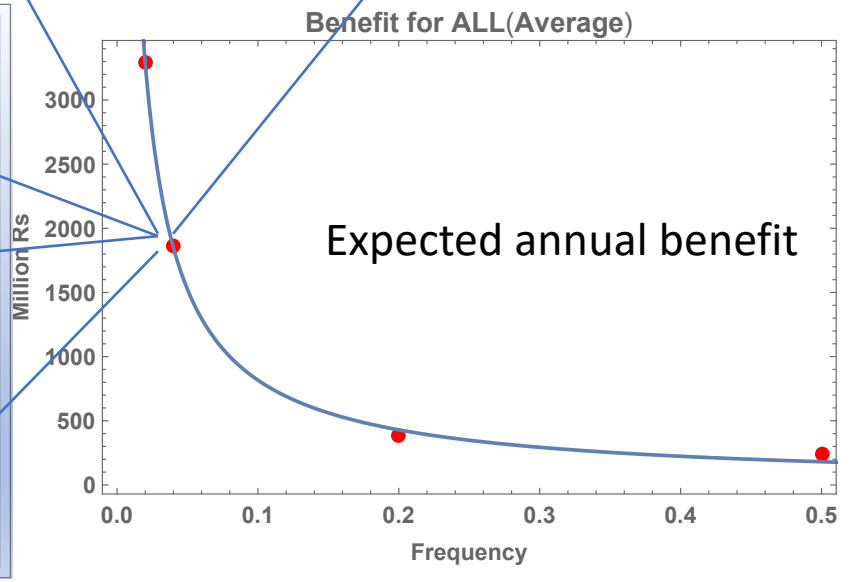


30mx30m grid









1:50 yr return flood

1:50 yr return flood reduction

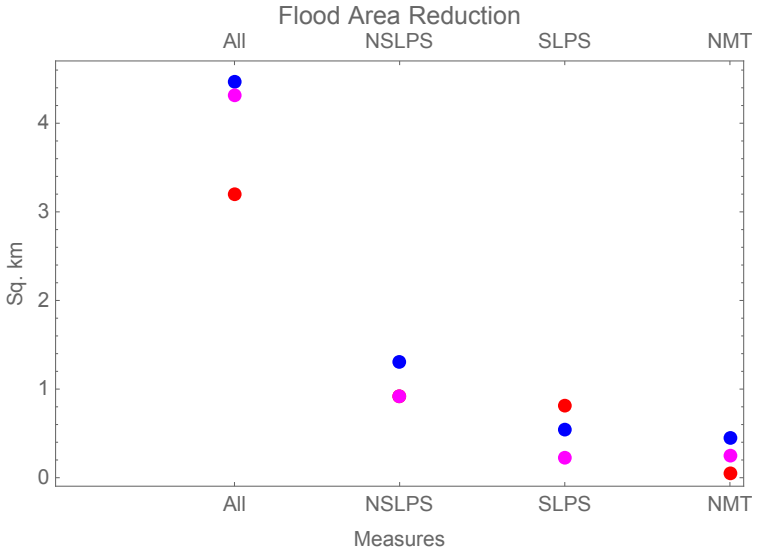
High Kelani Scenario

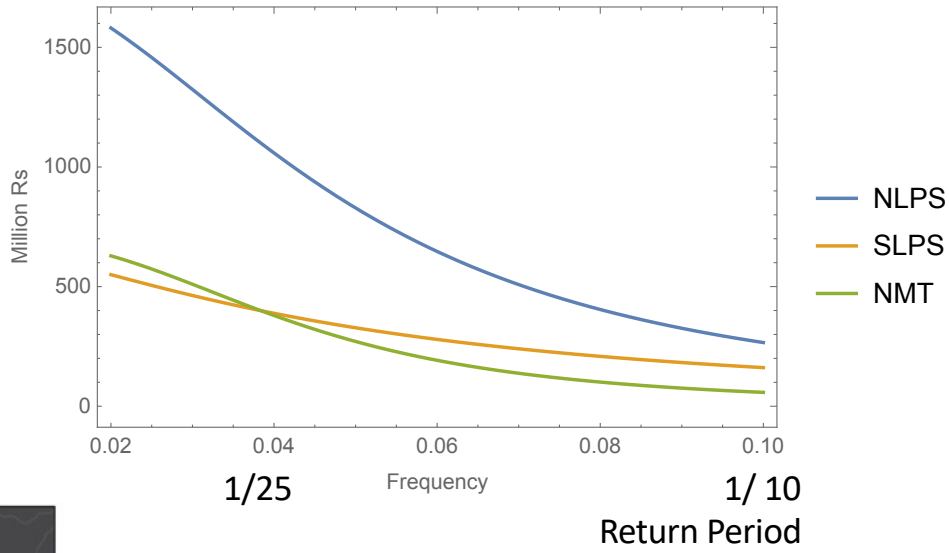
Measure	Capital Cost (m)	Annual Benefit	Recovery Period
All	22 500	2720	8
SLPS	1200	168	7

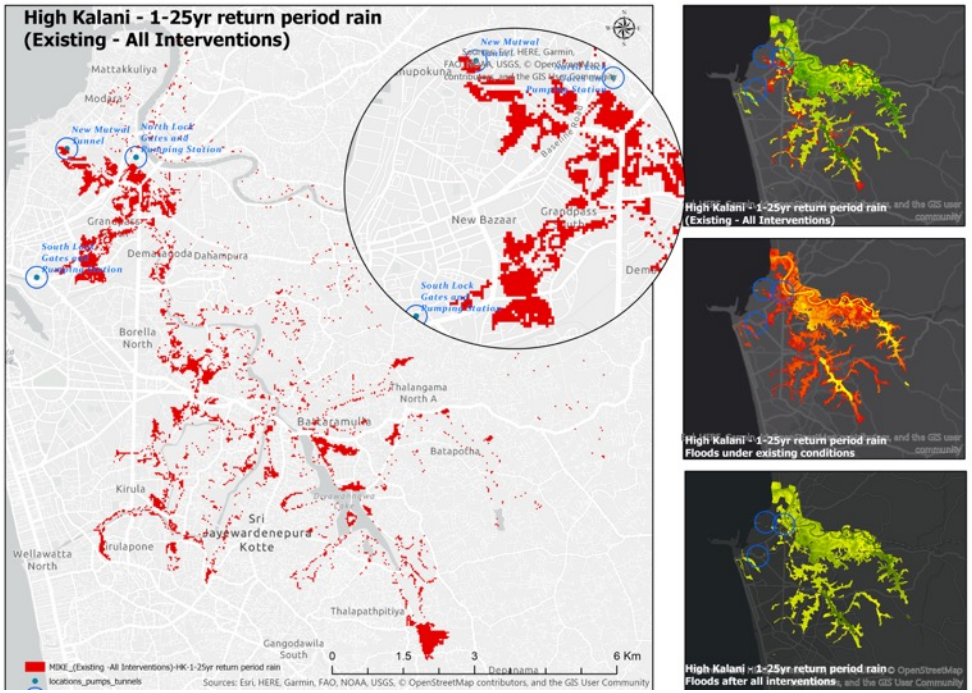
Aveage Scenario

Measure	Capital Cost (m)	Annual Benefit	Recovery Period
All	22 500	1460	15
SLPS	1200	116	10

Effectiveness of measures for flood damage reduction

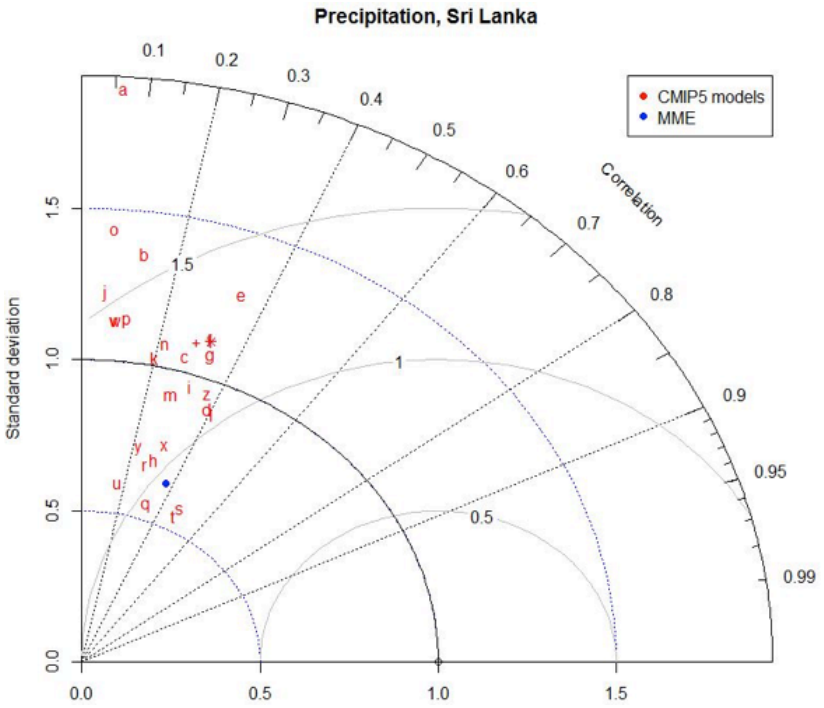


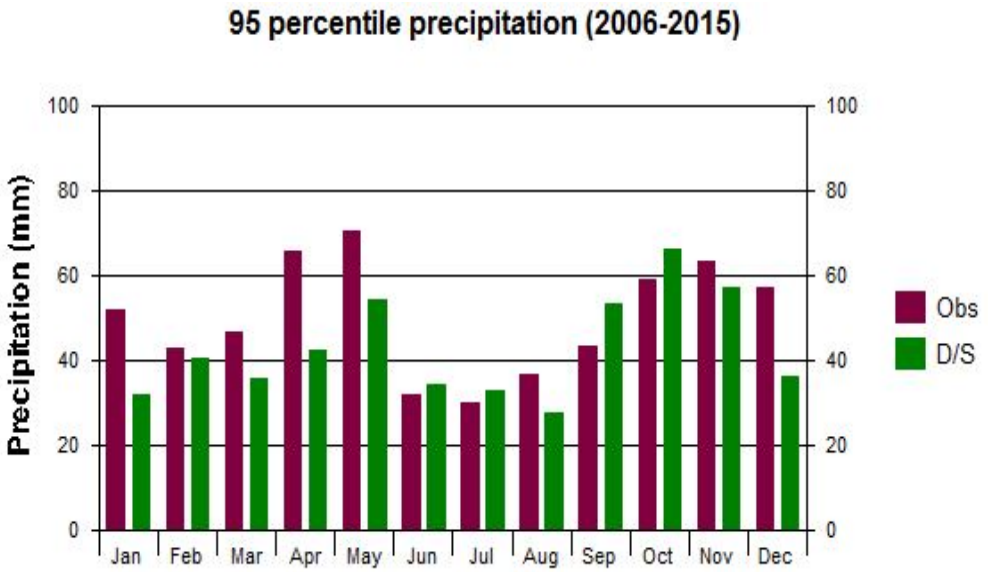


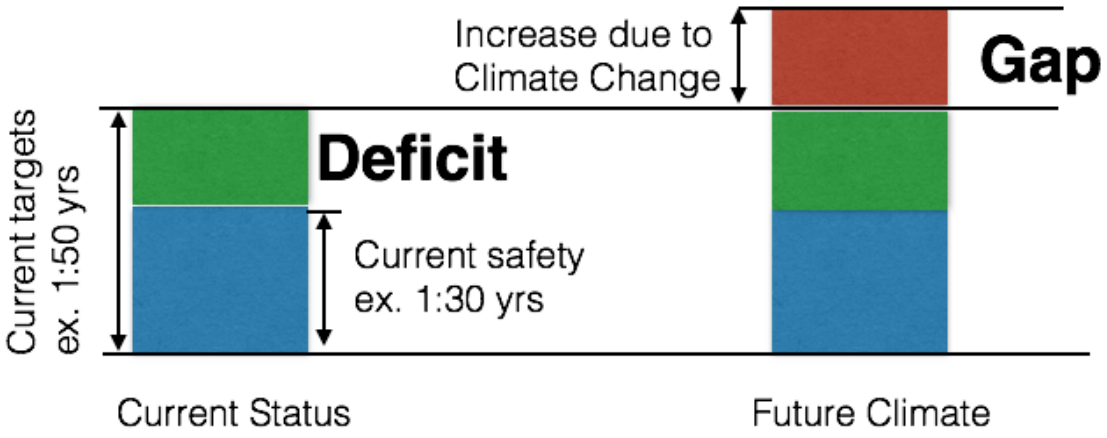


- Project objectives of reducing flood area can be achieved
- Pump characteristics in loss reduction can be used in pumping strategy development
- Real time impact assessment is coupled to pump operation selection

Climate Change



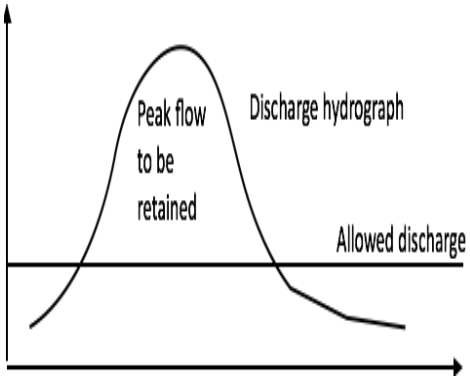


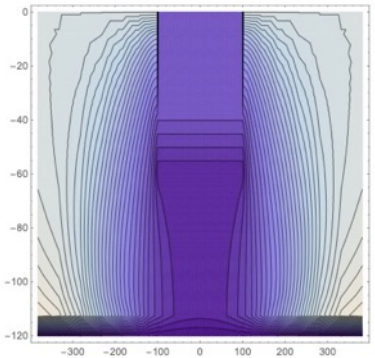


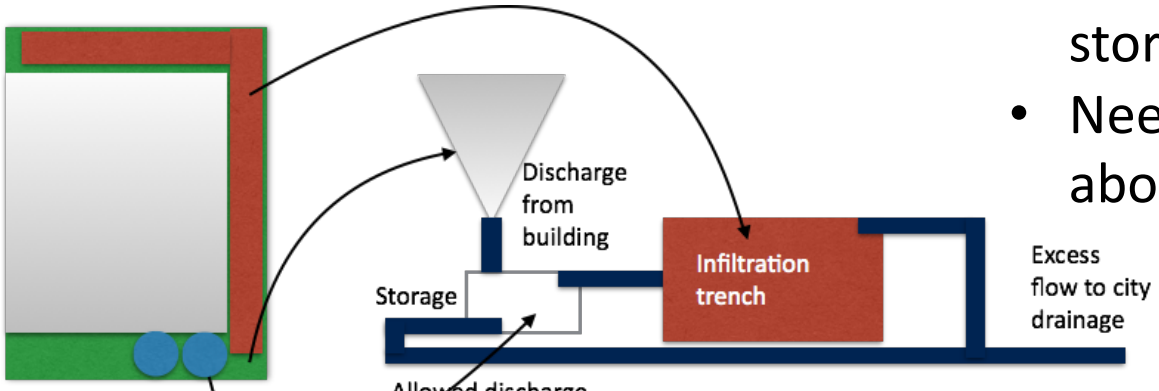
Mean (10%-23%), Maximum(2%-24%), peaks over the threshold of 50mm daily precipitation (30%-90%), 95 percentile precipitation (8%-21%) For Colombo RCP4.5 and RCP8.5 for the 2075 to 2100 period relative to 1981 to 2005

USING WETLANDS FOR STORAGE MANAGEMENT

Urban Storm water retention and Infiltration







- Large residential complex developers need to manage storm water onsite
- Predevelopment drainage allowed
- 1:5 Year return period rainfall runoff to be managed.
- CUrW requested to provide designs by CMC.
- High ground water reduces infiltration capacity and storage potential.
- Need to use also storage above ground.

Capacity Development and Sustainability

Current Members

Ovindhee Dayaratne
Project Administration
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B.Sc. Eng (Hons), Software Engineer
Computer Science & Engineering

Inoka Wijekoon
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B.A.
GIS & Remote Sensing

Raveena Hewajulige
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Applied Sciences

Sachithra Weerapperuma
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Facilities Management

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Chinthana Rajapaksha
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Civil

Muditha Dantanarayana
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Civil

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Piyumi Weerasinghe
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Chameera Randil
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B.Sc. Eng (Hons), AMIE(SL), Civil Engineer
Civil

Pavithra Weerasekara
SHER Modelling *(Visiting Researcher)*
M.Sc. in Water Engineering and Management
B.Sc. Eng (Hons), Civil Engineer
Civil

MBA MSc PhD

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Computer Science & Engineering

Niranda Perera
Scientific Workflow Management
B.Sc. Eng (Hons), AMIE(SL), Software Engineer
Computer Science & Engineering

Thilina Madumal
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Tharuka Dissanayake
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Civil

Sudam Samarasinghe
Monitoring & Program coordination
B.Sc. Eng (Hons), AMIE(SL), Civil Engineer
Civil

JOIN US

CUrW has opportunities for enterprising young engineers and scientists interested in high performance computing, data integration, IoT development and information management. On the job M.Eng and M.Sc. opportunities are available for qualified candidates.

We are also looking for partners to join us in environmental monitoring and education.

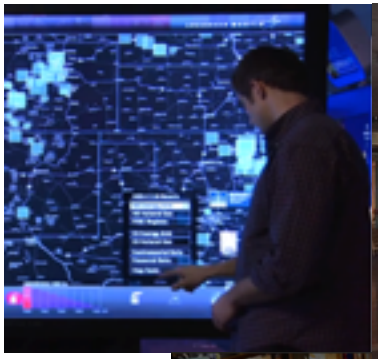
CUrW

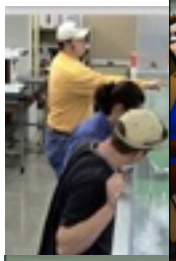
METRO COLOMBO URBAN DEVELOPMENT PROJECT

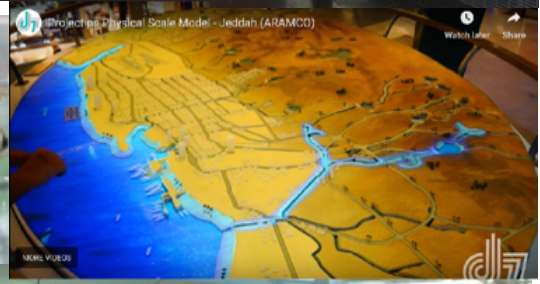
Agreements with leading Engineering Universities make it possible for staff to complete a research M.Eng/M.Sc based on the work done at the center (half currently enrolled)

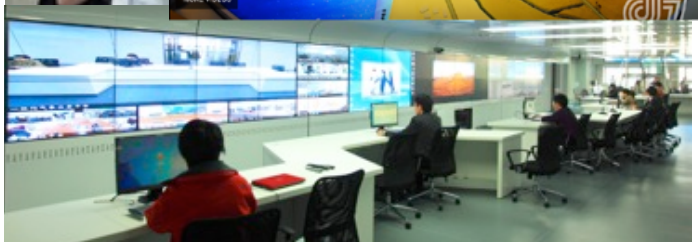
Last year 30 graduate students doing final year projects and internships (3-6 months)

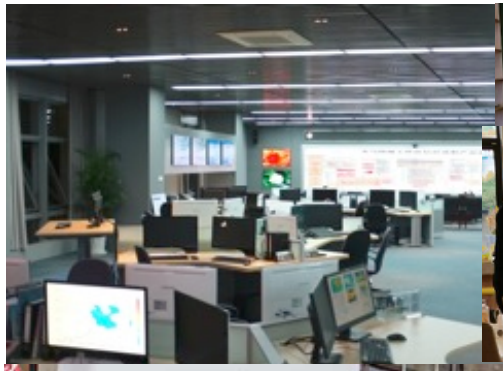
Contributions

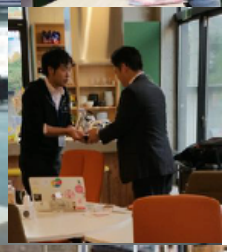


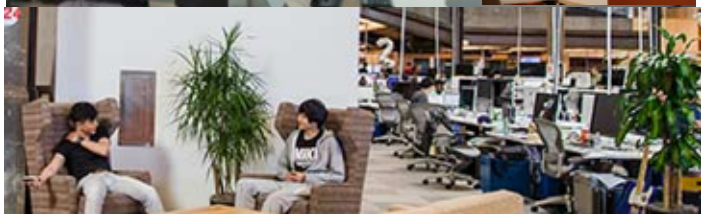












- 1st Floor & 2nd floor, Public outreach, education, equipment maintenance, information
- 3rd floor Information integration, forecasting and operation
- 4rth floor Environmental services/Innovation center
- 5th floor R&D:

CUrW aims to help the stakeholder agencies and local community in flood risk reduction with available investments using ICT. It aims to raise the levels of the research staff through applied research and international collaboration.

The Center building will contribute to develop an ecosystem to foster research, development and innovation among government, academia and private sector.

Thank you

https://www.curwsl.org

CUrW Academic Programs

Internships

1. Faculty of Engineering - University of Ruhuna

13 Undergraduate students (1st year) for 2 months (2019 02 18 - 2019 04 20) -- Completed.

- Flo-2D model setup for Flash flooding Locations
- Economic Exposure Field data collection

2. Earth Resource Management - University of Moratuwa

5 Undergraduate students (3rd year) for 6 months (2019 06 24 - 2019 12 24) -- Ongoing.

Project - GIS for Flood Safe and Livable City

- Hydrodynamic information and Monitoring Device maintenance
- City behavior on City Engine
- Disaster Response and Recovery Assistance

Comprehensive Design Project (CDP)

Faculty of Engineering - University of Ruhuna

Title : Development of a Master plan to convert 'Diyasaru Park' into Sustainable Wetland

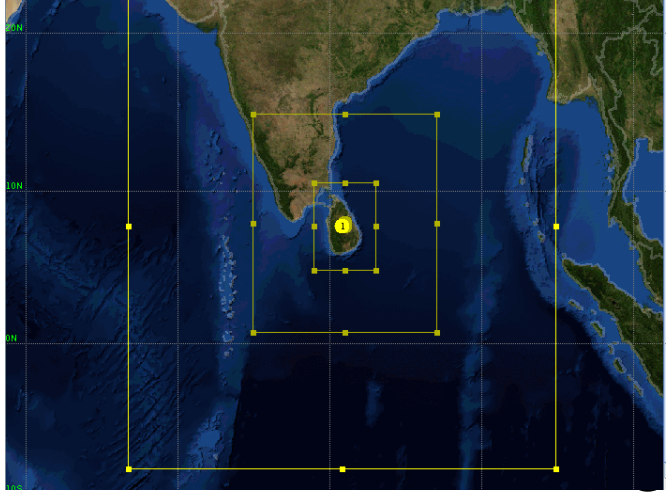
7 Undergraduate students (4th year) for 7 months (2019 06 01 - 2019 12 31) -- Ongoing.

Undegraduate Research Projects (URPs)

Faculty of Engineering - University of Ruhuna

6 Research areas collaborative with CUrW ongoing studies by Undergraduate students (4th year) for 8 months (2019 05 01 - 2019 12 31) -- Ongoing.

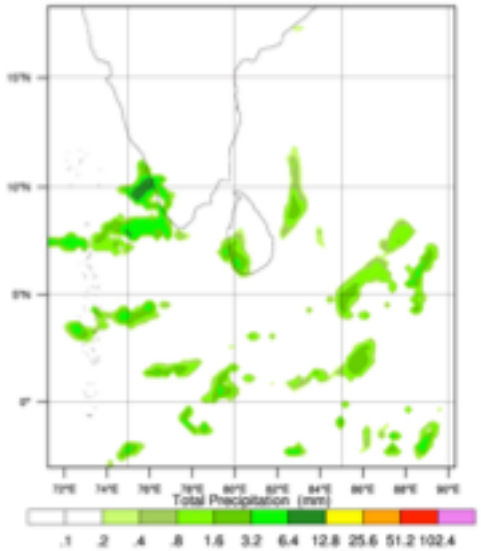
- ❑ Flood damage estimation model to evaluate economic and lifelines losses
- ❑ The impact of intense weather conditions on surface transport: A depth/Duration-disruption function
- ❑ Kelani river basin water resources analysis to optimize the hydropower reservoir operations
- ❑ Evaluation of Storm water drainage options with respect to national policy making; Case study for Galle Municipal area
- ❑ Study the management of Wetland water storage for flood mitigation; A case study at Diyasaru Uyana, Colombo
- ❑ Study on on-site water management in urban areas to mitigate flash floods

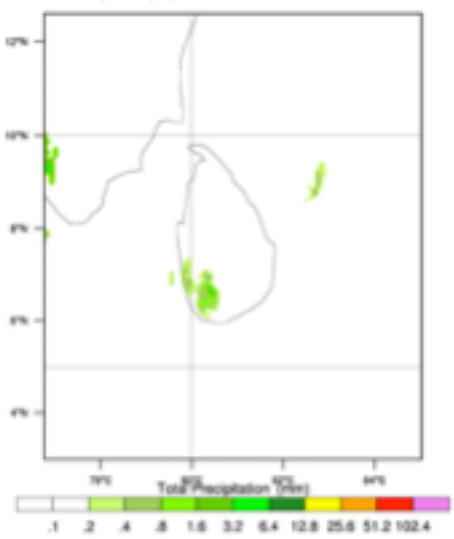


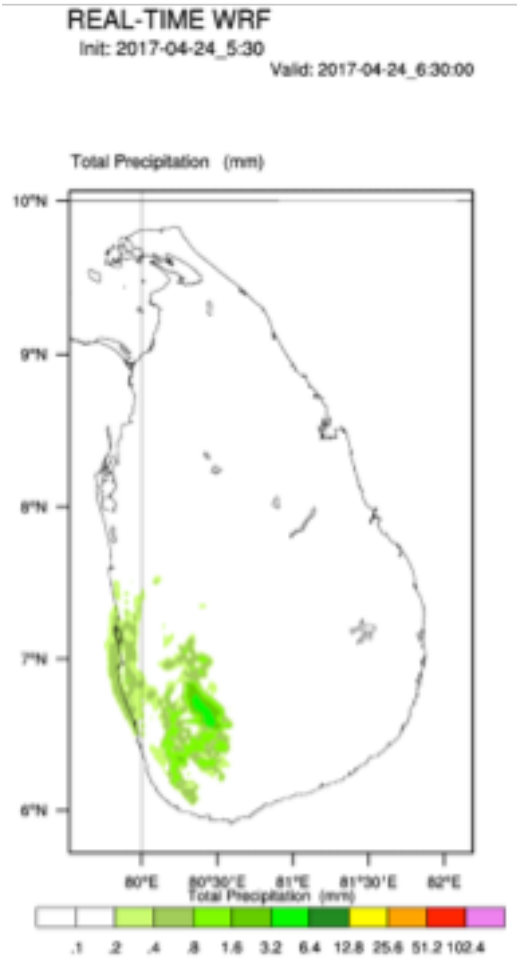
Rainfall Forecasting Domains

Numerical weather forecasting model, WRF (Weather Research and Forecasting) is used

Currently, the rainfall is forecasted for three cascading domains as shown below.

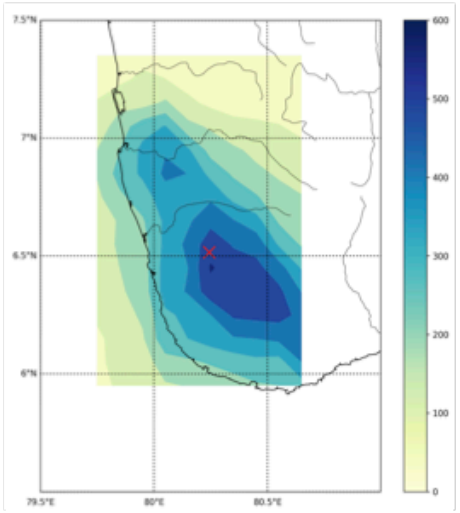




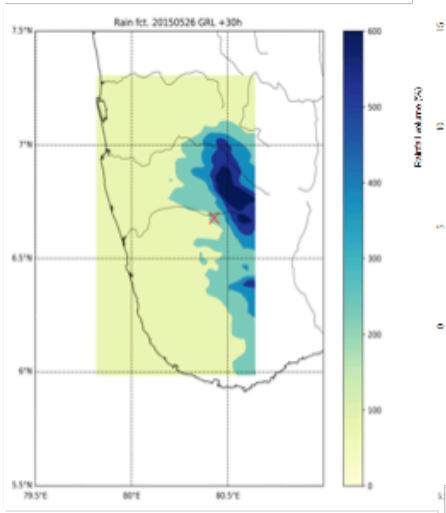


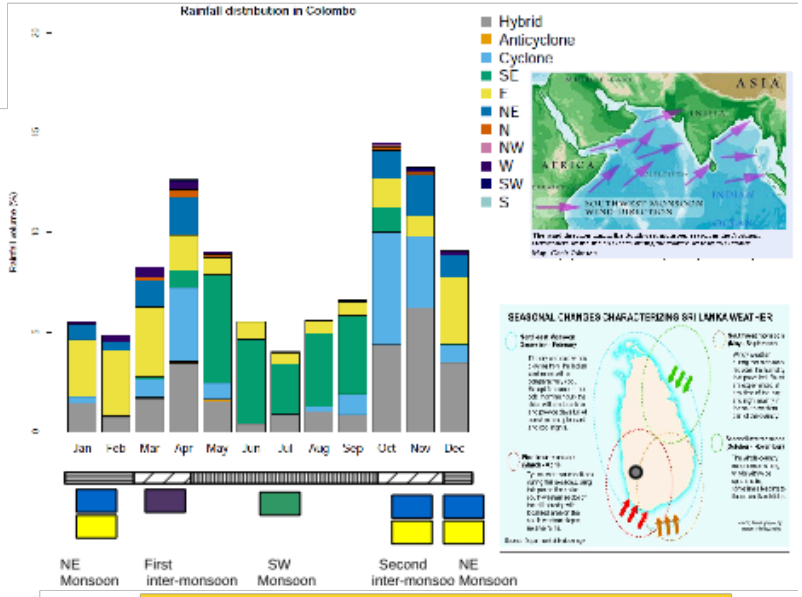
Comparison of different WRF outputs

GSMAP Obs

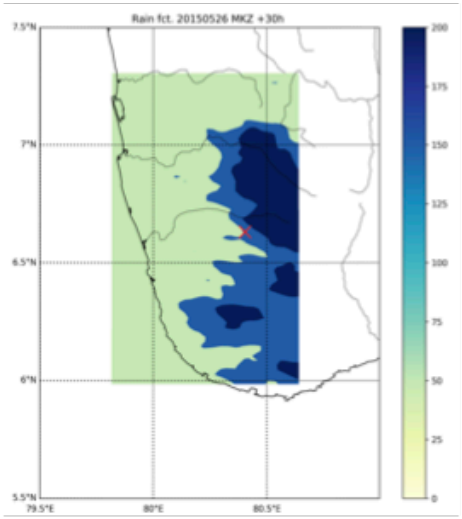


GRL





MKZ



GRL3D