Decision Support System for Water Resources Planning for Mahaweli River Basins

NKM Nanseer

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Overview

- Introduction to Mahaweli System
- Major Components in Water Resources Planning
- Decision Support System – Why?
- Water Availability, Demand and Other Features in Mahaweli Basin
- Setting up and Simulating Model
- Multi Criteria Analysis and Prioritizing Projects
- Environmental Flow
- Climate Change

Introduction to Mahaweli Basins

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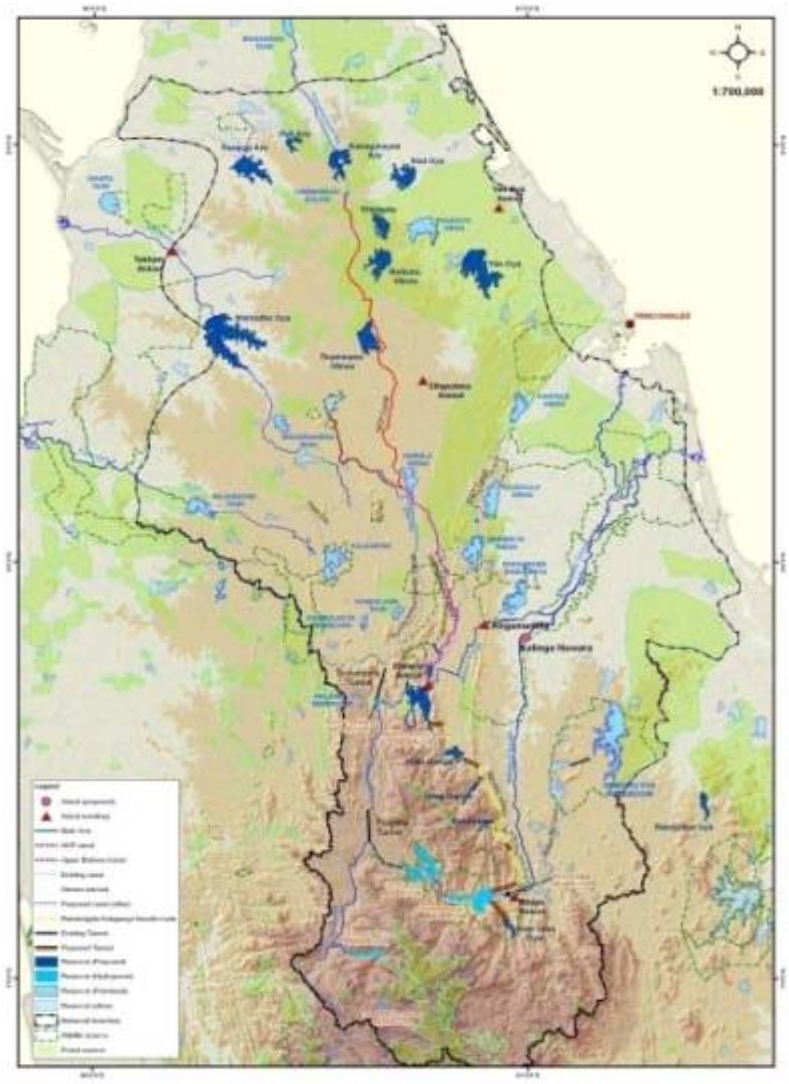
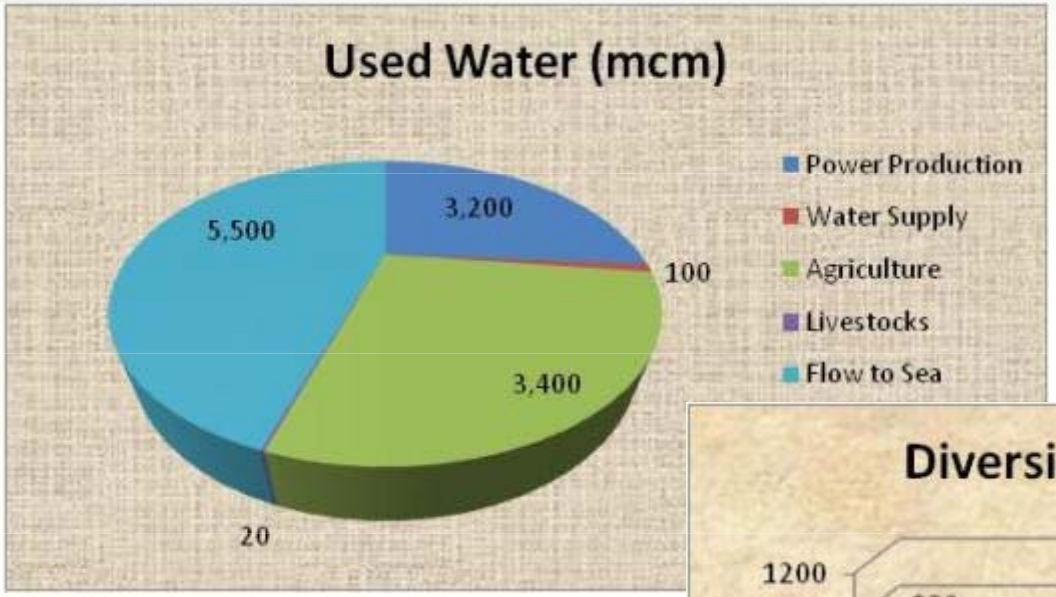
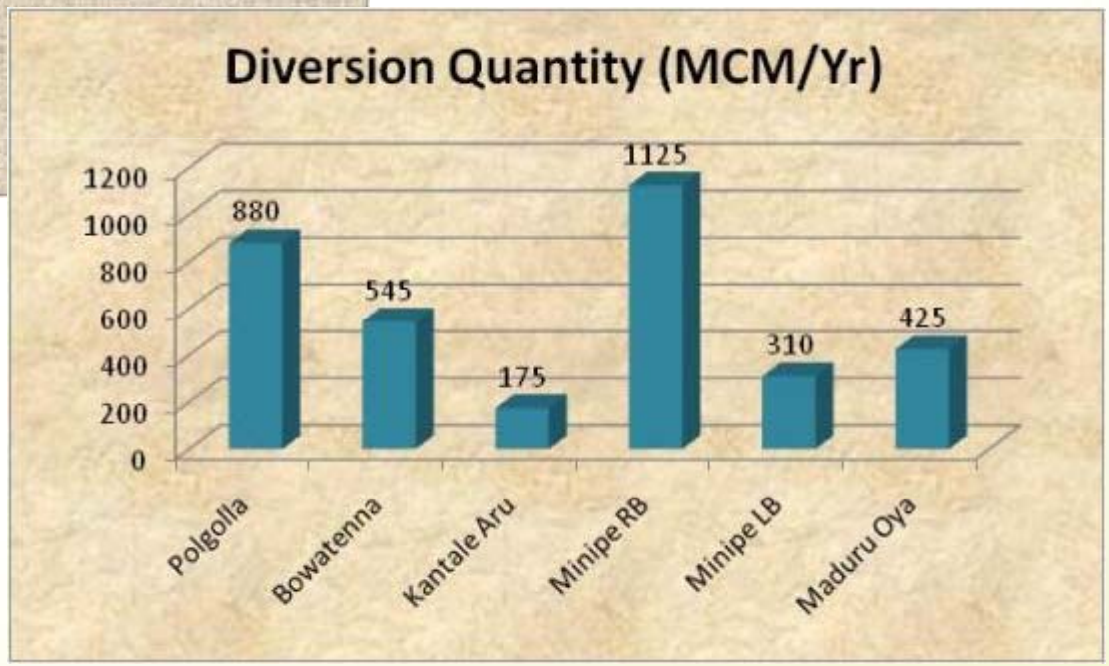
Introduction to Mahaweli System

- Largest river basin and longest river in Sri Lanka
- Water is used for
  - Irrigation
  - Hydro power
  - Water supply (domestic and industries)
  - Livestocks
  - Fisheries
- Many infrastructures
  - Reservoirs, Dams, Anicuts, Power Plants, Transbasin Canals
- Water is diverted to five adjoining river basins
  - Aruvi Aru, Kala Oya, Yan Oya, Kantale Aru, Maduru Oya



Introduction to Mahaweli System





Water Resources Planning

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Major Components in Water Resources Planning

Water Availability

- Surface Water
- Ground Water

Water Users and Their Demand

- Irrigation (major, medium and minor)
- Hydropower
- Water Supply
- Environment…….

Water Allocation for Optimum Usage

- It is not just maximum use of water or water resources
- Economical, social, environmental and political benefit should be considered

Decision Support System (DSS)

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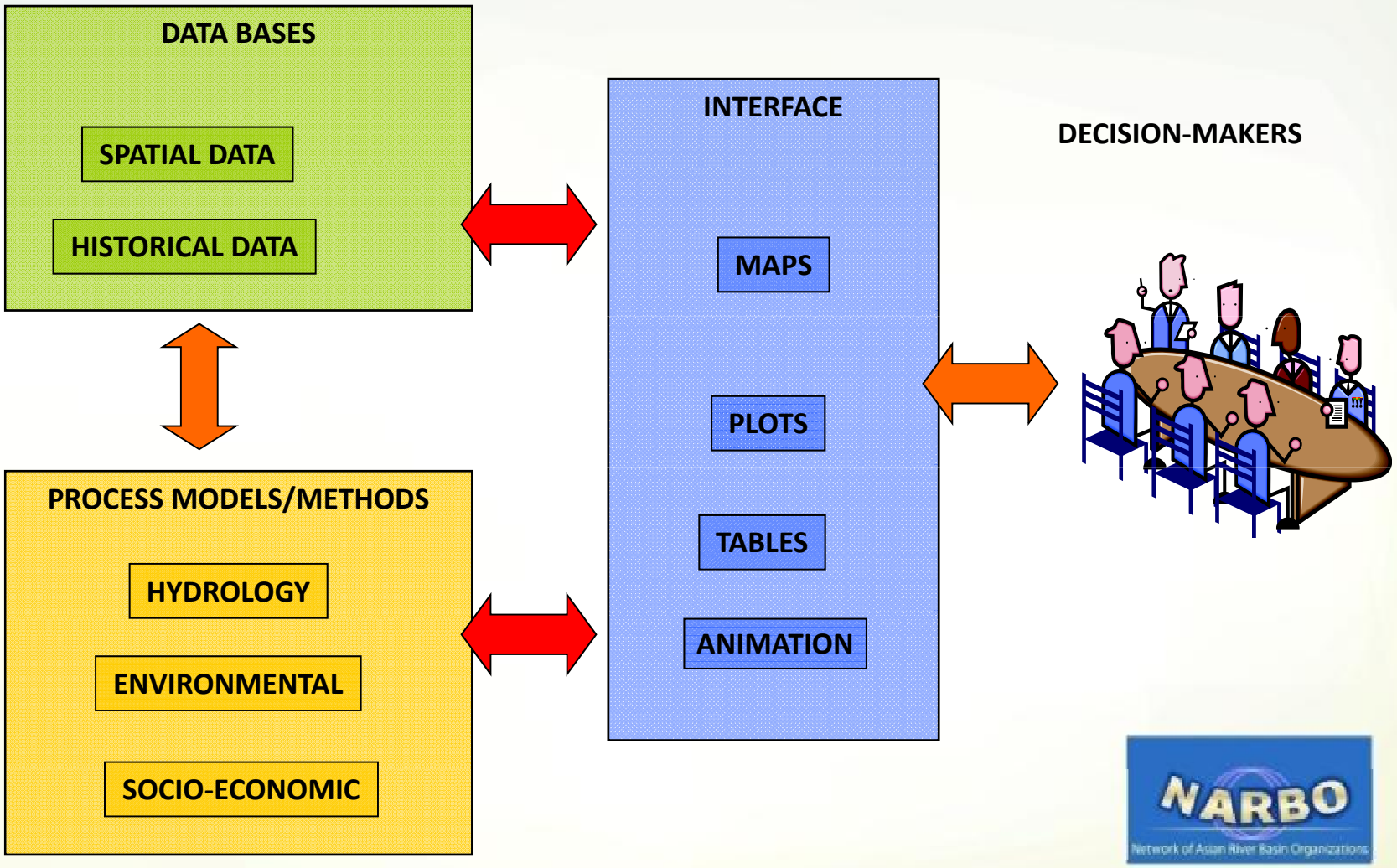
Decision Support System (DSS)

- Collection of information/indicators that assists to reach a decision for an organization or authority
- It is not decision making system
- Weighting factor may be assigned to each indicator to reach a better informed decision, depending on situation
  - Gross economic benefit
  - Sectoral growth or target (agriculture, power, industry, domestic etc.)
  - Social benefit
  - Environmental impact
  - Political need

Decision Support System (DSS)

- Steps in Decision Support System
  - Build databases
  - Identify problems, issues & options
  - Design system or establish models
  - Identify potential improvements
  - Develop & evaluate management scenarios
  - Present results to decision-makers

Decision Support System (DSS)



DSS – Basin Features

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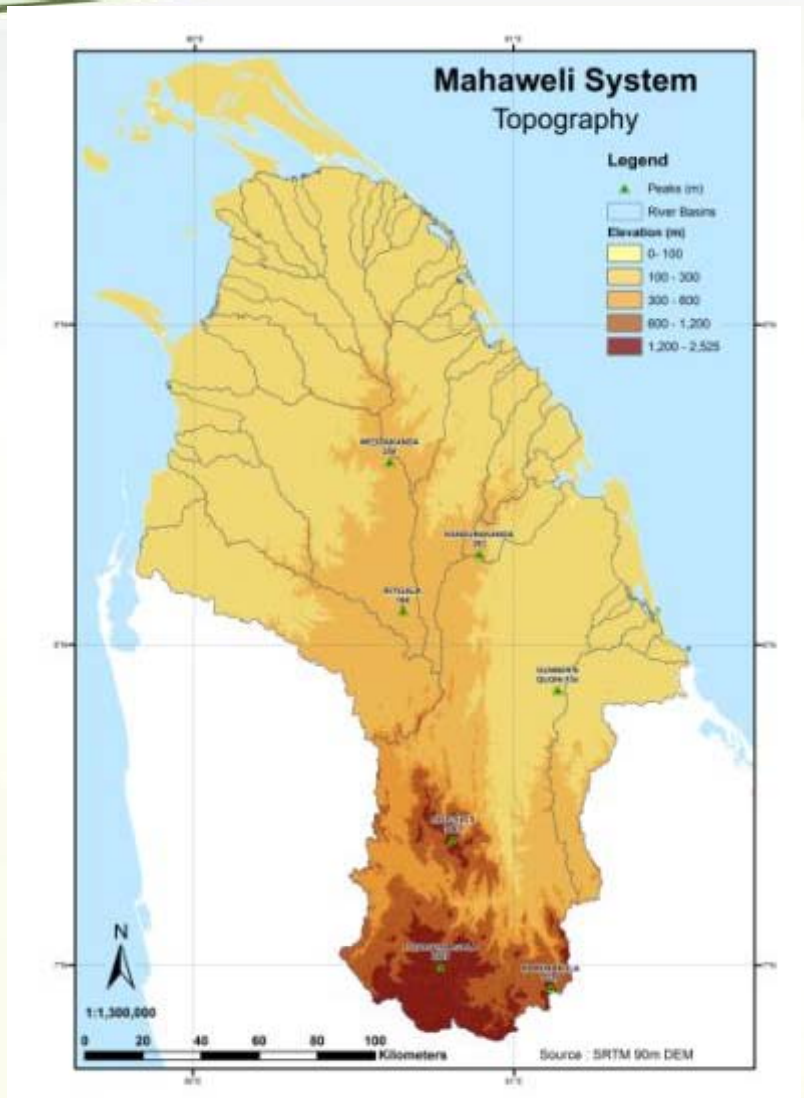
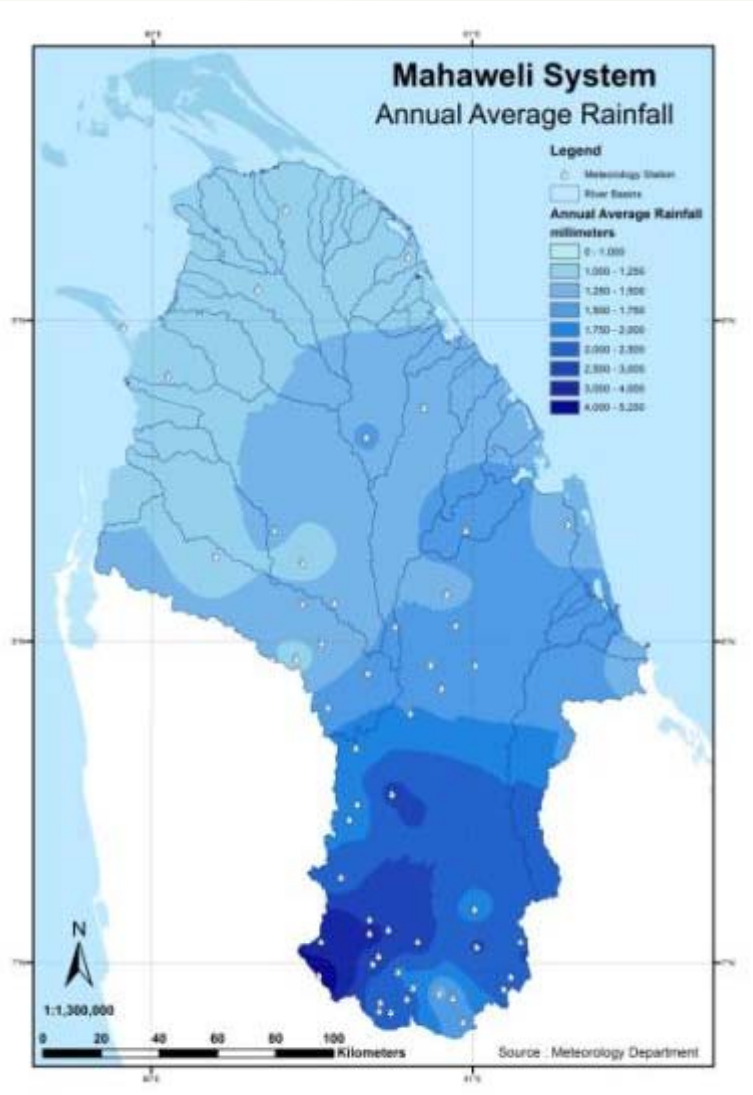
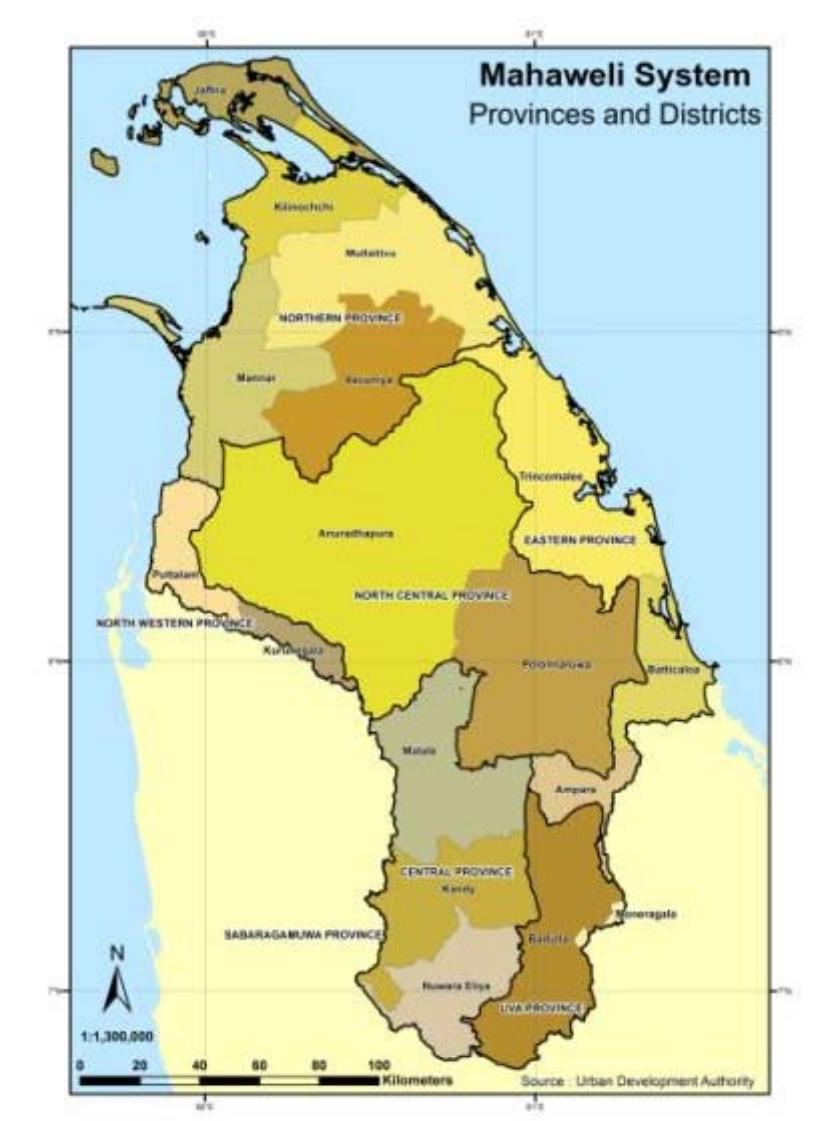
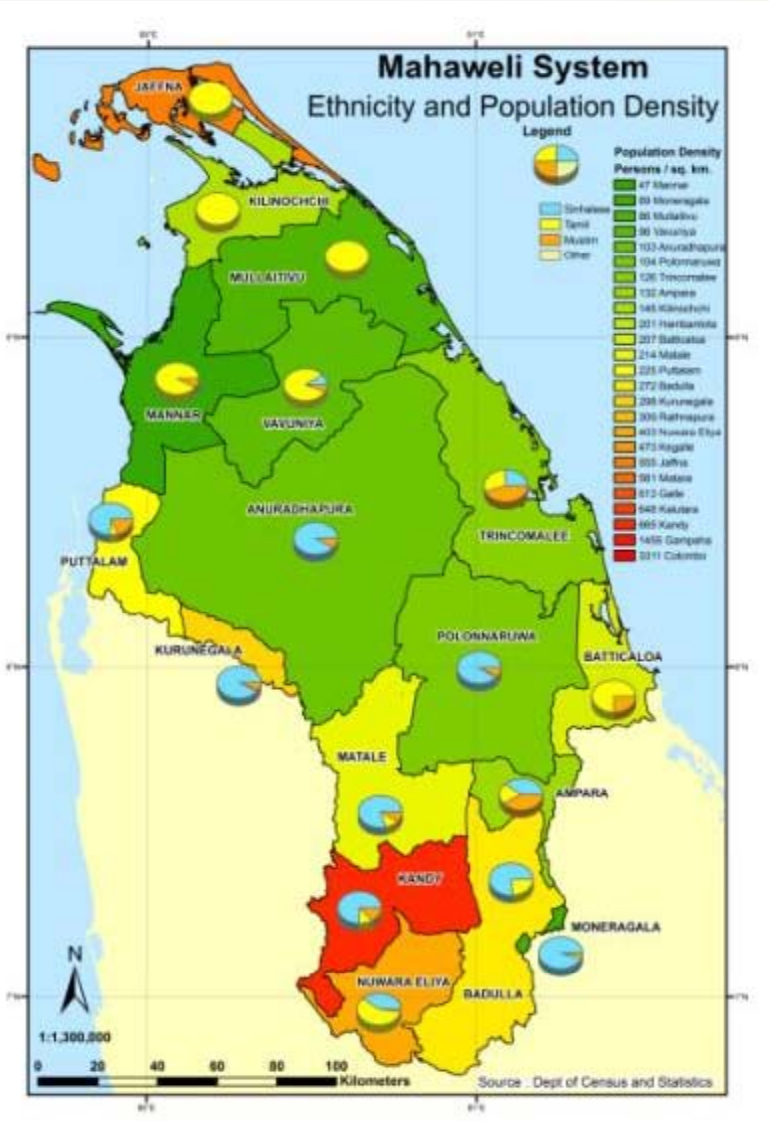
Features of Mahaweli Basin from Data Base



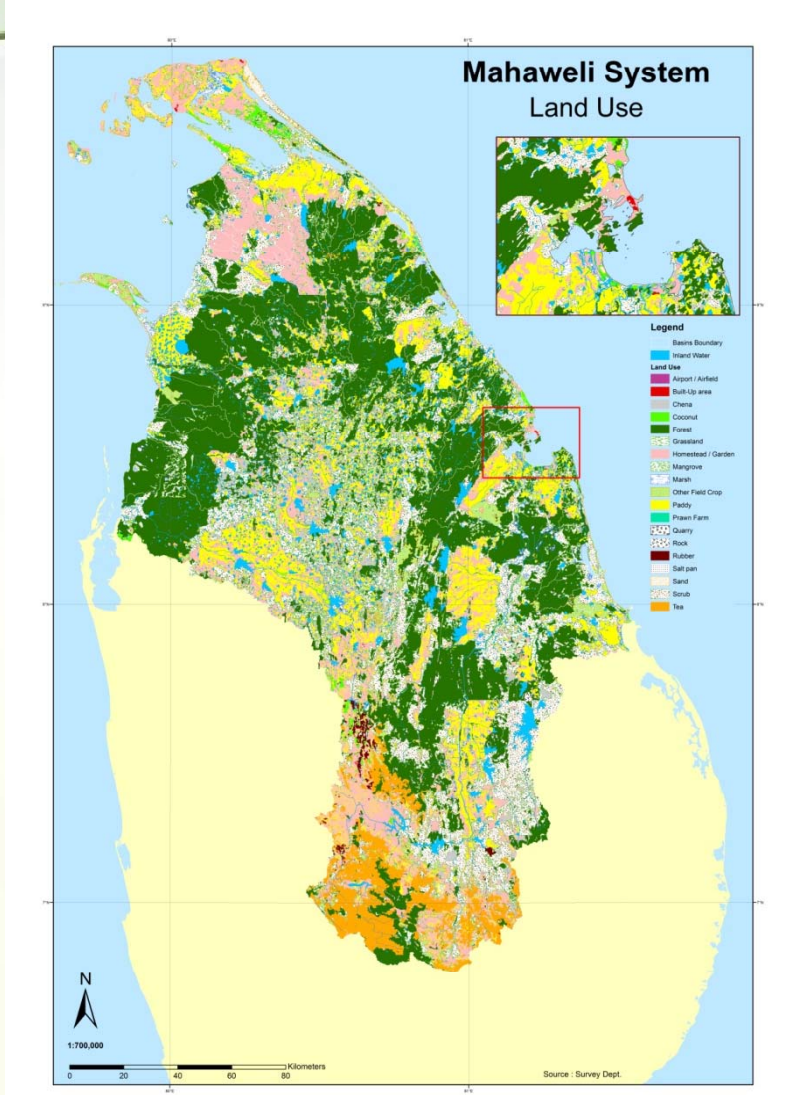


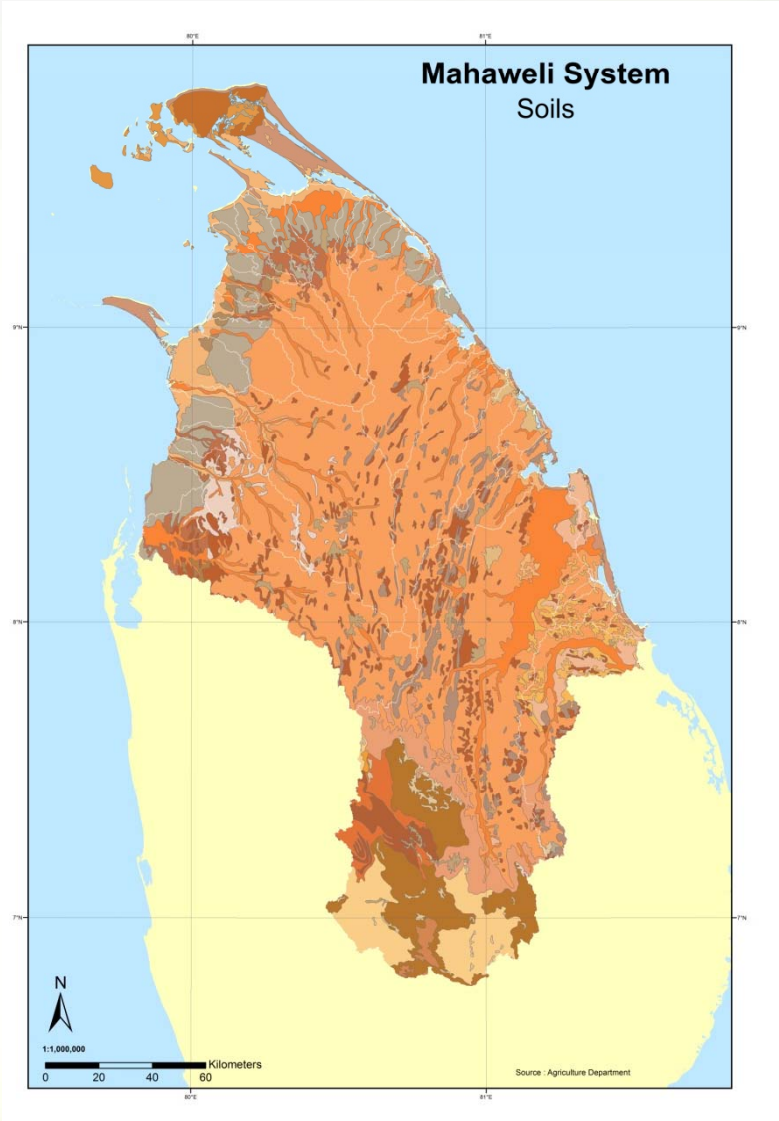
Features of Mahaweli Basin from Data Base





Features of Mahaweli Basin from Data Base





DSS - Identification of Problems

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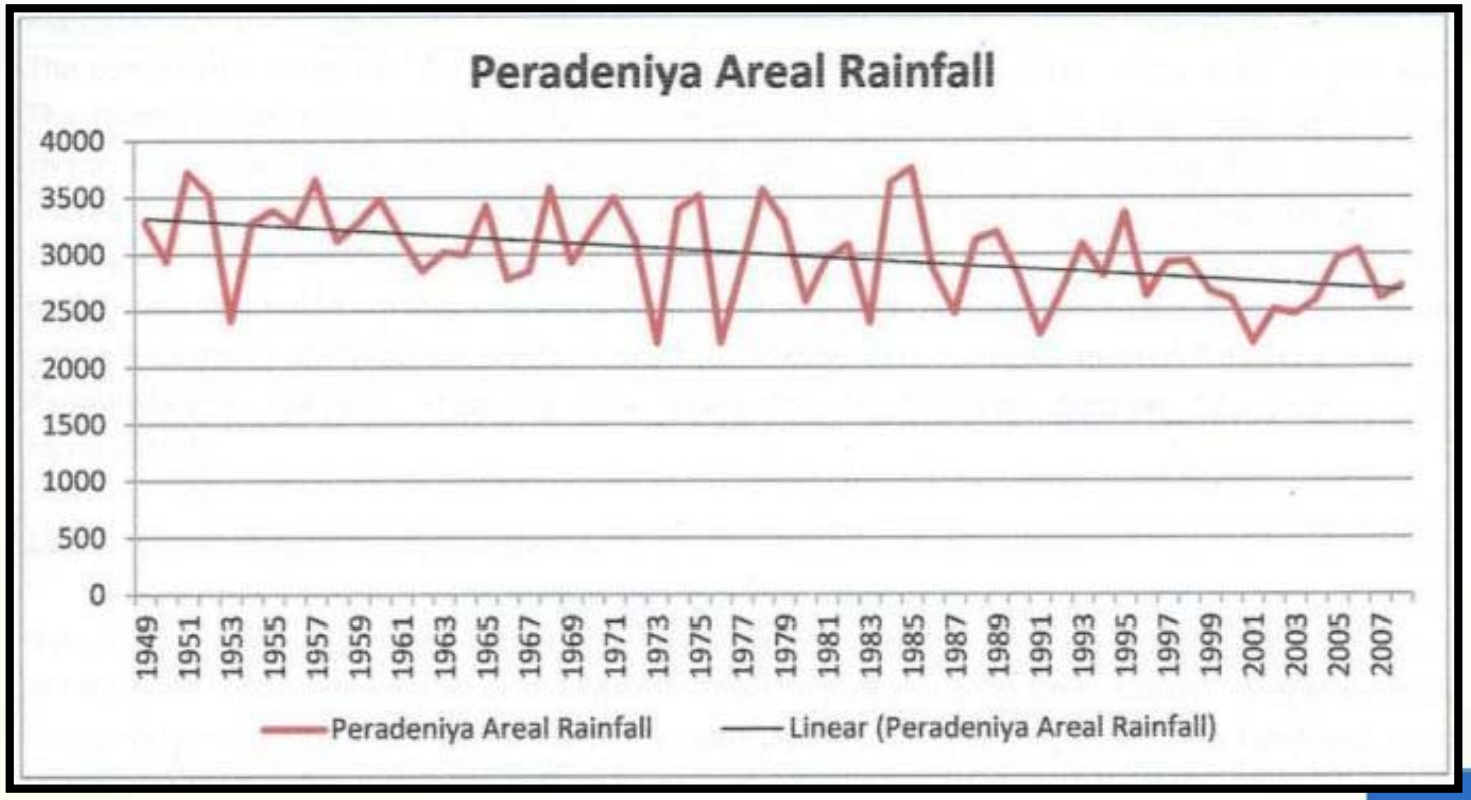
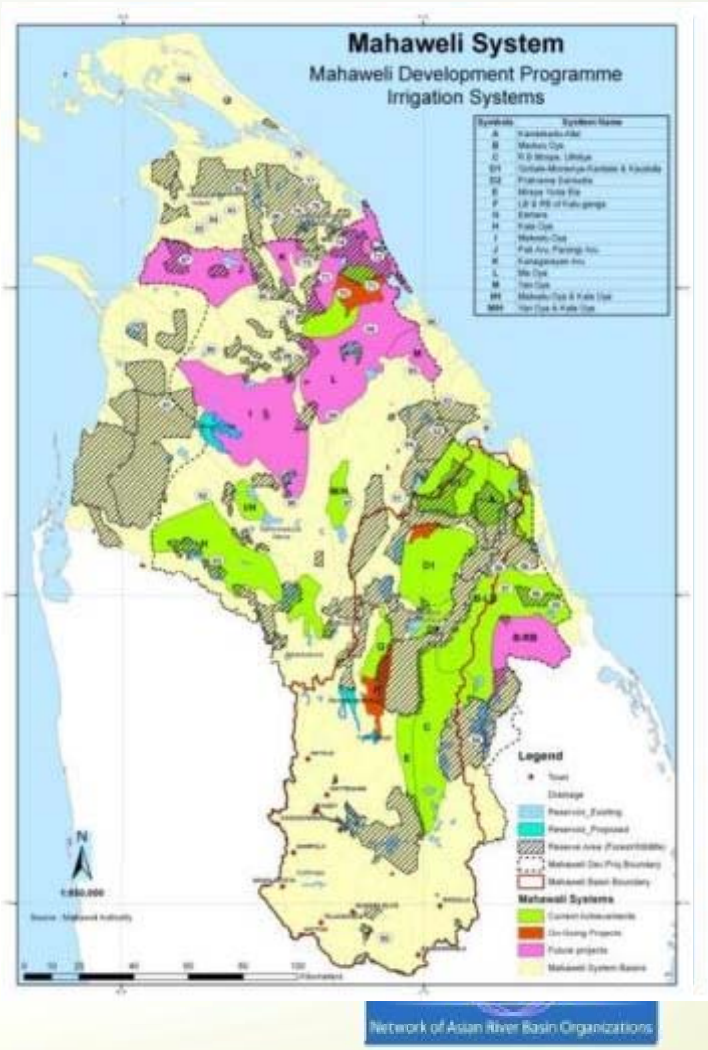
Identification of Problem and Issues

- Significant change in water availability:



Identification of Problem and Issues Cont.

- Need to Update Irrigation Demand
  - Change in Land Use
  - Crop Type based on National Target (Paddy, OFC, Sugarcane)
  - Change in Priority/Government Policy
- Need to Update Hydropower Production
  - Contribution from Mini Hydro
  - Maximizing power generation – Raising Kotmale, Construction of other plants



Identification of Problem and Issues Cont.

- Need to Include Domestic and Industrial Water Supply Demand
  - Higher Priority
  - Future demand = 3.5 x Present demand

- Possible Transfer Route and Diversion Quantity
  - North Central Diversion (NCP)

- Consideration of Environmental Flow
  - Treating Environment as an User

MULTI PURPOSE DEVELOPMENT

DSS – Model Setup and Calibration

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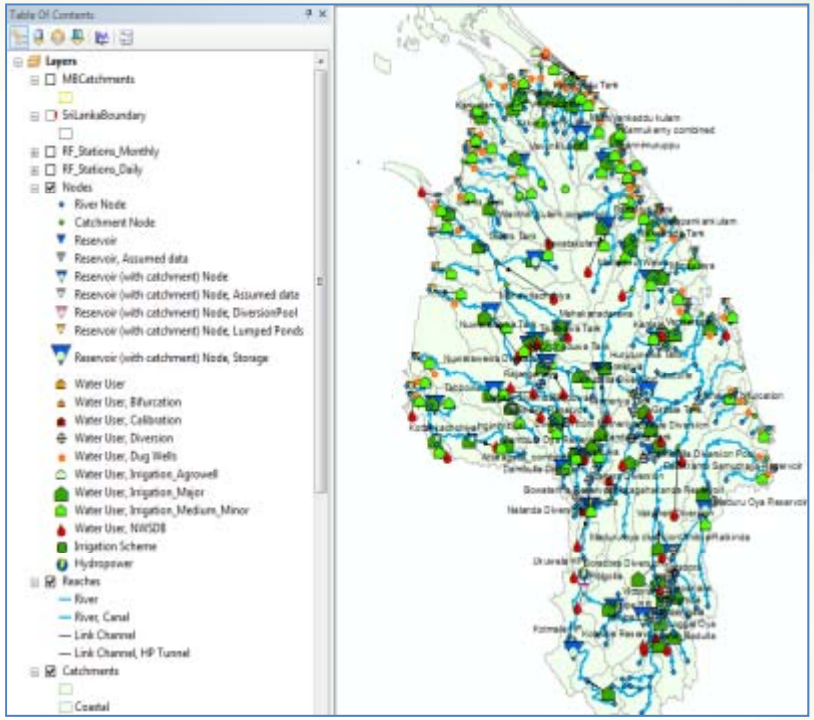
Model Establishment

- Model Setup
  - GIS based model
  - For basins that would be benefited from Mahaweli
  - Sub catchments at important locations (> 60)
  - Demands for Water Users
    - Irrigation (major & minor)
    - Hydropower
    - Water supply (domestic & industrial)
  - Infra-structures



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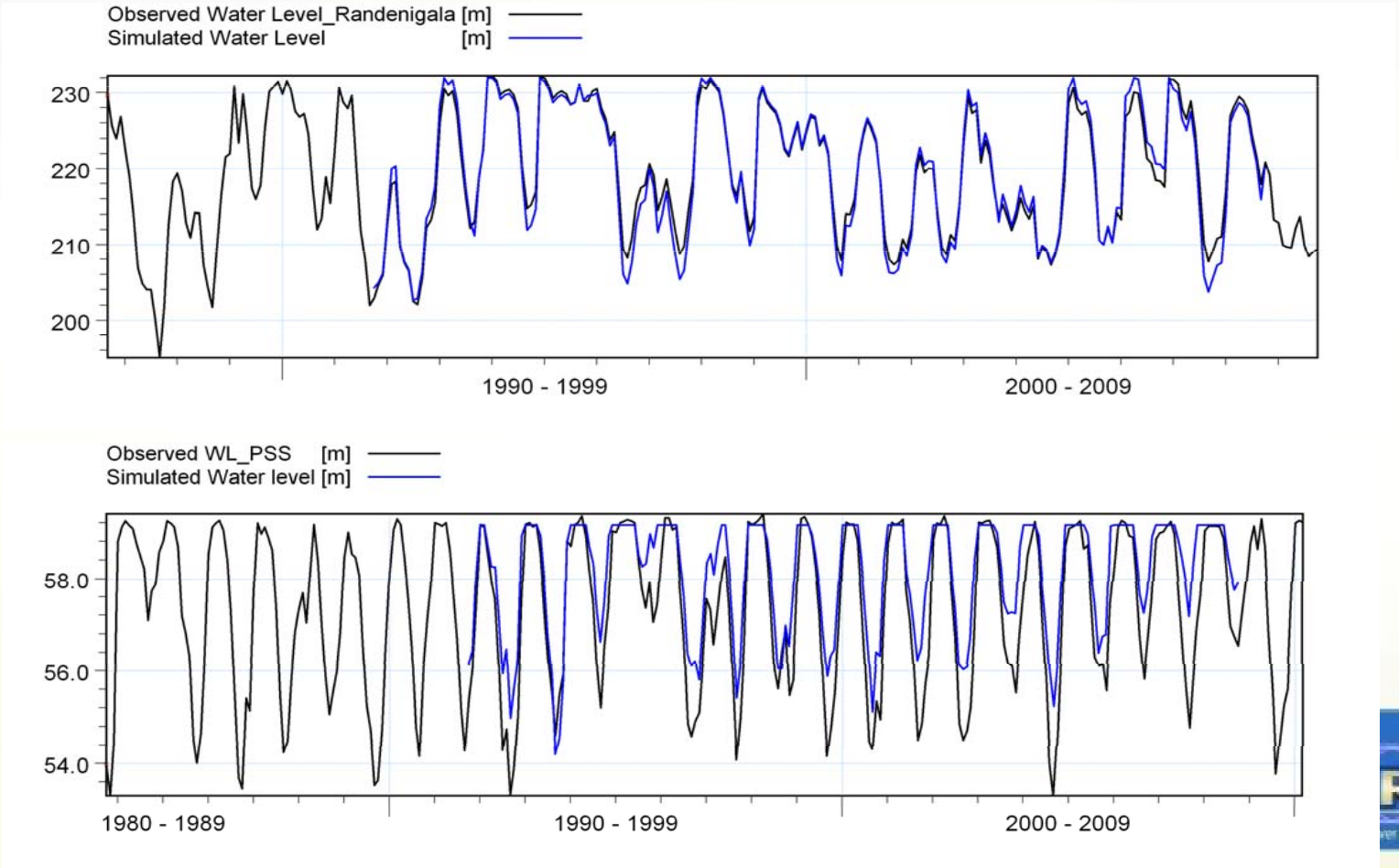
Model Establishment Cont.

- Model Calibration and Validation using reservoir water levels



DSS – Potential Improvements

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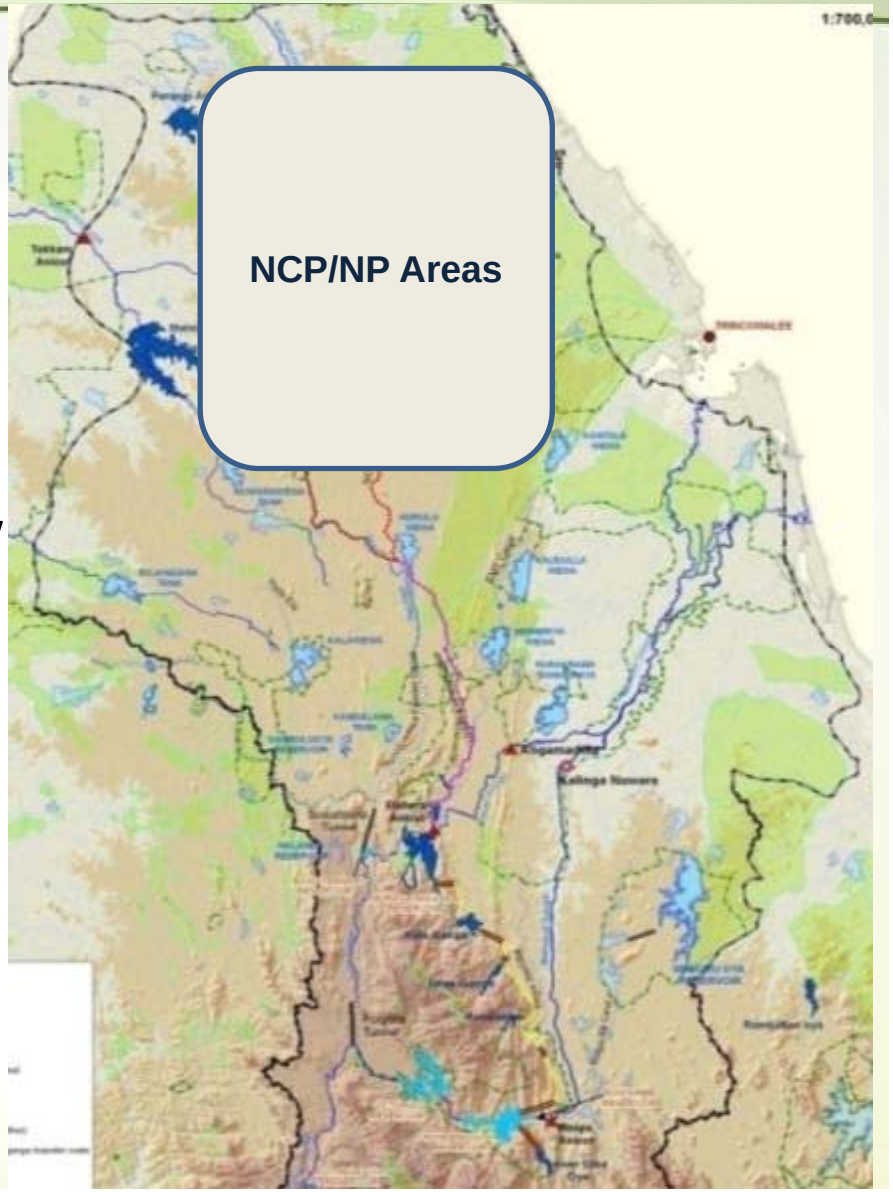
Potential Improvements

Water to North Central Province

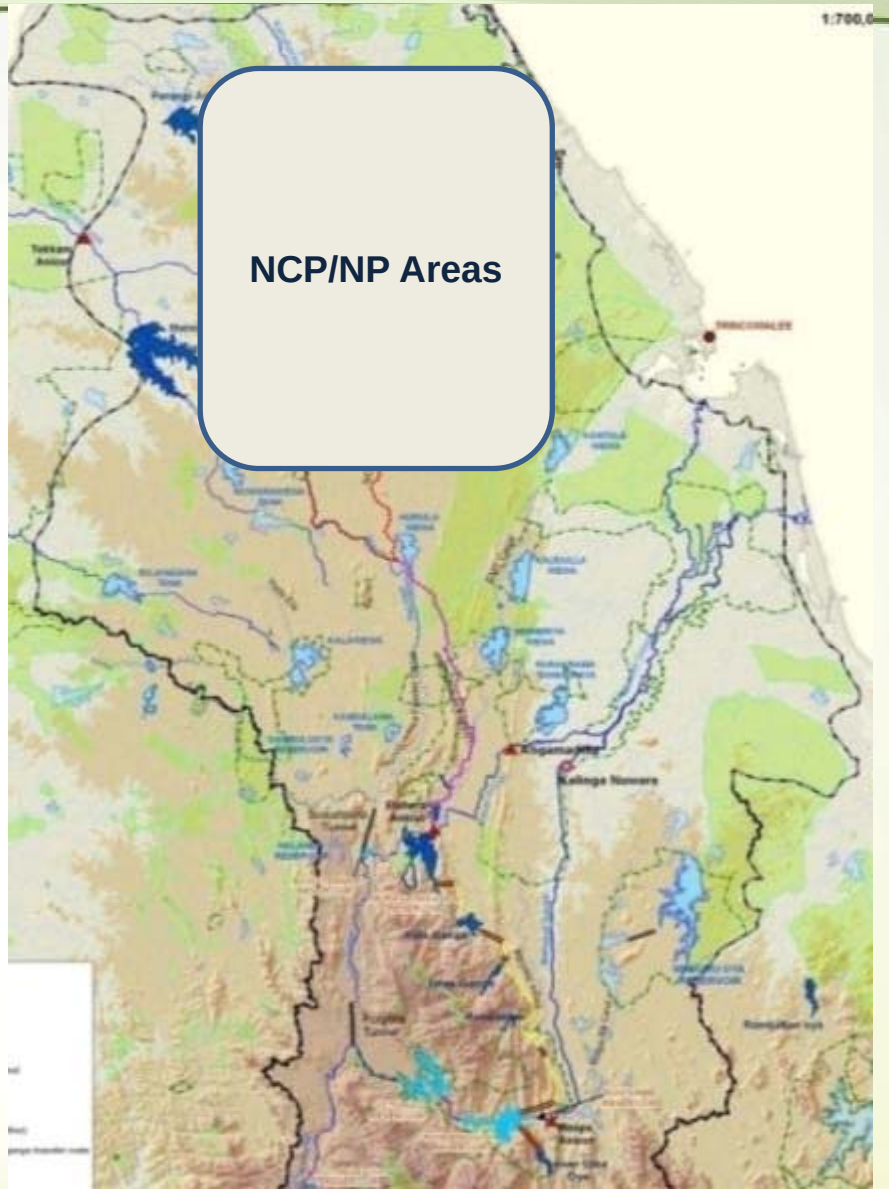
- Water for Post Conflict Area
- Irrigation for Major and Minor schemes
  - ✓ In both existing (~80,000 ha) and new areas (~10,000 ha)
  - ✓ Target cropping intensity = 1.8
  - ✓ Growing both paddy and OFC
- Domestic and Industrial Water Supply



Potential Improvements

Water to North Central Province

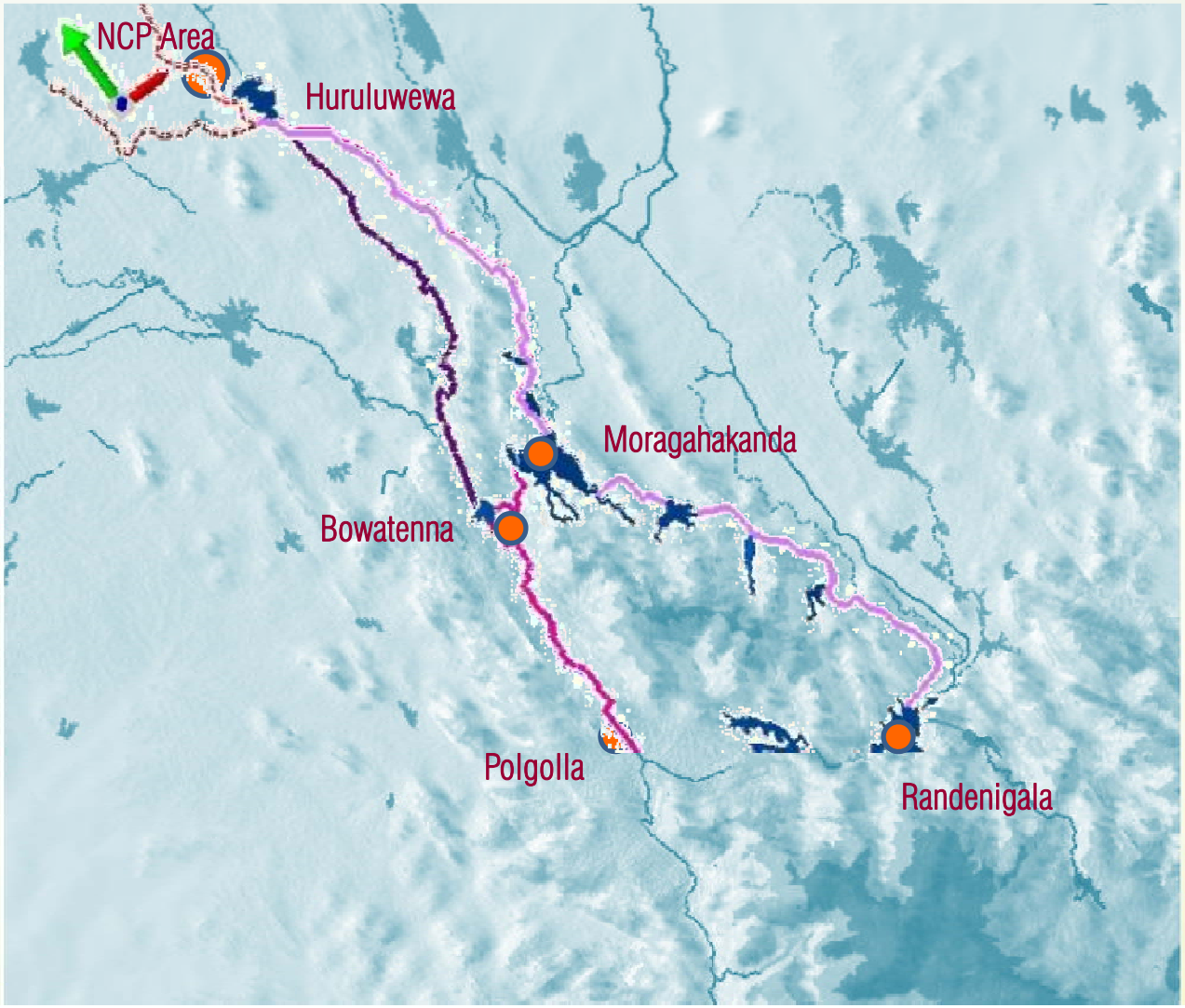
- Hydropower loss due to diversion
- New reservoirs and power plants to compensate power loss
  - ✓ Heen, Hasalaka and Lower Uma Oya Reservoirs/Power Plants
  - ✓ 08 Mini Hydro along Suduganga



Management Scenarios/Options

Possible Routes for Diverting Water to North Central Province

- From Polgollla via Bowatenna Tunnel and KHF Canal - **Option 1A (*open policy*)**
- From Polgolla via Bowatenna and Upper Elahera Canal - **Option 1B (*open policy*)**
- From Randenigala Via Kaluganga and Upper Elahera Canal - **Option 1C (*fixed policy*)**



DSS Results and Multi-Criteria Analysis

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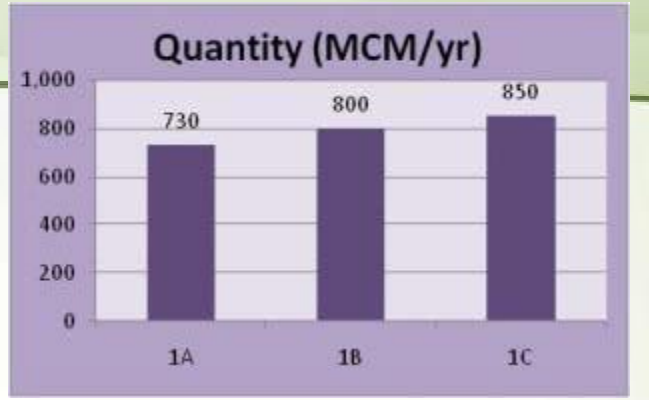
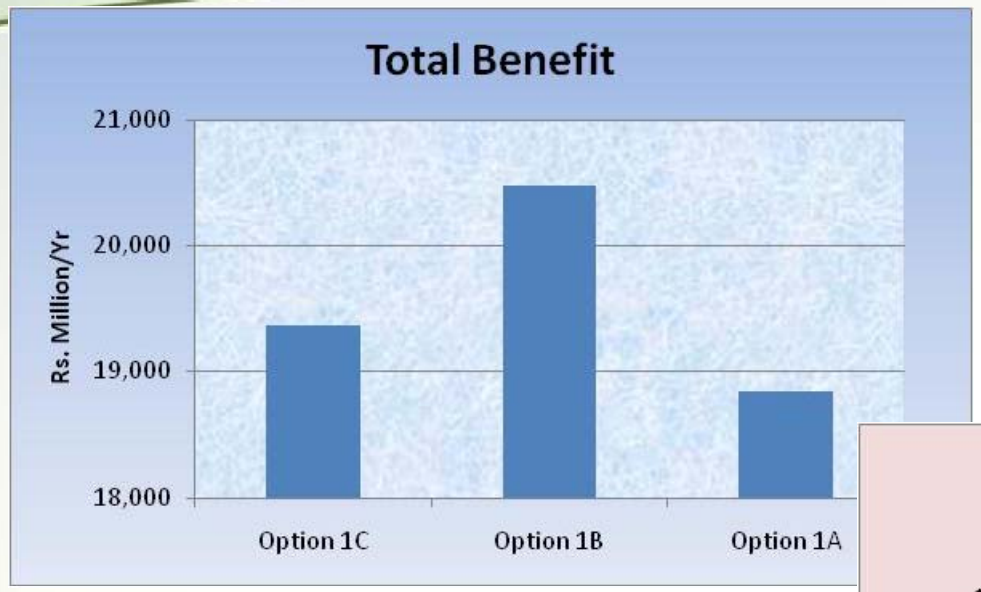
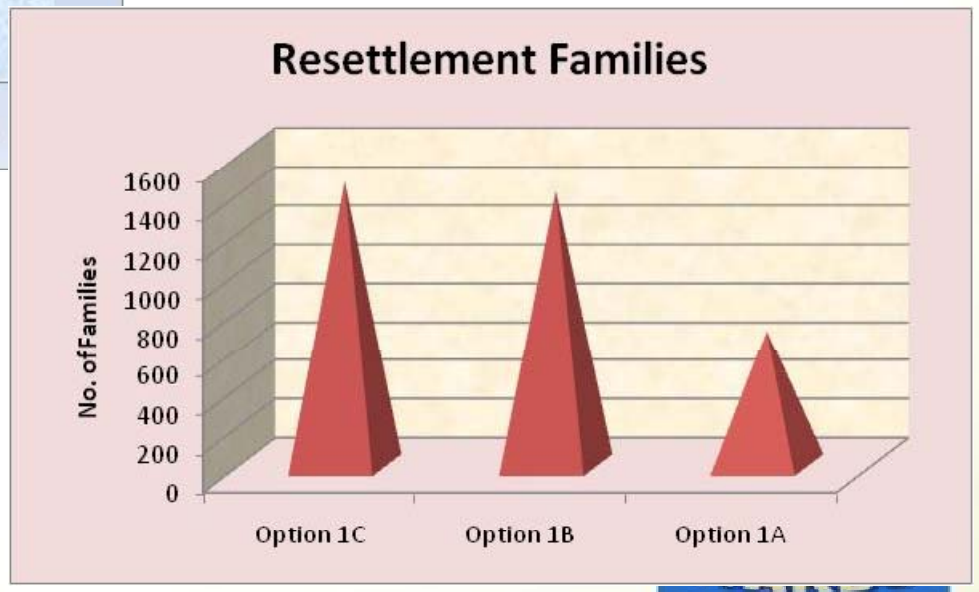
DSS Results and Multi-Criteria Analysis

Scenario Name		Opt 1C	Opt 1B	Opt 1A
Select Baseline Scenario ----->		B	B	B
Indicator	Metric	**850 mcm**	**800 mcm**	**730 mcm**
Economic Development				
Additional Ecomnomic Annual Benefits	Mill SLR	19,355	20,476	18,836
Agricultural Annual Benefits	Mill SLR	5,183	4,949	4,754
Industrial Annual Benefits	Mill SLR	2,298	2,298	2,298
Hydropower Annual Benefits	Mill SLR	2,679	4,034	2,589
Domestic Annual Benefits	Mill SLR	9,195	9,195	9,195
National Rice Target	%	6.55	6.55	6.55
National OFC Target	%	4.32	4.28	3.64
Economic Viability				
Total Investment	Mill SLR	212,158	180,338	160,652
Net Present Cost	Mill SLR	185,590	157,755	140,534
Net Present Benefits	Mill SLR	185,516	198,489	182,778
Economic Internal Rate of Return	%	7.00	9.22	9.56
Benefit Cost Ratio	Fraction	1.00	1.26	1.30
Social Development				
Additional Employment Generation	1000 man Days	6,123	6,094	6,249
Temporary jobs during construction	1000 No. Days	23,736	20,375	17,566
Resettlement Needed	Families	1,463	1,416	695
% Benefits in Post Conflict Areas	%	32	32	27
% Benefits in Low income Areas	%	60	60	57
% Benefits in the dry zone	%	60	60	57



DSS Results and Multi-Criteria Analysis





Prioritizing Projects

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Project Prioritization

- It is a rational method to prioritize project considering benefits and impacts
- Indicators, score , value range for scores, weight age for indicators to be decided collectively by decision makers
- Exercise could be repeated at set interval with updated data and information.

Economic Development	Unit	Value
Additional Ecomnomic Annual Benefit	Mill SLR	12,138
Agricultural Annual Benefits	Mill SLR	6,164
Industrial Annual Benefits	Mill SLR	(0)
Hydropower Annual Benefits	Mill SLR	374
Domestic Annual Benefits	Mill SLR	5,600
National Rice Target	%	3.22
National OFC Target	%	10.91
Economic Viability		
Total Investment	Mill SLR	133,155
Net Present Cost	Mill SLR	116,480
Net Present Benefits	Mill SLR	116,360
Economic Internal Rate of Return	%	6.99
Benefit Cost Ratio	Fraction	1.00
Social Development		
Additional Employment Generation	1000 man Days	9,465
Temporary jobs during construction	1000 Number Days	18,864
Resettlement Needed	Families	976
% Benefits in Post Conflict Areas	%	16
% Benefits in Low income Areas	%	81.9
% Benefits in the dry zone	%	50
Environmental Sustainability		
Rivers Violating Target, by % of numbe	%	77.40
Length of reaches violating target	Km	1566.11
Average Modification in classes	-	2.62
Maximum Modification in classes		7

Project Prioritization Cont.

WEIGHTS, SCORE AND RANGES

Weight	Item	Unit	Score				
			5	4	3	2	1
6.0	Agricultural Annual Benefits	Mill SLR	5,000	2,500	1,000	250	25
4.0	Industrial Annual Benefits	Mill SLR	5,000	2,500	1,000	250	25
6.0	Hydropower Annual Benefits	Mill SLR	5,000	2,500	1,000	250	25
10.0	Domestic Annual Benefits	Mill SLR	5,000	2,500	1,000	250	25
2.0	National Rice Target	%	5	4	3	2	1
6.0	National OFC Target	%	5	4	3	2	1
10.0	Total Investment	Mill SLR	10,000	25,000	50,000	75,000	100,000
10.0	Economic Internal Rate of Return	%	12	9	7	6	5
4.0	Additional Employment Generation	1000 man Days	2,000	1,000	500	100	25
20.0	Resettlement Needed	No.Families	25	100	500	1000	2000
6.0	% Benefits in Post Conflict Areas	%	80	60	40	20	10
4.0	% Benefits in Low income Areas	%	80	60	40	20	10
4.0	% Benefits in the dry zone	%	80	60	40	20	10
8.0	Avg Modification Classes_Environment	No	2	3	4	5	6
0.0	Government Policy	%	100	80	60	20	10
0.0	Other Benefit	Mill SLR	5,000	2,500	200	50	10

Project Prioritization Cont.

SAMBLE

Basin	Projects	Score	Investment (Rs. Mill)
Mahaweli	Option 1B	67.0	180,338
Mahaweli	Option 1A	64.0	160,652
Mahaweli	Option 1C	52.8	212,158

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Environment Flow

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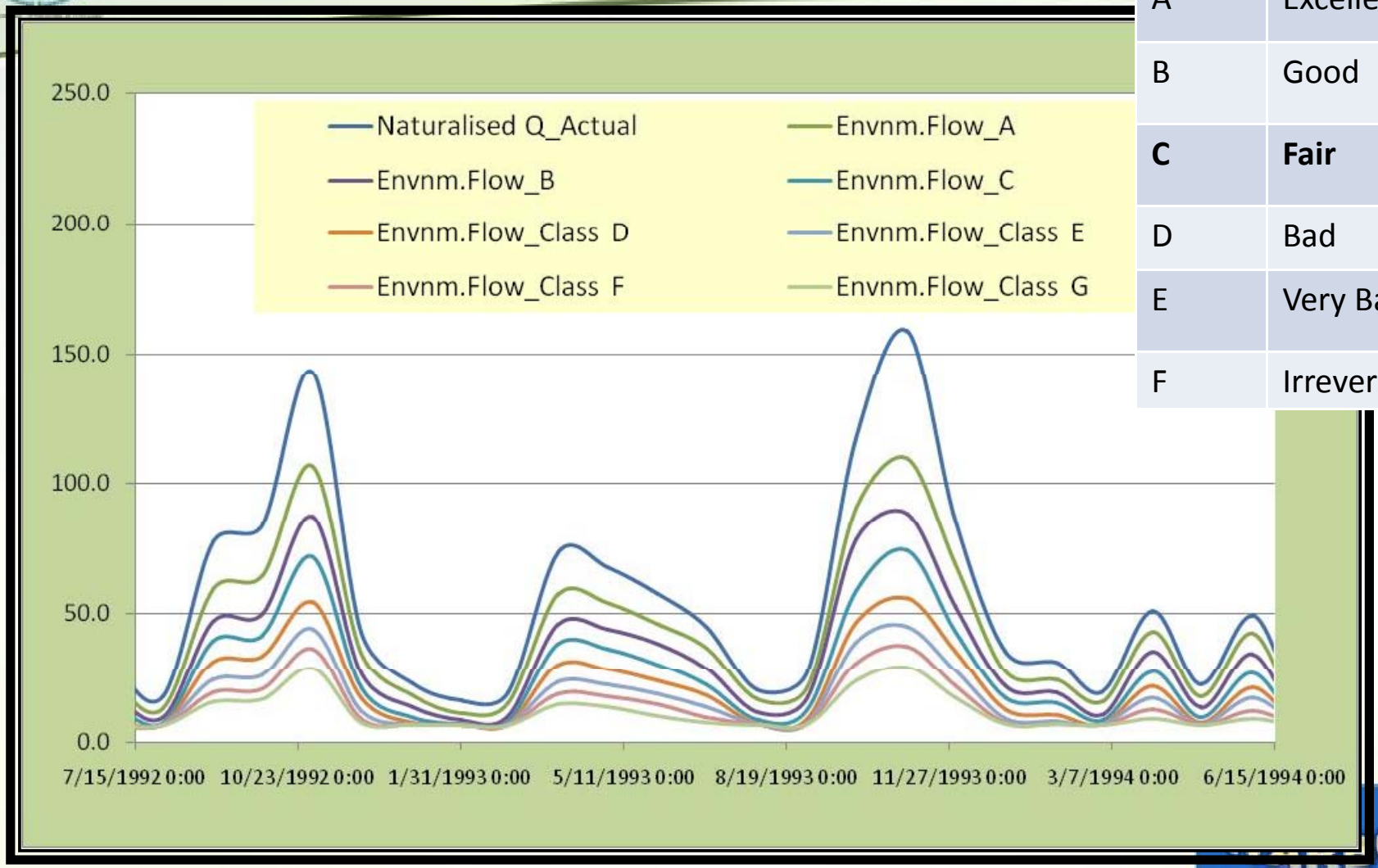
Environmental Flow

- “Environmental Flows” implies a range of flows and not just “a minimum flow”
- Represent the flows needed to maintain ecosystems in the basin for both present and projected future development
- Do not seek to restore poor water quality caused by anthropogenic pollution – this should be dealt with at source
- We have very little “hard” ecological data in the basins
- Approach by IWMI was adopted

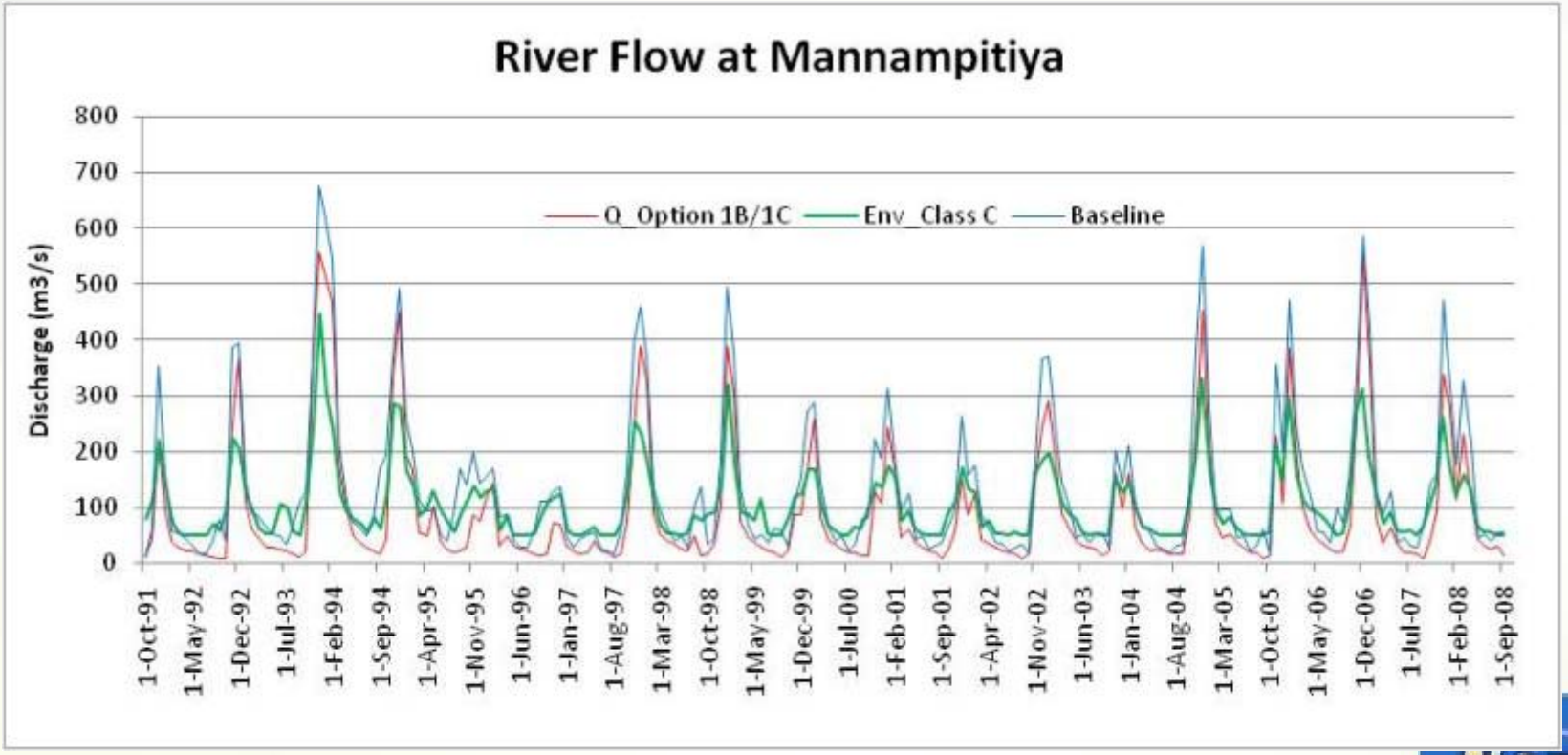
Environmental Flow Cont.



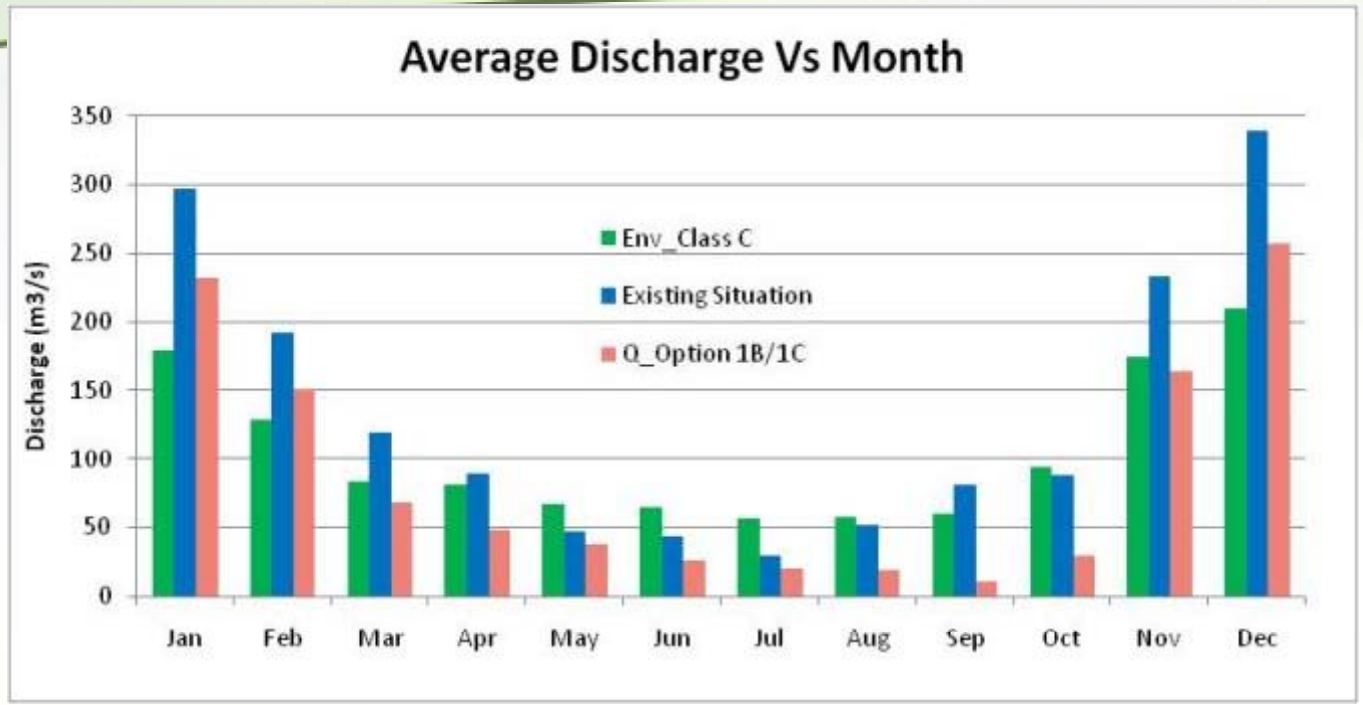
Class	Status
A	Excellent
B	Good
C	**Fair**
D	Bad
E	Very Bad
F	Irreversible

Impact on Environmental Flow

- Class C considered – Disturbed habitats but basic ecosystem functions are still intact
- Tested for Option 1B/1C



Impact on Environmental Flow Cont.



- Satisfying environment flow = 55% for baseline and 18% for Option 1C
- Satisfying environmental flow requirement at baseline condition would cause loss of ~ Rs. 900 million/yr
- Detail study to quantify the impact due to proposed diversion

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Climate Change

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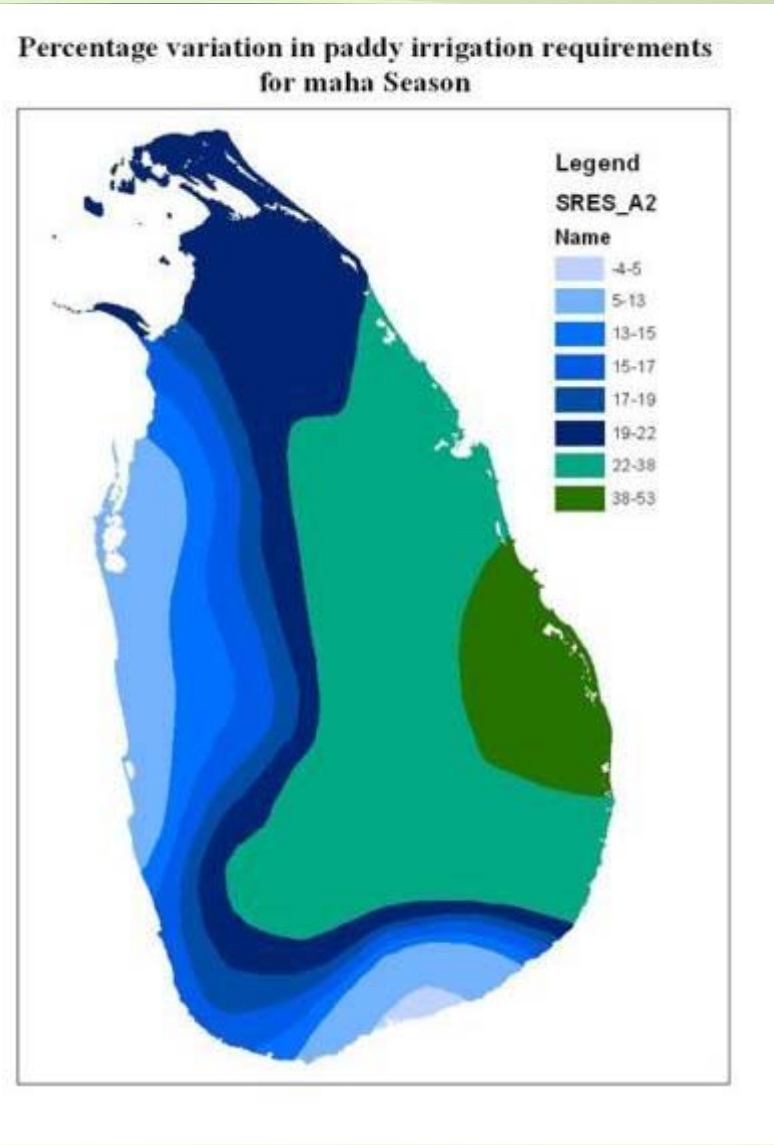
Climate Change

- Positive change during Yala and Negative change in Maha

- Maha Change

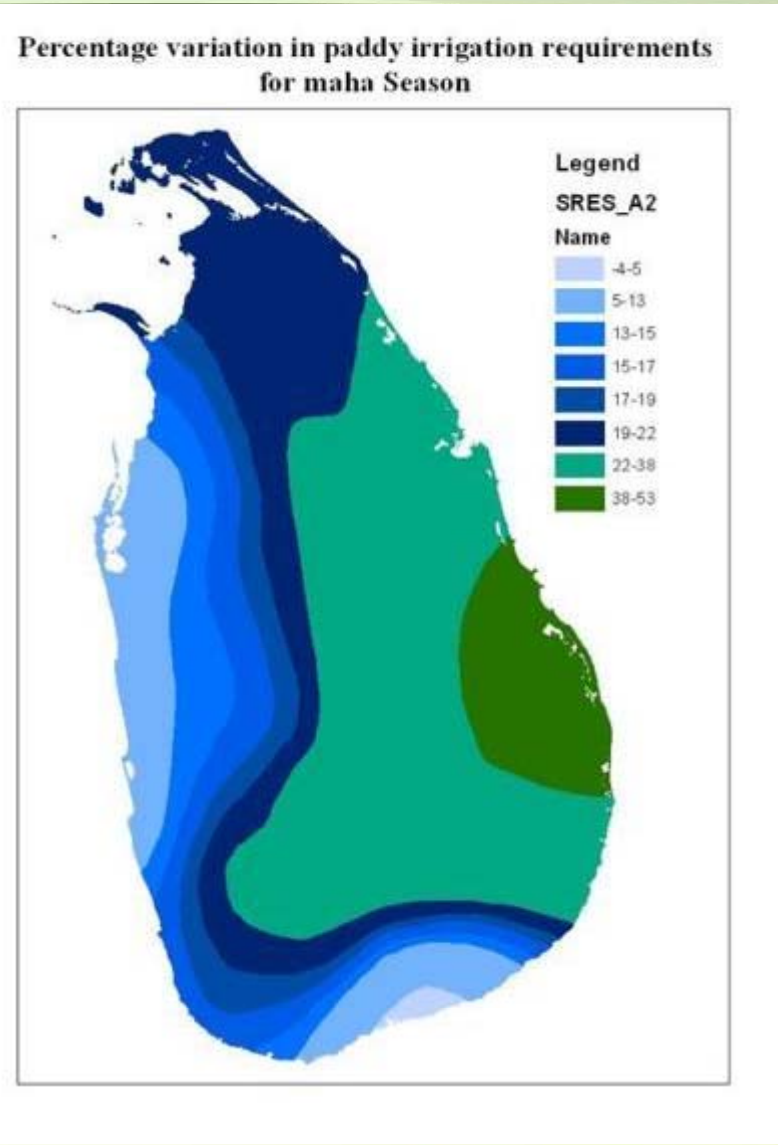
Item	Severe	Moderate
Rainfall	17%	9%
Evaporation	3.5%	3%
Irrg.Requirments	23%	13%

- Change predicted in 2050s
- Rainfall will increase in Nov and decrease in Jan & Feb. Hence, chanage is towards the late stage of crop growth



Climate Change Cont.

- Irrigation to major, medium and minor schemes are mostly through reservoirs or tanks.
- Early planting , use of shorter durtaion paddy and crop diversity will minize the impact
- Detail analysis on Mundeni Aru option shows losss of ~0.6% of Net Return due to climate change (~45% of increase in irrigation demand)
- Impact could be quantified for the selected proposals if it is necessary



Conclusions

Updating Water Resources Plan for Mahaweli Basins is highly required at this stage and DSS is a robust tool for it

DSS could be designed to look into economic, social, environmental and other benefits or impact due to existing/proposed projects

Both technical staffs and decision-makers could use DSS to arrive at Optimum Development Plan that would lead to brighter future for Sri Lanka

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Thank You