Impact of water abstraction on the water balance of Lake Ziway, Ethiopia

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Outline

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II. Study Area
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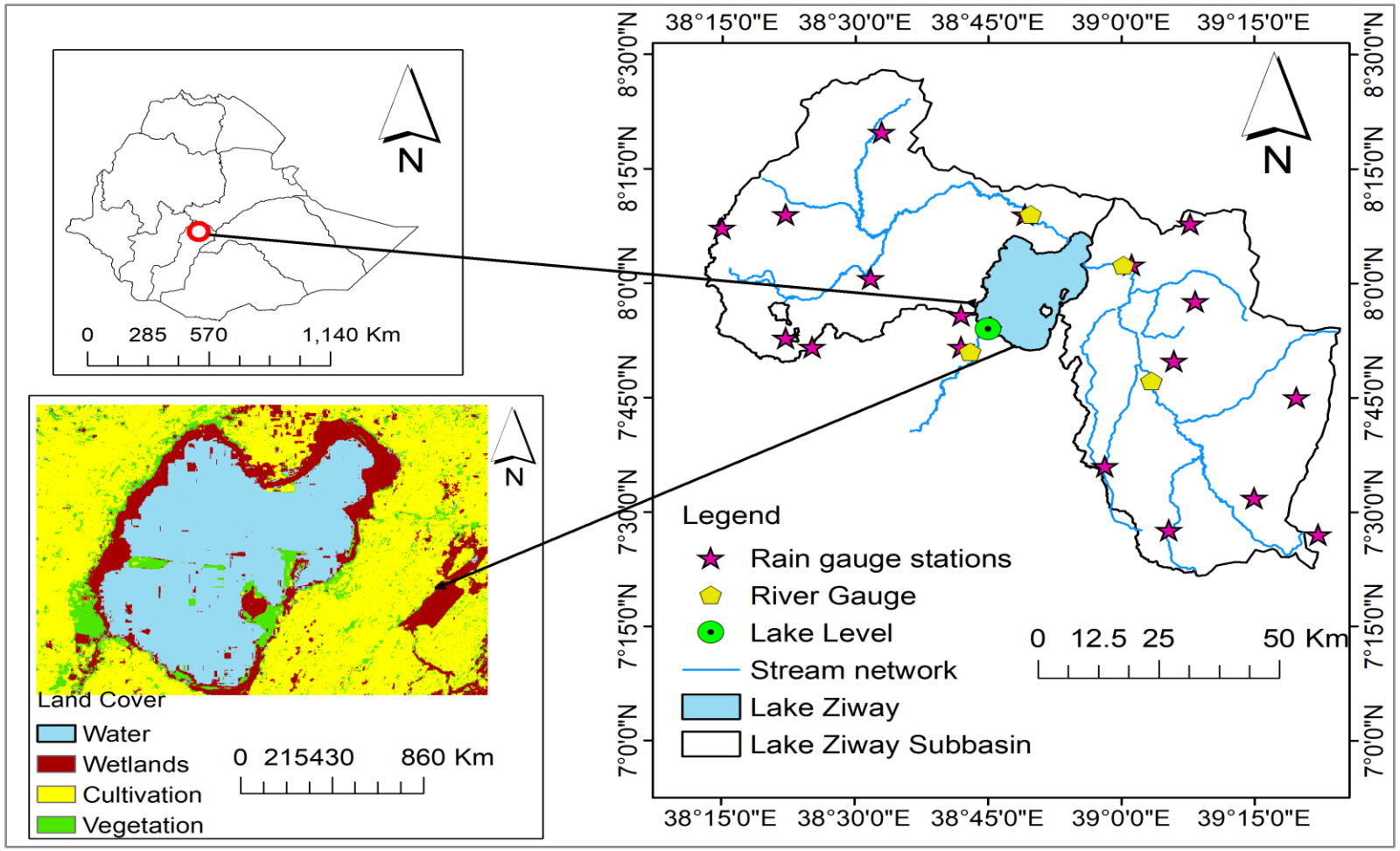
Introduction

- Significant change has been observed in the water level of different Rift Valley Lakes in Ethiopia, as a result:
  - Natural processes
  - and human activities
- However, lack of data is a major challenge in the estimation of actual water abstracted for irrigation Remote sensing products
- Previous studies estimate irrigation water demand from a crop that requires the highest amount of water using national statistics, reports and climatic database
- The hydrology of many lakes has been relatively well documented
- However, the hydrology of Lake Ziway is not well documented in scientific literature as compared to other lakes

Introduction

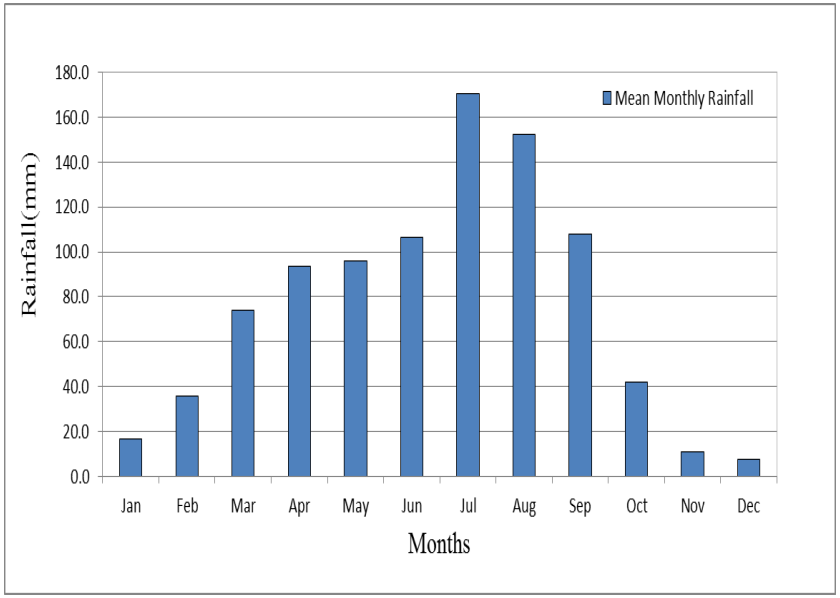
- Most of them focused on the water budget of the lake under the natural conditions.
- However, there is no study that quantitatively estimated actual water abstraction from the lake and its impact on the water level based on WAS.
- The exact magnitude of water withdrawal and its impact on the water level from available studies are uncertain.
- The aim of this study is to estimate water withdrawal from the lake and its impact on lake water level using water balance modelling approach

Study Area


N
0 285 570 1,140 Km
N
Land Cover
Water
Wetlands
Cultivation
Vegetation
0 215430 860 Km
38°15'0"E
38°30'0"E
38°45'0"E
39°0'0"E
39°15'0"E
8°30'0"N
8°15'0"N
8°0'0"N
7°45'0"N
7°30'0"N
7°15'0"N
7°0'0"N
N
Legend
Rain gauge stations
River Gauge
Lake Level
Stream network
Lake Ziway
Lake Ziway Subbasin
0 12.5 25 50 Km

Lake Ziway

- In the Central Rift Valley lakes basin(CRV)
  - 7°00’-8°30’ N & 38°00’-39°30’ E
  - Catchment Area: 6700 km^2
- Elevation
  - Vary bewteen:1600-4200m.a.s.l.
- Annual Rainfall: 650-1400 mm
  - 60% in July to September
- Mean temperature:13.5-22.5^oC
- Major rivers:
  - Meki and Katar rivers
  - Average annual runoff volume = 675 MCM



Datasets

- Meteorological data (1984-2016)
  - 20 Stations (Rainfall, Temp(max/min), humidity, Wind speed, Sunshine)
- Digital Elevation Model (DEM)
  - 30m x 30m resolution
- Land use/land cover
- Water abstraction survey (WAS) Data
- Daily Stream flow (1984-2016)
  - At Abura, Meki, Fite, Chuifa and Sagure
- Satellite Rainfall Data (1984-2016)
  - Climate Hazards Group Infrared Precipitation (CHIRP) dataset (http://chg.geog.ucsb.edu/data/chirp/)

Materials and Methods

- This study is based on the assessment of existing and satellite hydro-meteorological dataset, water abstraction survey, and review of published studies.
- We applied the hydrological model output coupling with water balance modelling and field surveys.
- The methodologies followed in this study are:

1. We estimated water abstraction for all abstraction points based on Water Abstraction Survey (WAS).
2. We evaluated the water balance components of the lake under the natural condition on a monthly time steps.
3. TThe implication of existing and future water abstraction on the water level was evaluated using a water balance modelling approach.

Impact of water abstraction

- First, the amount of water abstracted was measured using a bucket with a known size. Then, the inflow and outflow water balance components of the lake were determined at monthly time steps including water abstraction.
- After all water balance terms estimated a spread sheet water balance model is developed to simulate lake volume.
- The lake volume was then converted to lake level using the bathymetric relationships.
- Three development scenarios were built: existing development (ED), likely future development (LD) and full development potential (FD).

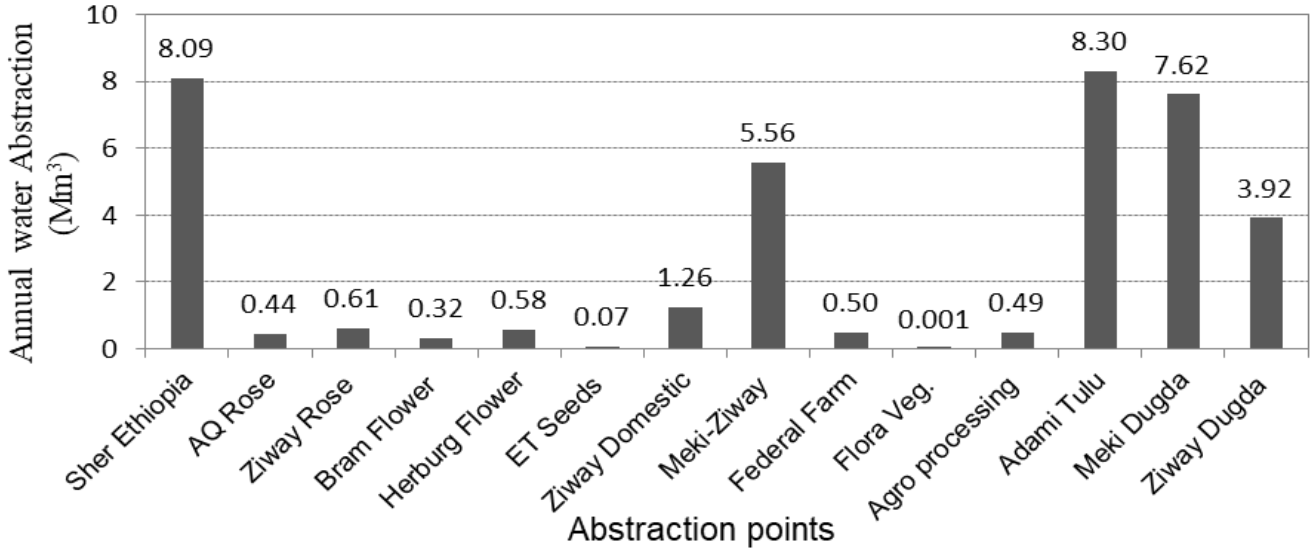
Impact of water abstraction

- The BS is the natural simulated water level from 1986-2000 without water abstraction.
- ED, LD and FD scenarios 2000 , 3100 and 5000 ha of irrigate land withdrawing water from the lake.
- this, first we assessed the lake water balance without and with water abstraction components.
- Then, we simulated the lake volume (corresponding lake level) for the baseline natural condition and scenario development.
- The isolated impact of water withdrawal from the lake on the water level will be estimated from the net difference between the simulated for natural and scenario condition

Results and Discussion

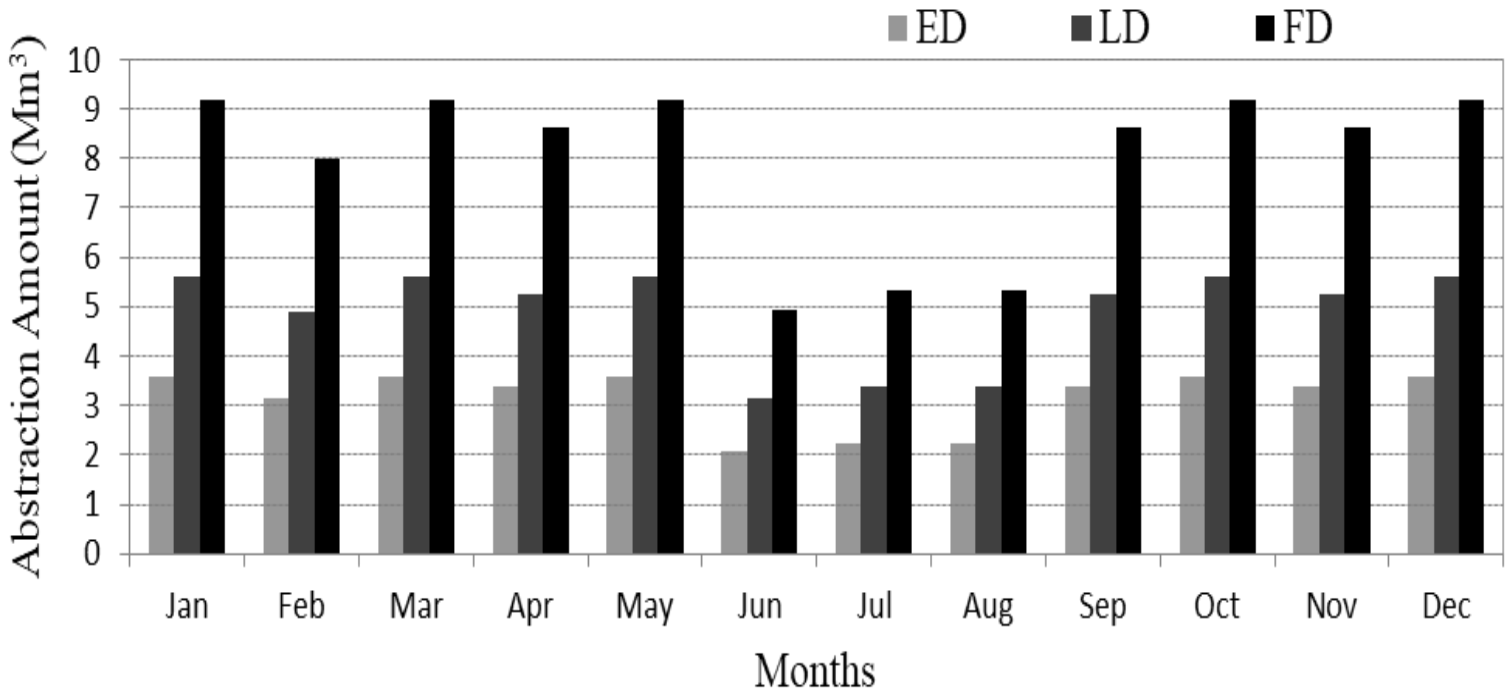
Water Abstraction

- The amount of annual water withdrawal from the lake for irrigation and domestic purpose revealed 38 Mm^3 volume of water to irrigate 2000 ha of agricultural lands for three seasons per each year.



Water abstraction for development scenario

- Estimate of Monthly water abstraction



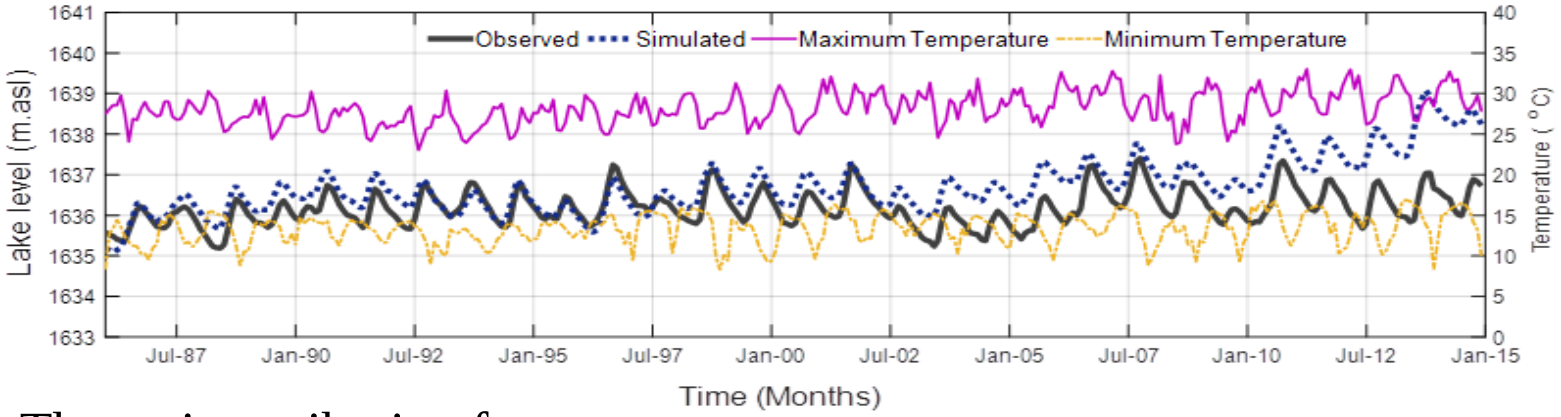
Lake Water Balance

- The monthly average simulated water balance components of Lake Ziway from 1986 to 2000 result revealed that rainfall, river inflow and evaporation constitute 33, 60 and 83 % of the annual water balance of the lake, respectively.
- This indicates that the river inflow contributes the major Lake inflow and evaporation over the lake surface accounts the major lake water loss.

	Inflow				Outflow		Water Abstraction	
Water Balance	R	Q_M	Q_K	Q_U	Evap	Q_{out}	Irrigation	Domestic
This study (2019)	338	233	380	81	832	171	37	1.26
Vallet-Columb et al. (2001)	335	273	418	50	832	157	-	-
Ayenew (2004)	323	265	392	48	890	184	28	-
Jansen et al. (2007)	327	274	411	-	774	185	27	1.31
Desta et al. (2017)	356	262	394	-	854	-	41	-

Lake water level simulation for natural condition

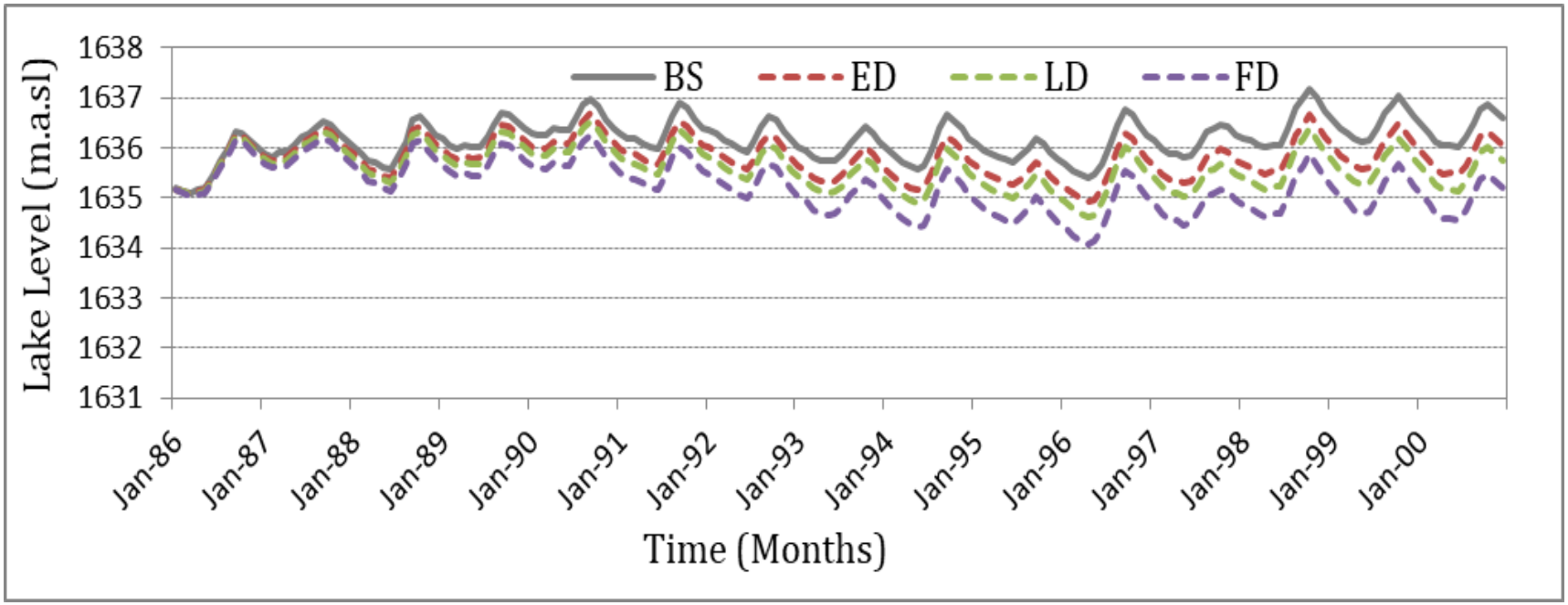
- The simulated monthly lake levels reasonably fit the pattern of observed water level up to 2000. However, for a recent period (after 2000) the simulated lake level significantly deviated from the observed counterparts.



- The main attribution factors are:
  - Variation of any of the water balance terms
  - human activities (e.g. pumping water abstraction for irrigation)
  - Climate change

Lake water level simulation for development scenario condition

- The simulated monthly water level for the three scenarios was not reasonably followed the baseline lake level over the simulation period.



Summary of simulation results for each pathway from 1986-2000

Scenario	Mean annual lake balance term			Change from the baseline		
	Water Level (m.a.s.l)	Area (km^2)	Volume (MCM)	WL Change (m)	Area change (%)	Volume change (%)
BS	1636.18	442.24	1529.50			
ED	1635.82	424.35	1367.49	-0.36	-4.0	-10.6
LD	1635.61	415.49	1278.53	-0.57	-6.1	-16.4
FD	1635.25	403.95	1124.10	-0.94	-8.7	-26.5

Impact of water abstraction

- The result indicates the mean annual lake level, volume and surface area decreased during water abstraction.
- For existing development (ED)
  - Water level decrease by= 0.36 m
  - Volume decrease=162 MCM
  - Surface area =18 km^2
- For Likely future development (LD)
  - Water level decrease by= 0.57 m
  - Volume decrease=251 MCM
  - Surface area =27 km^2
- For future full development (FD)
  - Water level decrease by= 0.94 m
  - Volume decrease=405 MCM
  - Surface area =38 km^2

Concluding Remarks

- This study indicated that an accurate estimate of actual water withdrawal and its impact on the water level can be estimated using WAS and water balancing approach, respectively.
- As a result of 37 Mm^3 annual water withdrawals from the lake for irrigation, the mean water level and volume of Lake Ziway drop by 0.36 m and 162 Mm^3, respectively.
- If full planned development pathway to be implemented the water level and surface area of the lake drop by an additional 0.37 m and 11 km^2, respectively. This consequently will yield to a significant reduction in the volume of the lake by 405 MCM, which accounts for 26% reduction of average lake volume.
- Our study indicates that water abstraction directly from the lake has a significant impact on the water level, volume and surface area of the lake. The water level change also further reflected in the temporal variation on the climate change trend.
- Further studies should incorporate **future climate change** impact assessment.


Thank you for your attention!!