UNITED NATIONS
Office for Outer Space Affairs

Assessment of Water Quality Change in Ziway and Hawassa Lakes, Central Rift Valley of Ethiopia Using Remote Sensing Data

THIRD SPACE4WATER STAKEHOLDER MEETING

CO-ORGANISED BY THE UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS (UNOOSA)

AND THE PRINCE SULTAN BIN ABDULAZIZ INTERNATIONAL PRIZE FOR WATER (PSIPW)

FROM 24-25 OCTOBER 2023, VIENNA INTERNATIONAL CENTRE

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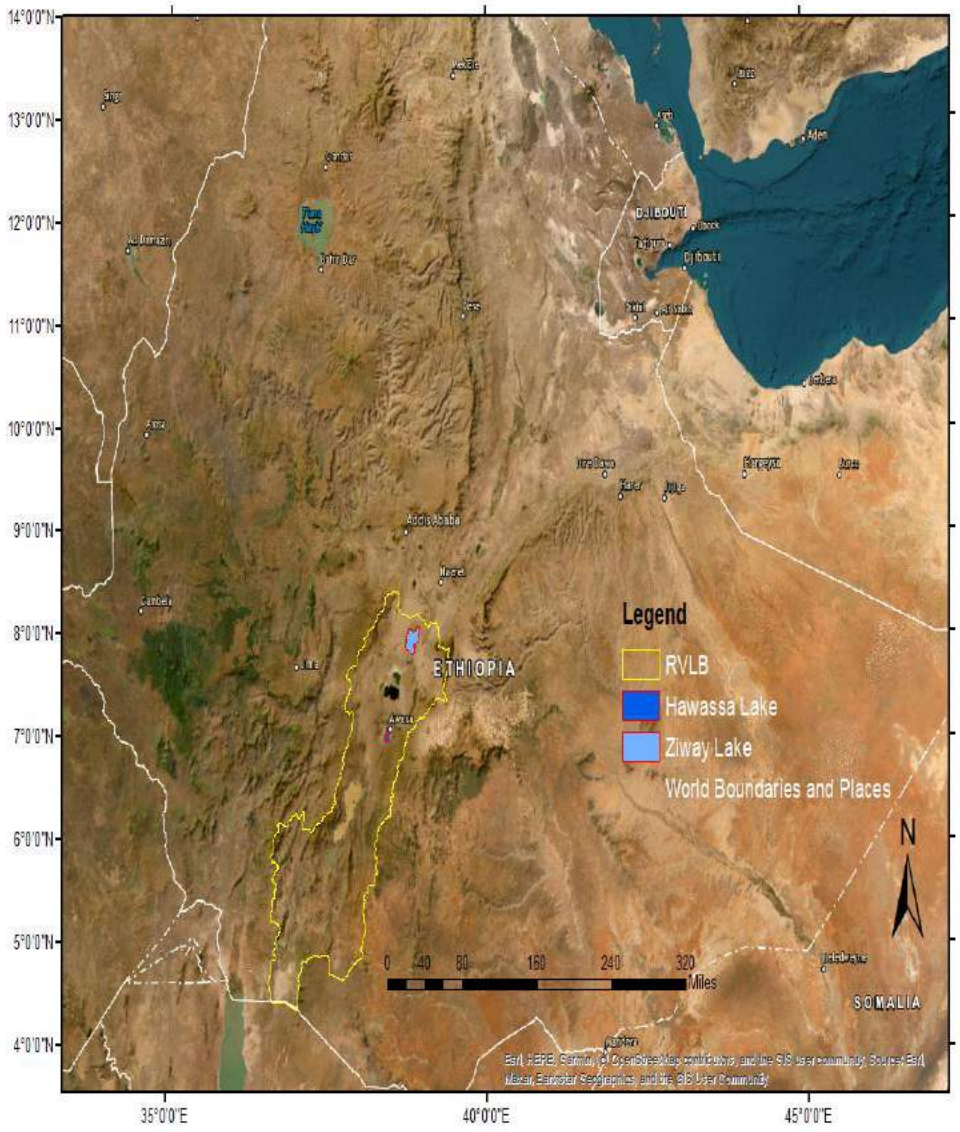
Background

- The lakes in RVLB have been under continuous pressure from rapidly increasing population, intensive agriculture, rapid urbanization and growing infrastructural expansion.
- Particularly Lake Ziway and Hawassa have huge anthropogenic impacts.
- The LULCC resulted in sedimentation, point and non-point pollution sources, and chlorophyll concentrations.
- It is causing severe ecological and socio-economic impact due to decline of water quality.
- The primary stakeholders impacted are farmers, fishermen and inhabitants (about 3-4 million) living in cities and the surroundings.
- These challenges suggest the urgent need for monitoring fresh water in the basin in rapid and more comprehensive way.

Description of RVLB

- RVLB is part of the Great African Rift Valley
- Major lakes basin having a total area of 49524.54 km2
- Geographically, it is between 7-8.30'N latitude and 38.07'–39.30'E longitude.
- Situated in three Regional States: Sidama, Oromiya and SNNPR with population of about 9.8 million
- Hawassa covers 8638.22 ha, while Lake Ziway has area of 43030.59 ha.



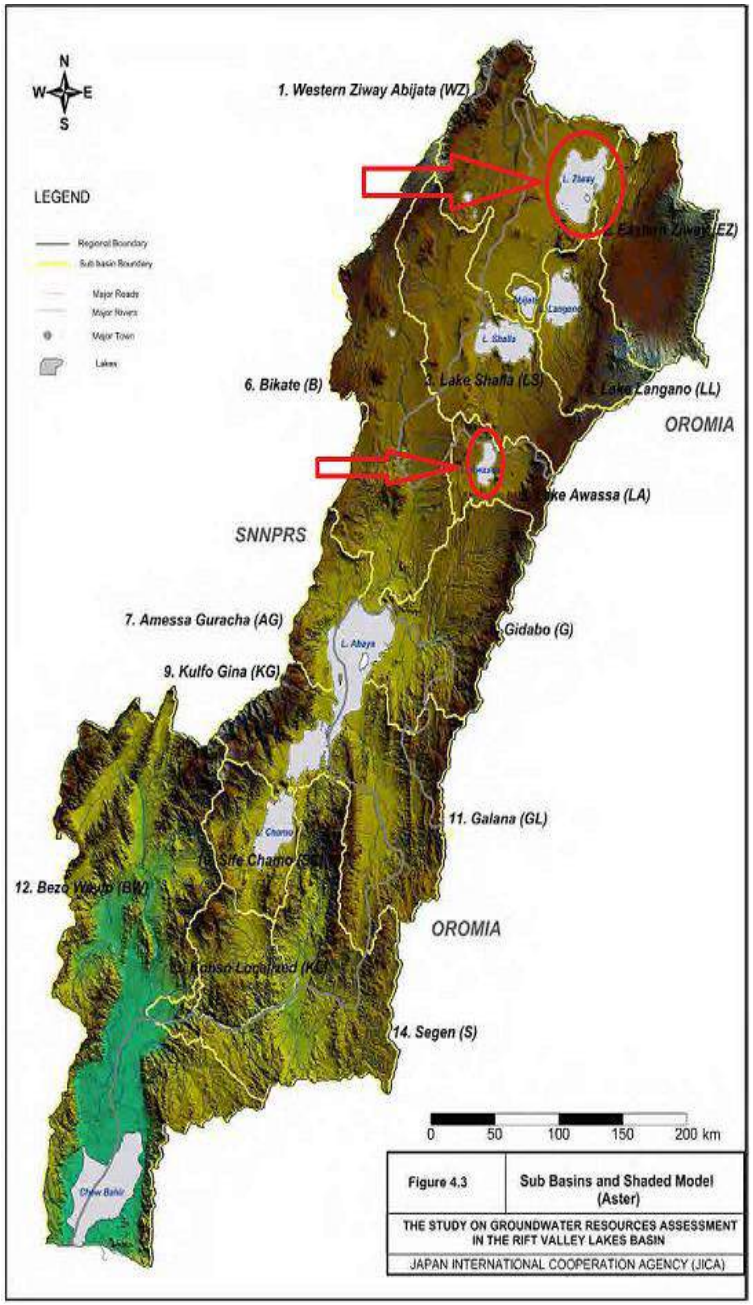
WQ of Lake Ziway and Hawassa

- Lake Hawassa:
  - Turbidity (NTU), Apr. 46.0, Aug. 54.0
- Lake Ziway
  - Apr. 13.0, Aug. 16.0

Parameters	ZiwayLake		LakeAbiyata		LakeShala		LakeLangano		LakeAwasa		Abaya		Chamo	
	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug
pH	8.7	8.0	10.1	10.0	9.8	9.8	8.9	9.2	9.0	9.0	9.1	9.1	9.6	9.4
TDS(mg/l)	220.0	214.0	41.5	41600.0	23160.0	21300.0	923.0	959.0	424.0	408.0	628.0	540.0	1004.0	899.0
DO(mg/l)	460.0	445.0	2.9	2.3	2.8	2.7	1932.0	1941.0	6.7	6.7	6.1	6.8	6.3	6.8
EC(SS/cm)	6.0	6.7	83.6	84250.0	48150.0	44000.0	6.7	6.8	886.0	848.0	1319.0	1116.0	2104.0	1827.0
TurbidityNTU	46.0	54.0	22.0	26.0	22.0	26.0	77.0	97.0	13.0	16.0	112.0	89.0	59.0	66.0
Na(mg/l)	63.5	59.0	12940.0	13100.0	6000.0	6950.0	405.0	375.0	162.0	168.0	246.0	222.0	430.0	425.0
K(mg/l)	11.9	11.2	6284.0	6300.0	240.0	244.0	23.5	23.0	26.0	30.0	19.0	16.0	20.5	20.0
Ca(mg/l)	22.4	20.8	3.2	4.0	0.0	6.4	4.8	4.8	11.2	10.4	15.2	14.4	6.4	8.0
Mg(mg/l)	7.3	6.3	0.0	0.0	3.9	0.0	1.5	0.5	4.9	5.4	1.9	2.9	7.8	7.8
HCO3(mg/l)	166.0	185.0	6286.0	6344.0	4652.0	244.0	426.0	505.0	194.0	310.0	354.0	395.0	566.0	568.0
Cl(mg/l)	12.5	12.0	10778.0	10900.0	3250.0	6300.0	182.0	200.0	27.0	51.0	63.5	107.5	130.0	300.0
F(mg/l)	1.5	1.6	370.0	370.0	156.0	220.0	7.9	10.2	7.7	9.6	8.2	8.0	9.3	8.9
SO4(mg/l)	1.4	25.4	17.3	15.8	5.2	12.6	2.1	1.2	0.1	4.8	3.4	9.7	1.2	5.2
SAR	3.0		653.0	267.0			41.5		10.2		15.7	27.0		

Water Quality of Major Lakes

Source : Lencha et. al, 2021



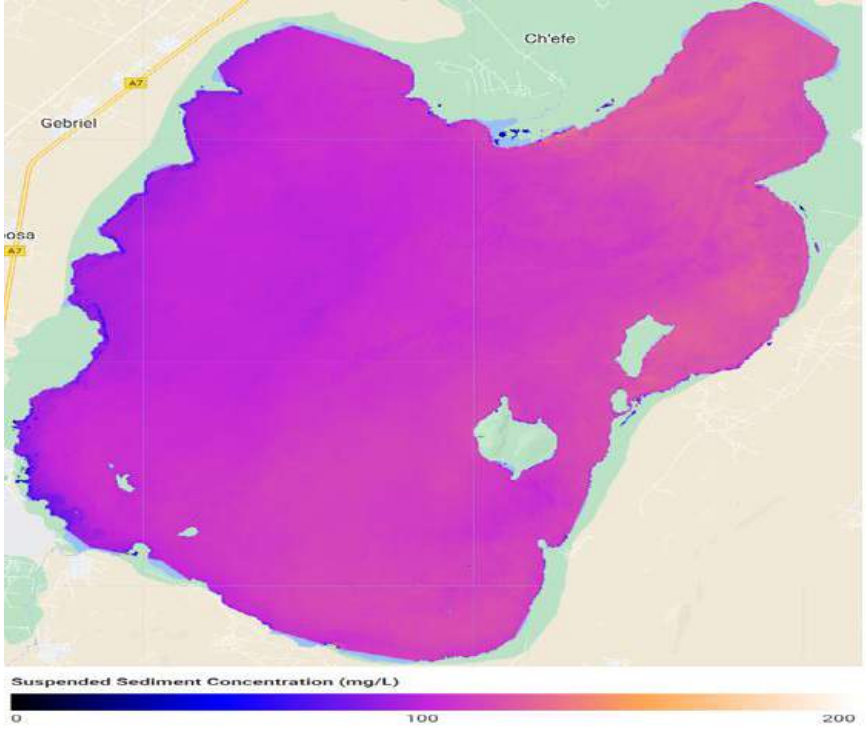
Methodology

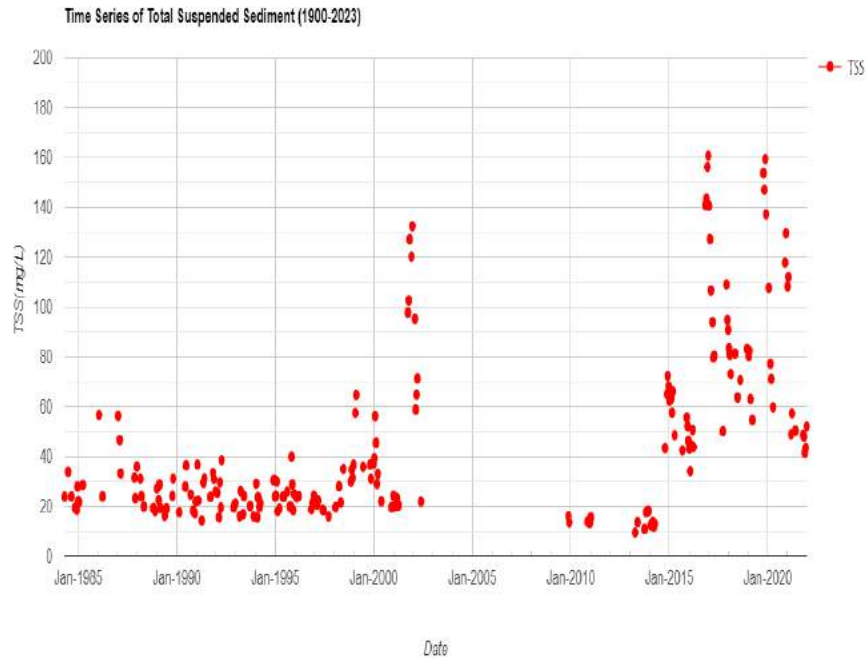
- The water quality of Ziway and Hawassa lakes was assessed using Landsat and Sentinel data.
- Total suspended matter (TSM), chlorophyll-a (Ch-a) concentration, water turbidity (T), and lake surface water temperature (LSWT) are the parameters used for this analysis.

Results

TSS of Lake Ziway

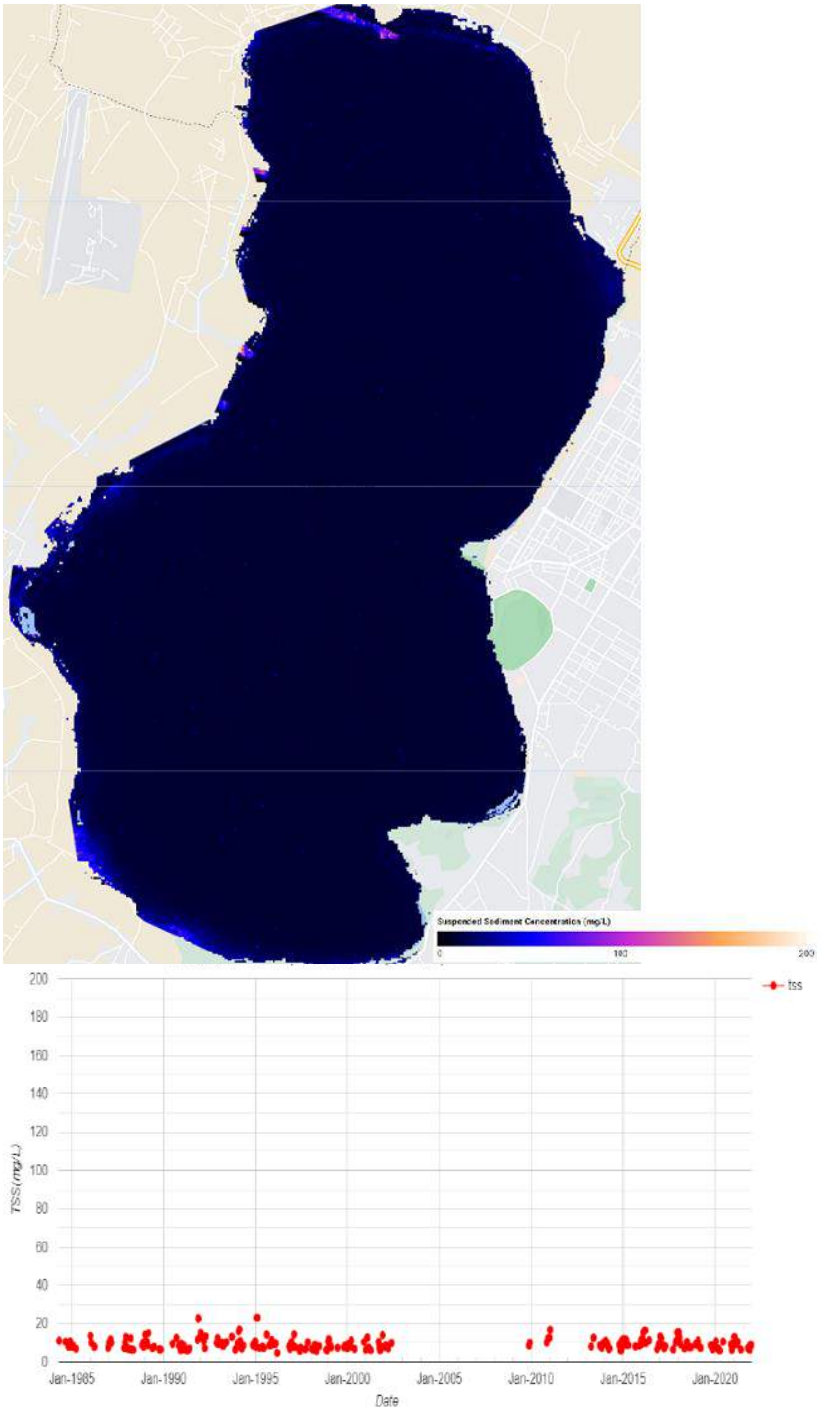
- Mean TSS map shows slight decrease towards the west.
- The mean TSS of the lake was 71.74 (mg/L)
- The highest value was 165.40 (mg/L) recorded on 15-Oct-19
- The smallest value of 9.93 (mg/L) was recorded on 7-Apr-13





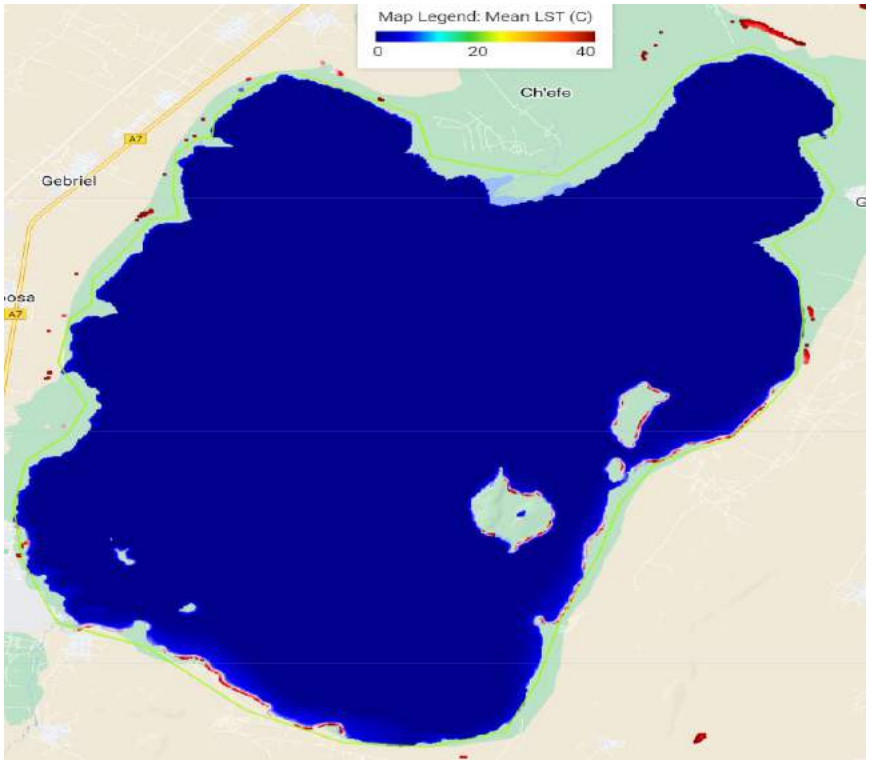
TSS of lake Hawassa

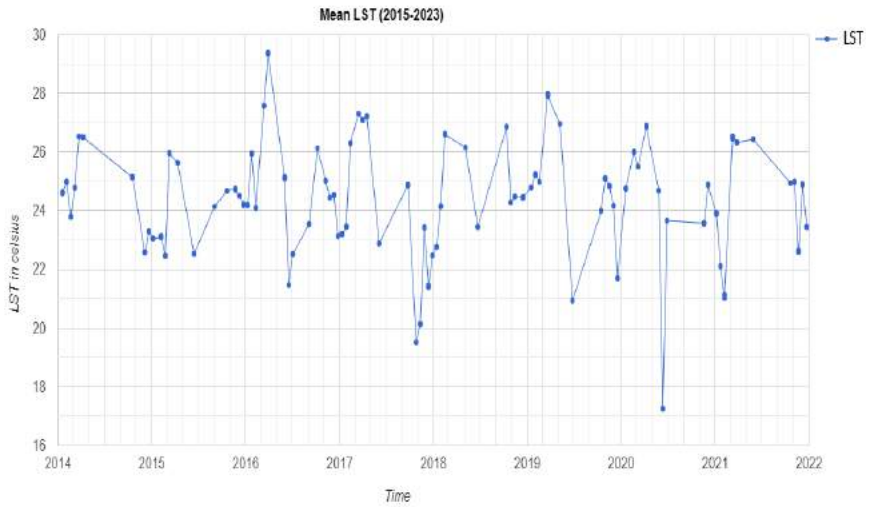
- The TSS was ranging from 4.70-23.04 (mg/L), while the mean was 9.48
- Mean TSS shows slight increase towards the shores.
- The highest value was 23.004 (mg/L) recorded on 30-Jan-95.
- The smallest value of 4.708 (mg/L) was recorded on 5-Mar-96



LST of lake Ziway

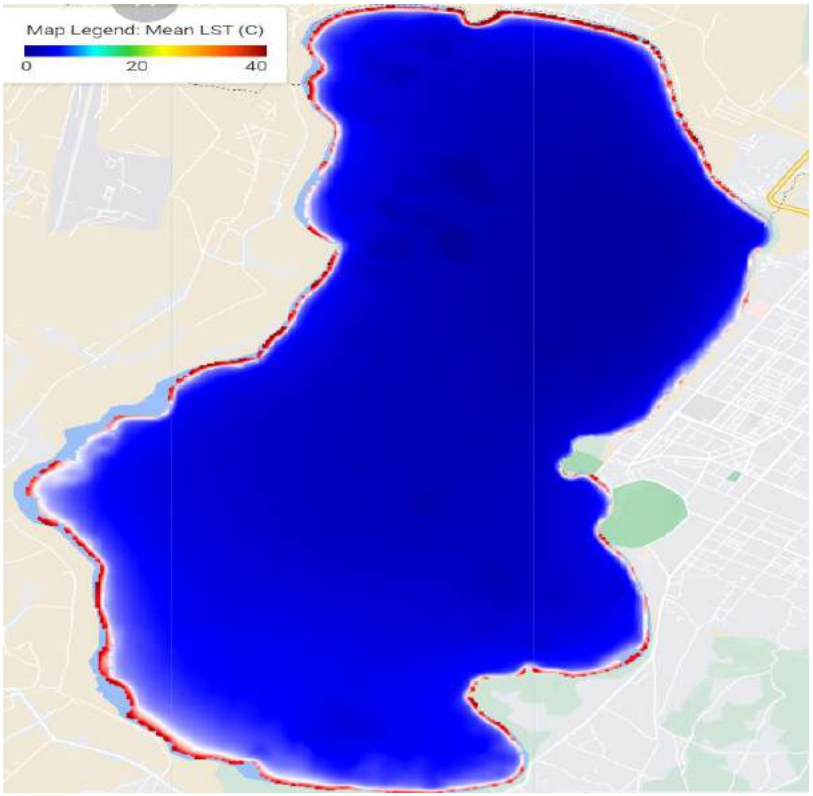
- Mean LST (2014-2023)
- The LST values ranged from 17.252 to 29.382.
- Where min values were recorded during Jun: (11-Jun-20) and max. during March (28-Mar-16)
- The mean LST was 24.29 Celsius.

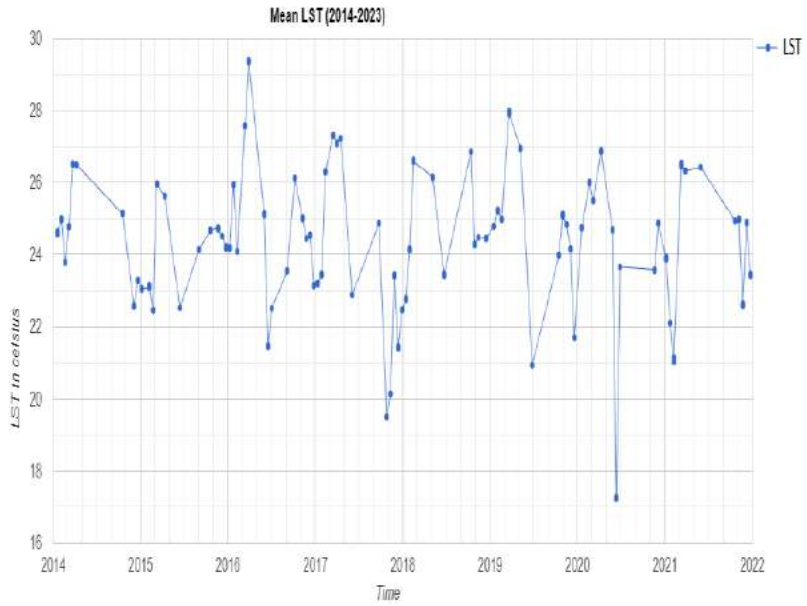




LST lake Hawassa

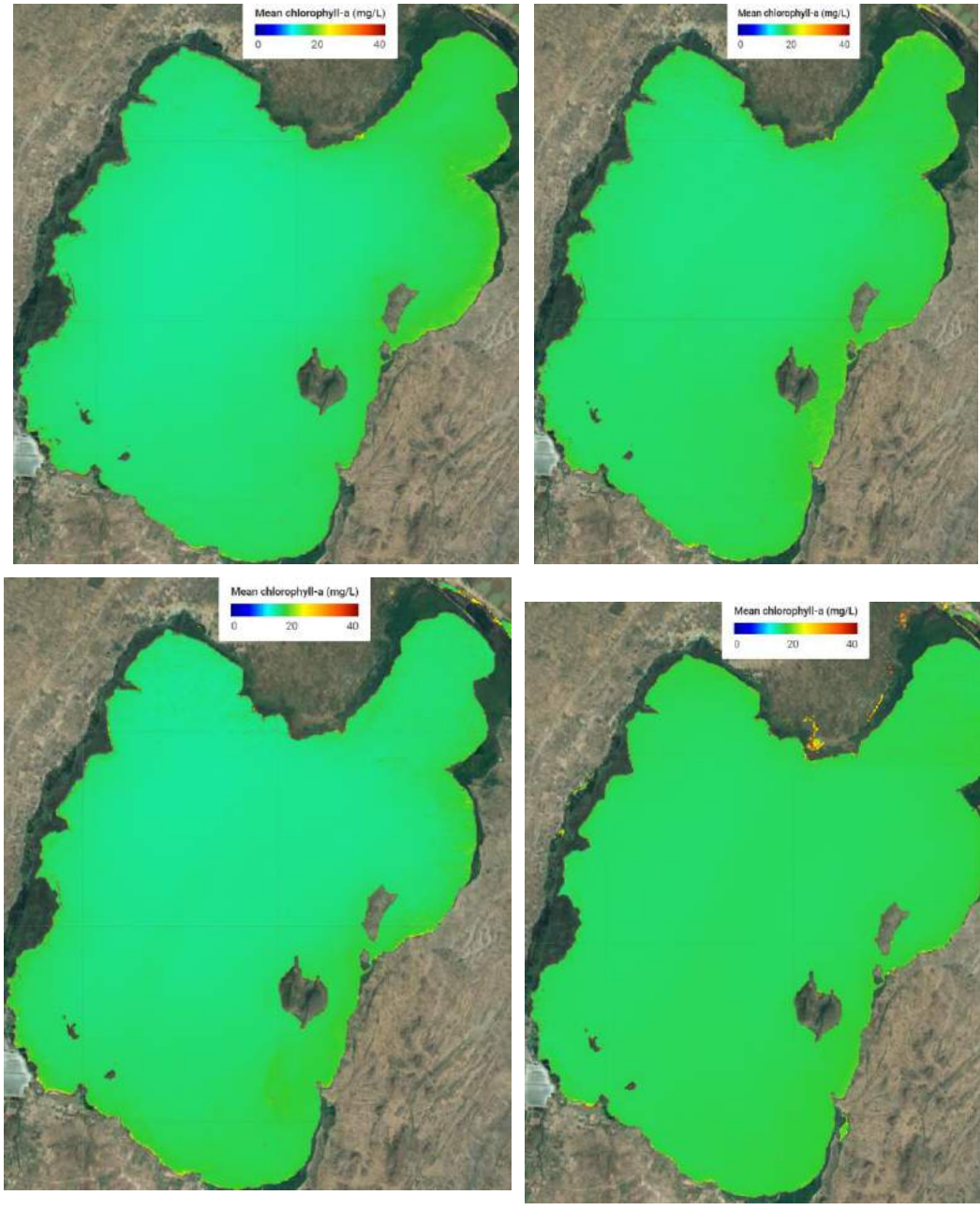
- Mean LST of the lake between (2014-2023) was 24.46, with Min, and Max. values of 17.252 and 29.38, respectively.
- Max LST was towards the shores
- The min value (17.25) was recorded during Jun: (11-Jun-20) and max. (29.38) during March (28-Mar-16)
- The mean LST was 24.46503472 Celsius.





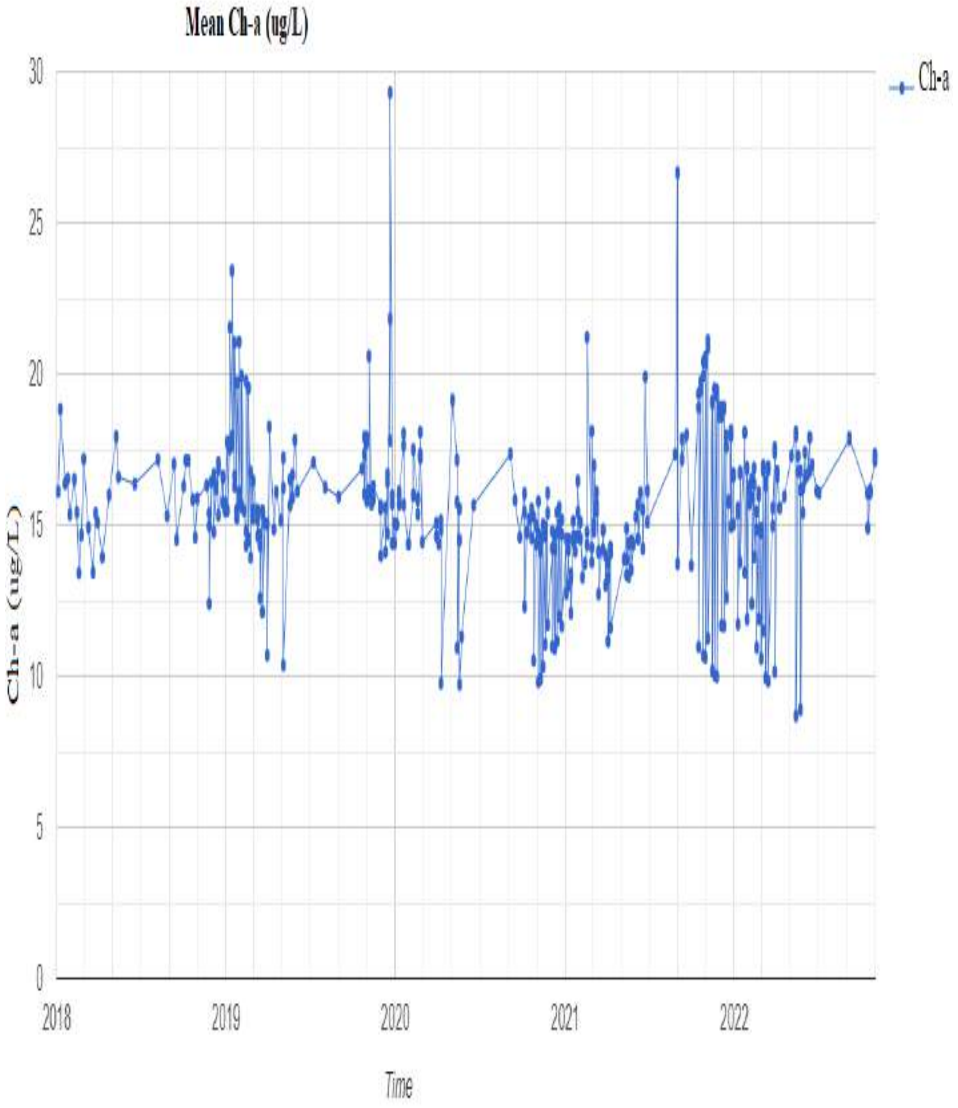
Chlorophyl-a concentration

- The time-series of Ch-a of lake Ziway shows that there is spatial and temporal variation and inter-seasonal fluctuations.
- The Chlorophyl-a concentration result indicates algal scums with mean of 15.59 ug/L



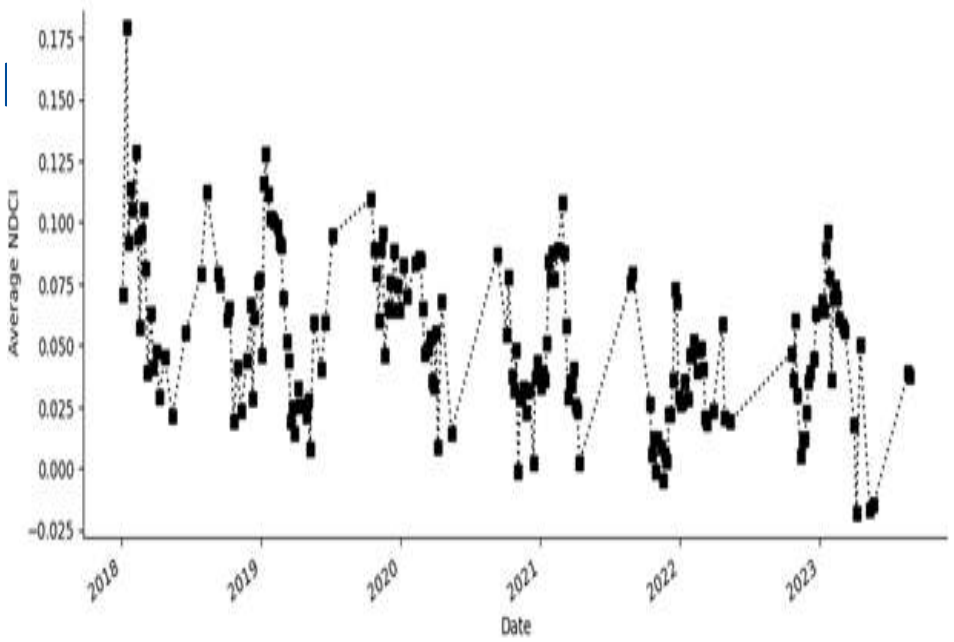
Ch-a

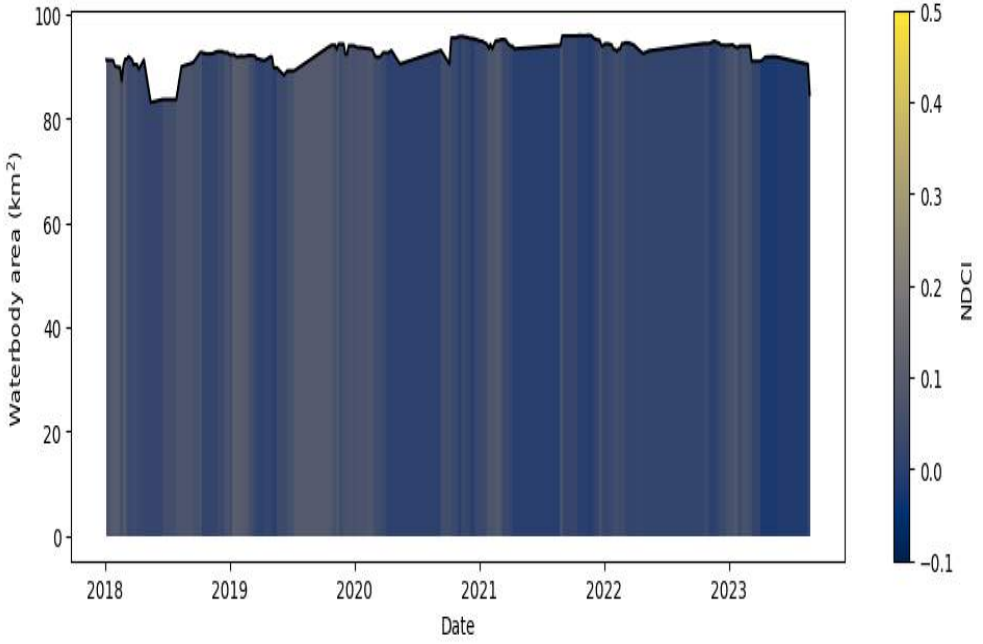
- The time-series of Ch-a of lake Ziway shows that there is spatial and temporal variation and inter-seasonal fluctuations of Ch-a consents.
- The value was 8.68 ug/L while the max was 29.31 ug/L.
- The max value was recorded on 20-Dec-19 while the least values were recorded in May



Normalized difference chlorophyll index (NDCI)

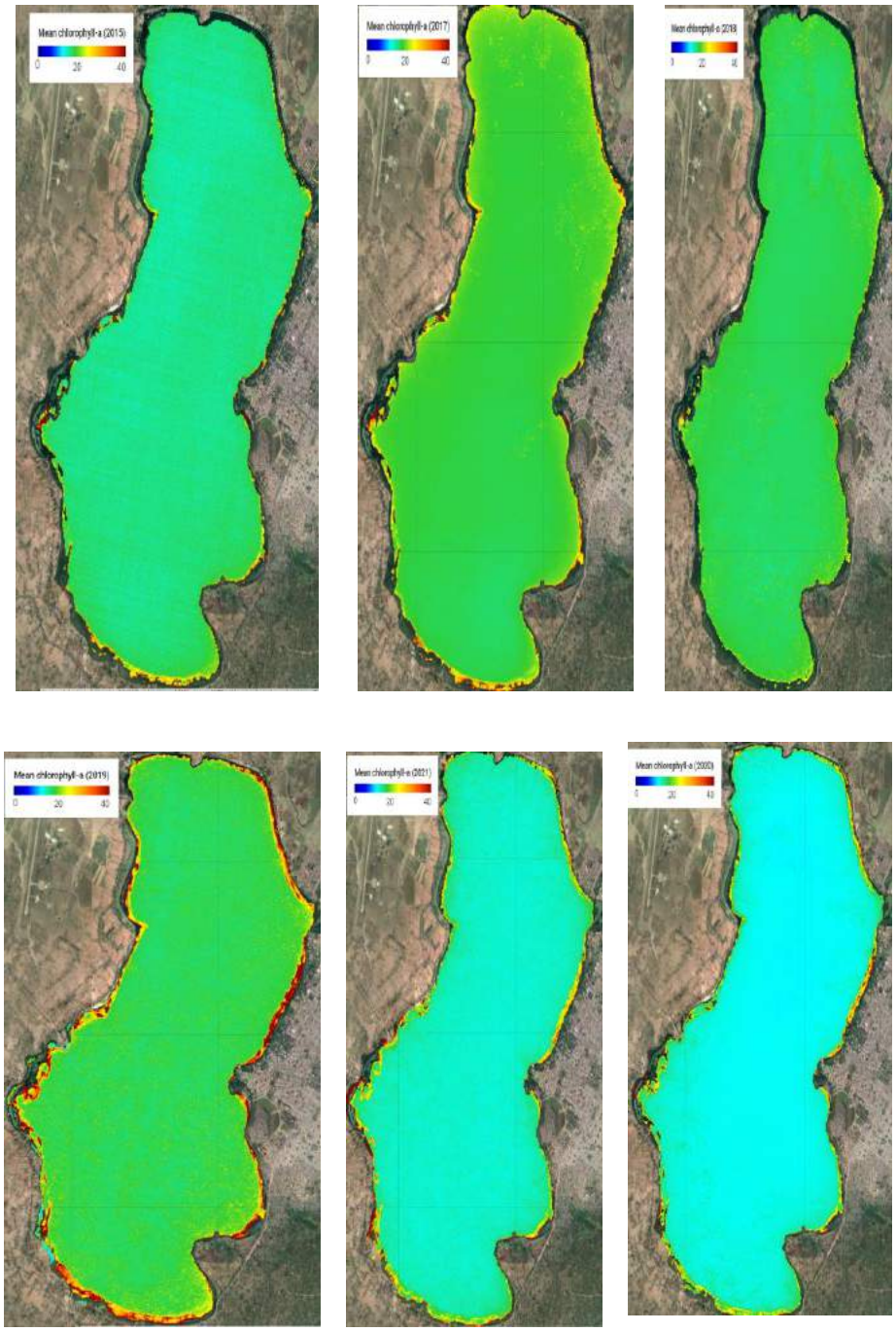
- Additionally, the NDCI trend shows that slight decrease of the concentration of chlorophyll-a from 2018 to 2023 on the surface water.
- NDCI was calculated using the red and the red edge spectral bands(Mishra et.al., 2012).
- $\text{NDCI} = \frac{\textbf{Red edge 1} - \textbf{Red}}{\textbf{Red edge 1} + \textbf{Red}}$
- Mean NDCI values are lower than 0.175 for lake Hawassa.





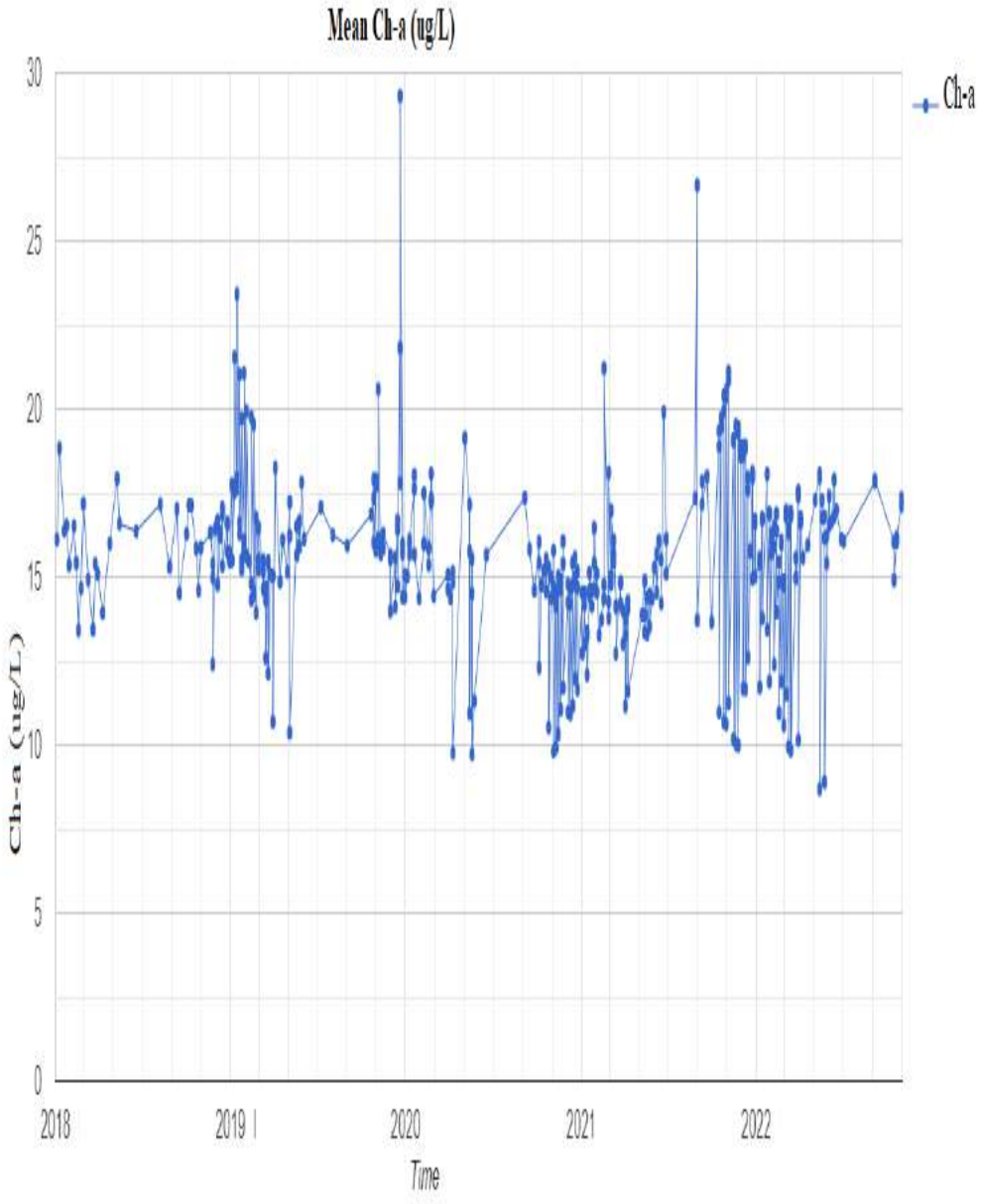
Chlorophyl-a concentration

- The time-series of Ch-a of lake Hawassa shows that there is spatial and temporal variation and seasonal fluctuations.
- In general the Chlorophyl-a concentration is slightly decreasing trend from 2018 to 2023.



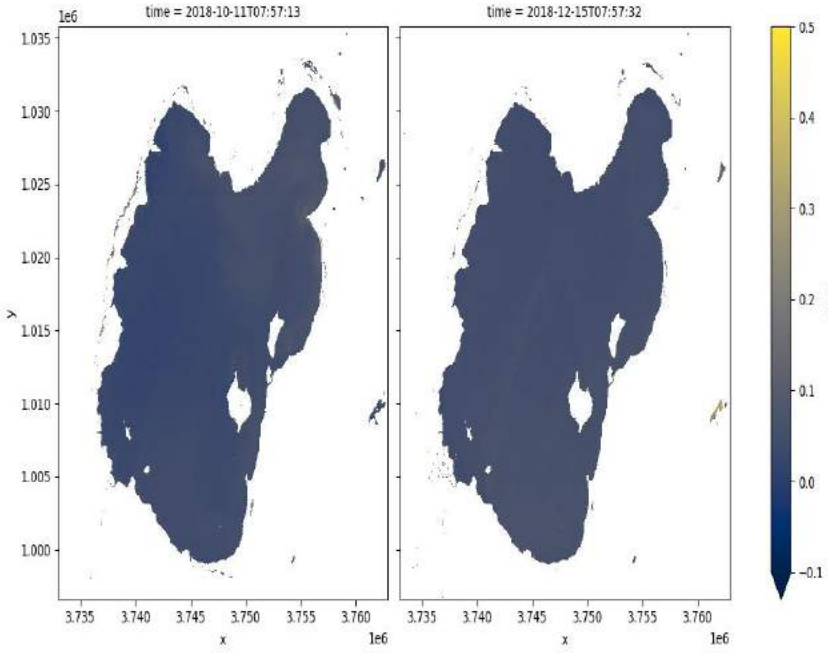
Ch-a

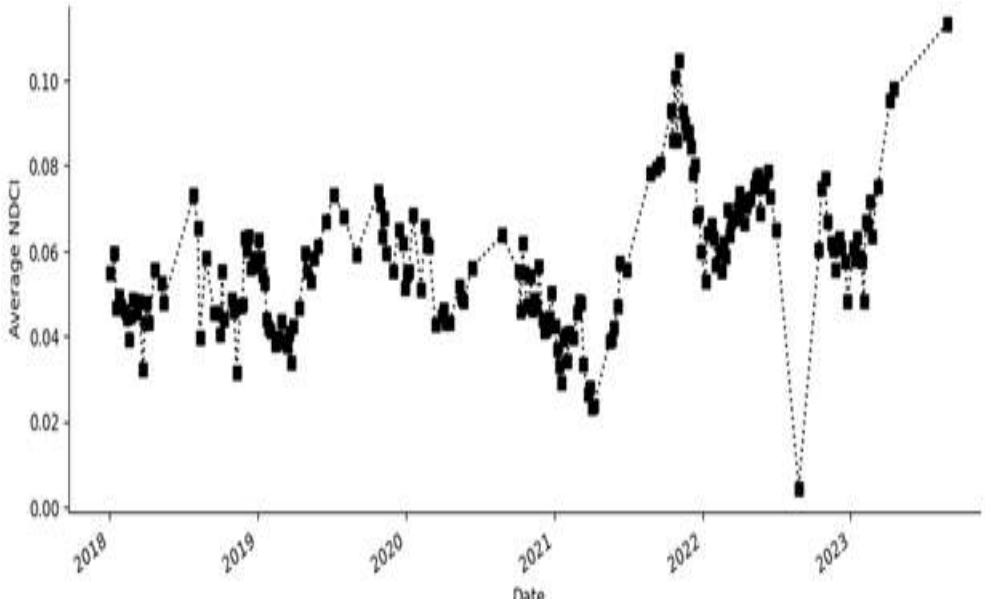
- The time-series of Ch-a of lake Ziway shows that there is spatial and temporal variation and inter-seasonal fluctuations of Ch-a consents.
- The mean Ch-a concentration was 15.59 ug/L, while the min value was 8.68 ug/L and the max was 29.31 ug/L.
- The max value was recorded during Dec while the least values were recorded in May

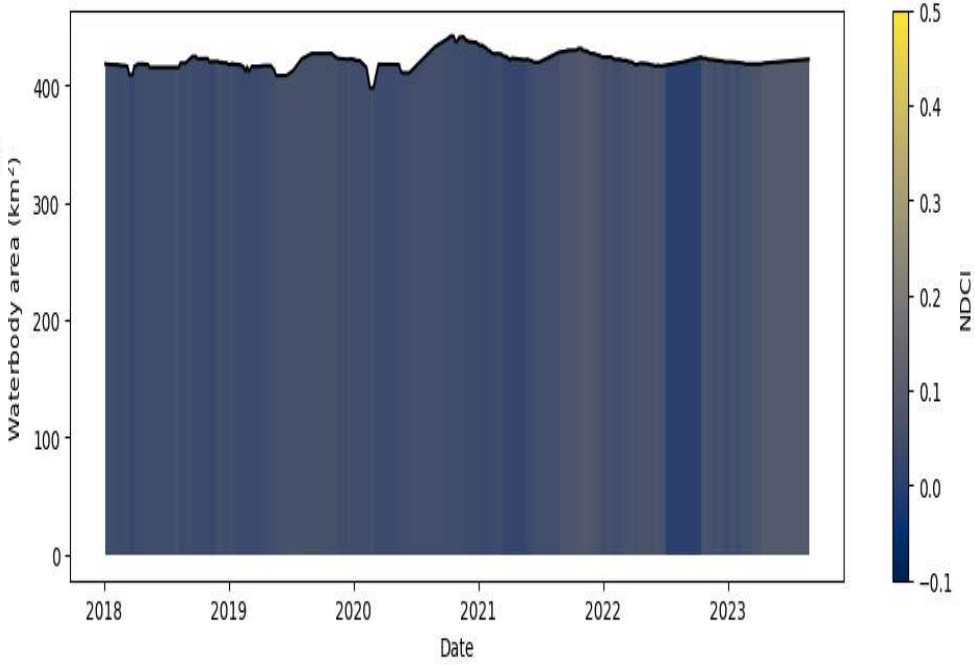


NDCI of Lake Ziway

- NDCI values are lower implying less algal bloom.

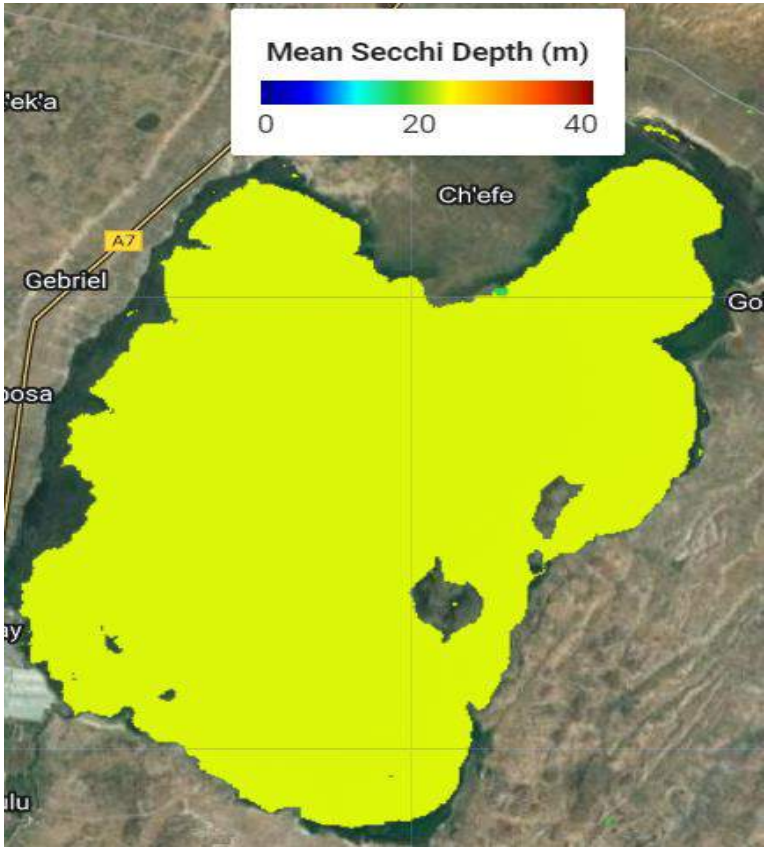


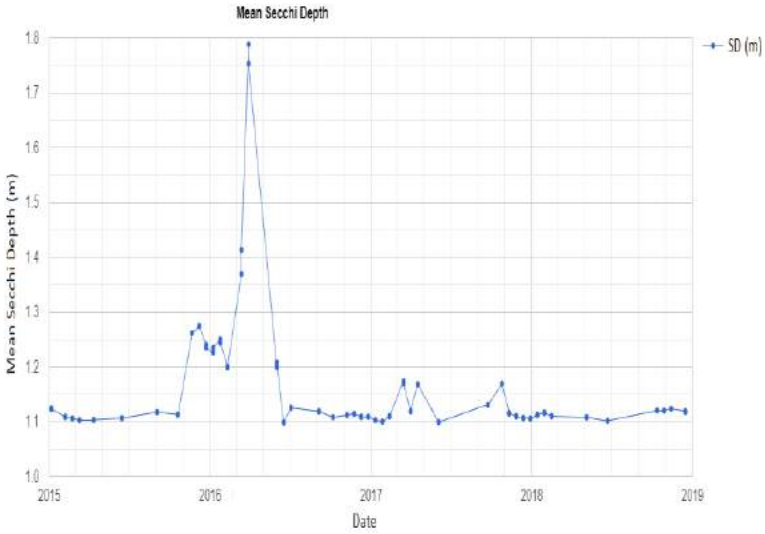




Secchi Depth (m)

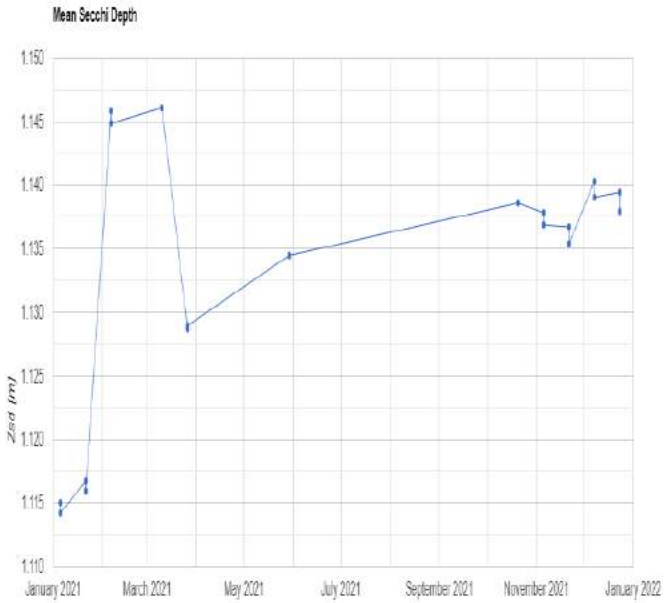
- The Secchi depth (Z_{SD}, m) has been used for characterization of lake clarity (Zhou et al., 2021).
- Inversely related to phytoplankton biomass.
- The mean Secchi depth of lake Ziway is 1.145m while the max. is 3.97 and min is 1.10

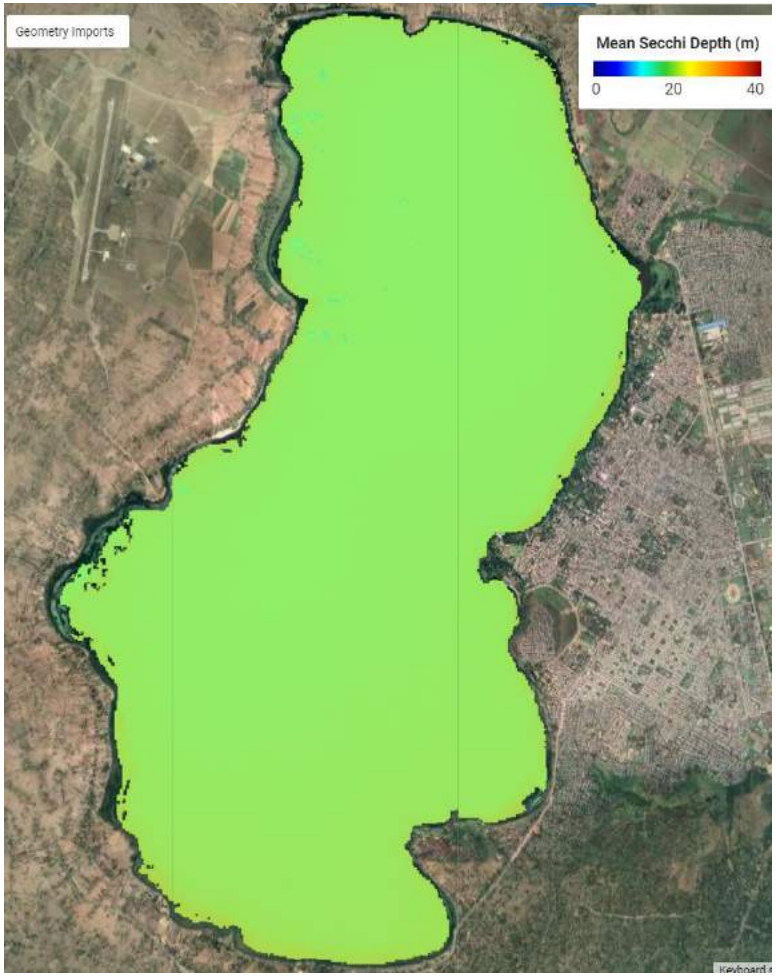




Secchi Depth (m)

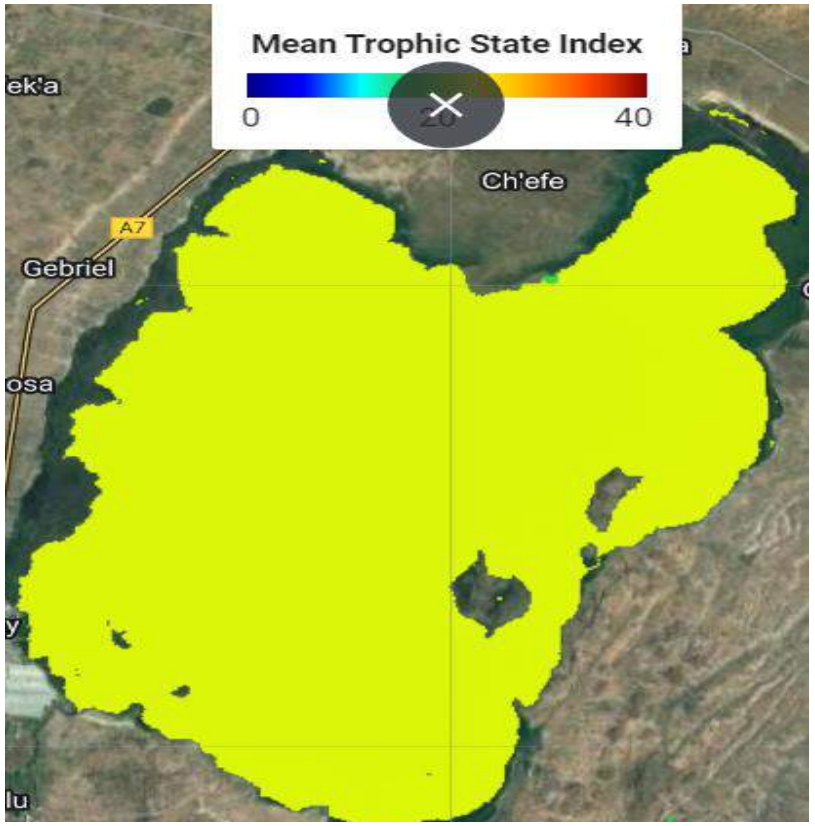
- The mean Z_{SD} of Lake Hawassa is 1.07m.
- Maximum Secchi depth is recorded during Feb month while the minimum is in January





Tropic State Index (STI)

- Used to characterize lakes based on the amount of biological productivity.
- The mean TSI is 54.22, while the max is 60.55 and min 52.47
- Based on the result the lake is Eutrophic with possible algae and aquatic plants.



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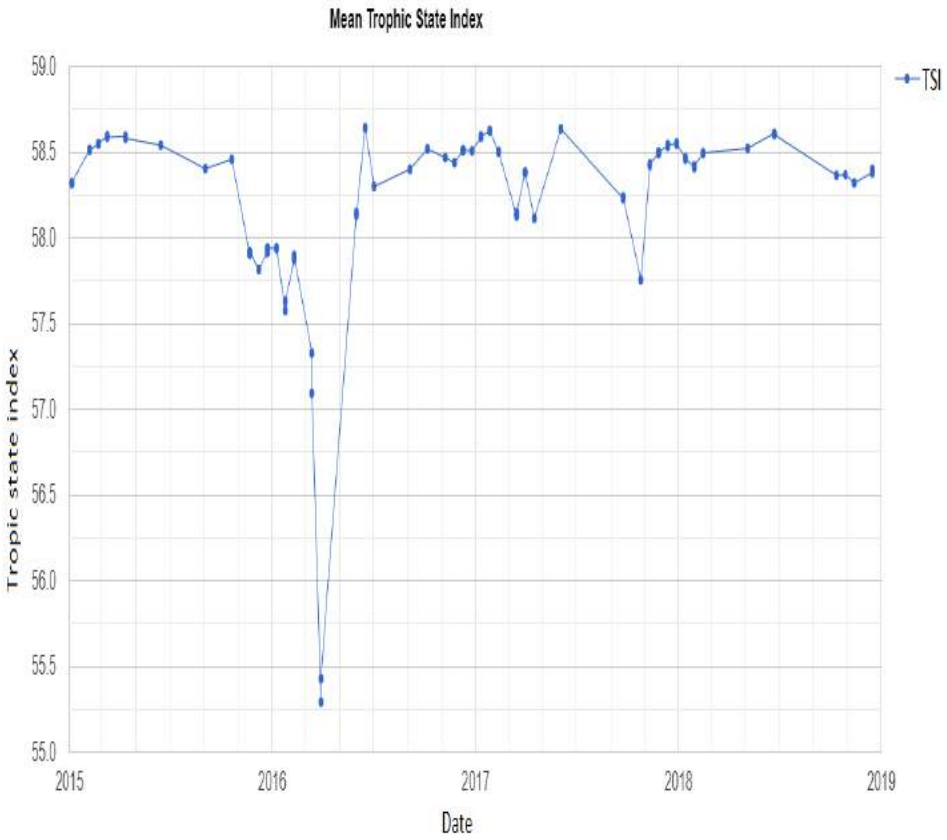
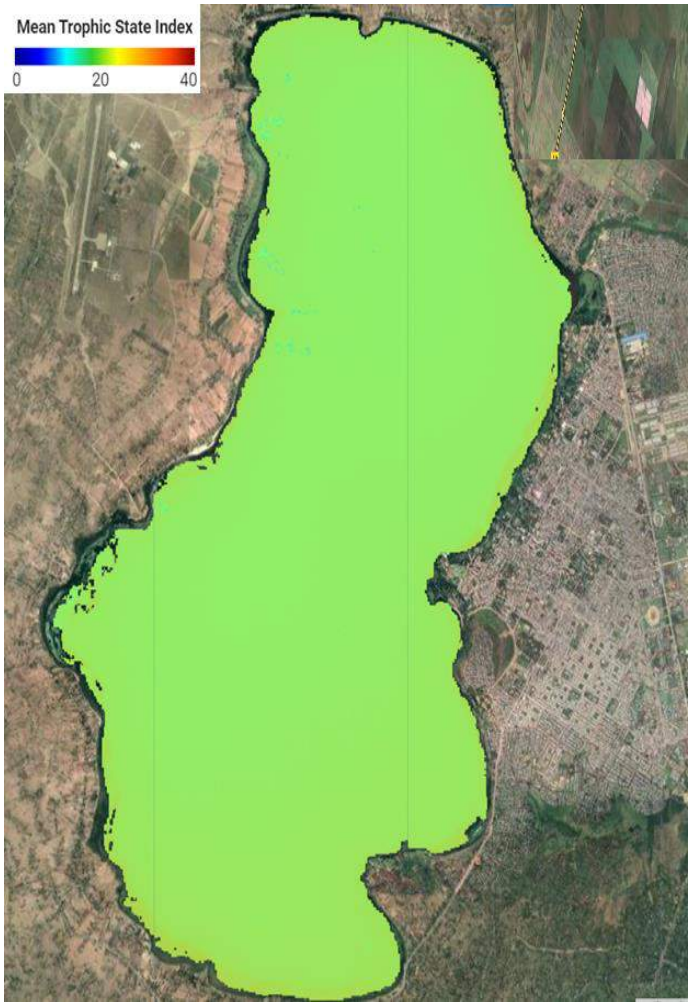
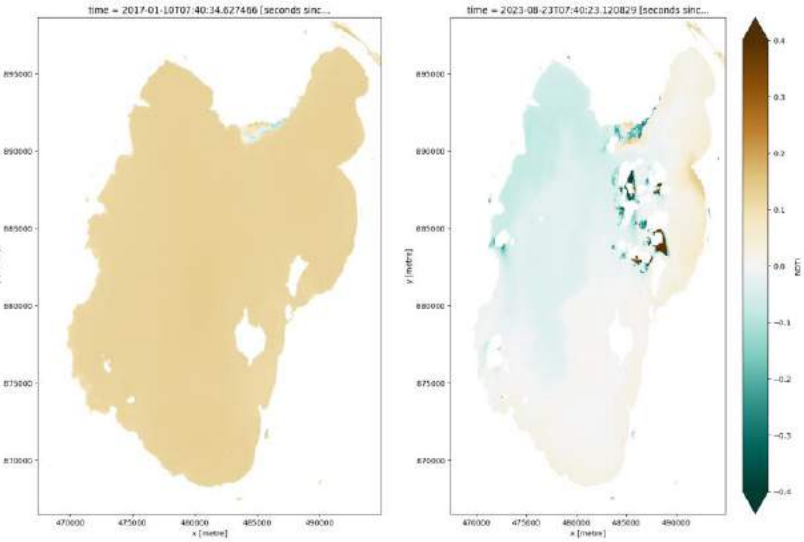




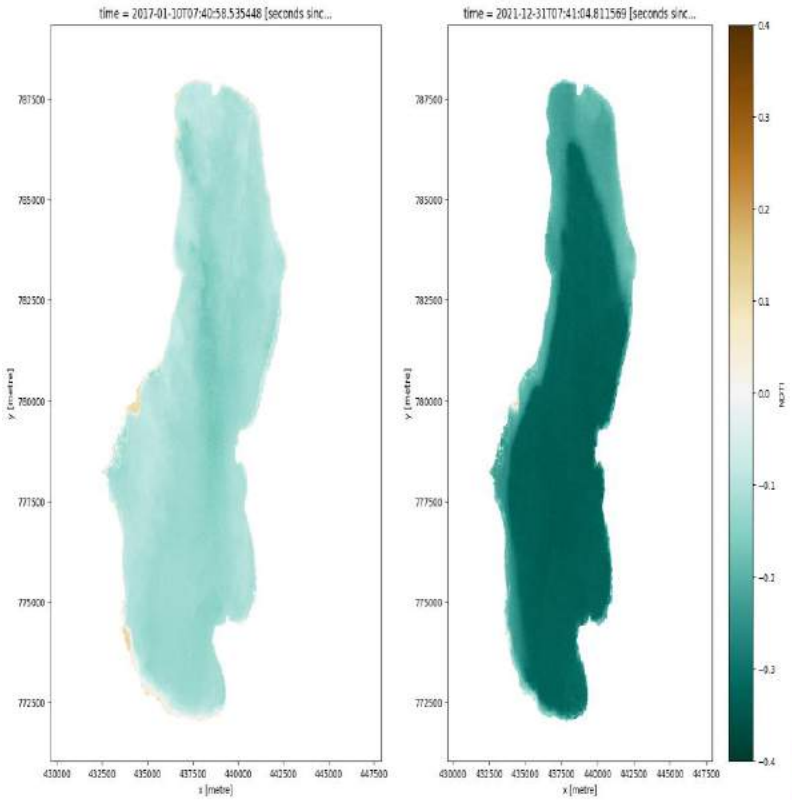
Turbidity of Lake Ziway

- Normalized difference turbidity index (NDTI): the ratio of red and green bands (NDTI = (RED-GREEN)/(RED+GREEN)) was used
- Mean NTDI is higher than the allowed turbidity in drinking water by WHO
- There is spatial and temporal variation of turbidity



Turbidity

- The turbidity of lake Hawassa wa spatially and temporally variable.
- Mean NTDI is slightly higher



Concluding points

- The water quality indices for inland lakes may depend on various purposes.
- Total suspended matter (TSM), chlorophyll-a, water turbidity, lake surface water temperature (LSWT), Secchi depth, and LWTI parameters were variable across time and space in both lakes.
- Based on the remote sensing indices, the WQ of lakes is poor
- Point and non-point source of pollutions from nearby cities and agriculture may be the main cause for changes.
- RS based parameters are useful to rapidly assess water quality.
- Riparian buffer zones of vegetation and grasses is recommended
- More results will be produced using ML and validated using point survey data.

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