Tracking Sources of excess nitrate discharge in Lake Victoria, Kenya for improved Nitrogen use efficiency in the catchment

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Lake Victoria

Nile basin- White Nile source
Shared by 3 EAC states
S.A = 68,800 km²
C.A = 195,000 km²
Kenya: S.A = 6%, C.A = 22%
Uganda: S.A = 45%, C.A = 16%
Tanzania: S.A = 49%, C.A = 44%
Supports > 30 million people

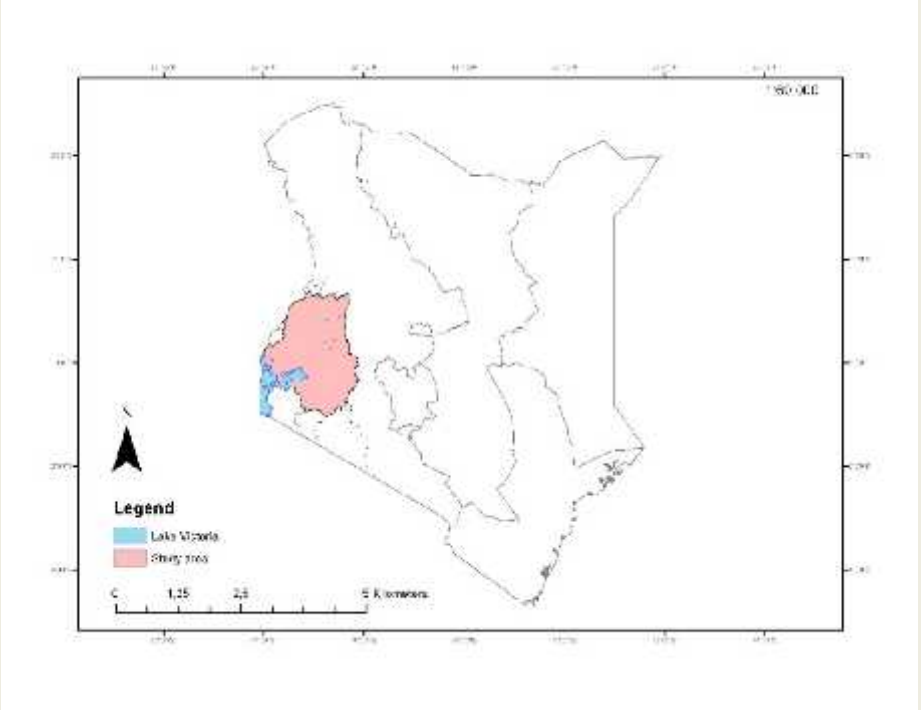
Nitrate Levels

Increasing during the last 5 decades

Lake: TALLING and TALLING (1966): 15–29 μgL^{-1}

- GOPHEN et al. (2001): 24.8 ± 21.8 μgL^{-1}
- LUNG'AYIA et al. (2001): 66.6 ± 44.0 μgL^{-1}
- GIKUMA-NJURU and HECKY (2005): 48.2 ± 21.4 μgL^{-1}
- L. SITOKI and C. EZEKIEL (unpublished): 98.7 ± 36.4 μgL^{-1}

Rivers: Raburu P and Okeyo J.B (unpublished): 4-6 mgL^{-1}



Eutrophication in Lake Victoria

Attributed to sewage effluents & agricultural runoff (Lung'ayia 2001).

Eutrophication effects in Lake Victoria

- ***water hyacinth, algal blooms***
- ***Decrease in sechi depth (5 to 1 metre)***
- ***hypoxia - decrease in fish population 1984(Ochumba, 1990)***
- ***Impairment of transportation, decrease in drinking water quality***

Nitrate pollution management

Policy and institutional framework is in place

- National and regional- WRMA, MW&I (Kenya), LVEMP, LVBC (EAC).
- **Approach = water quality monitoring network** (both lake and catchment stations).
- **Assess nitrate concentrations, against 50** mgL^{-1}**, (WHO).**

But:

- **Sources?**
- **How much each source??**

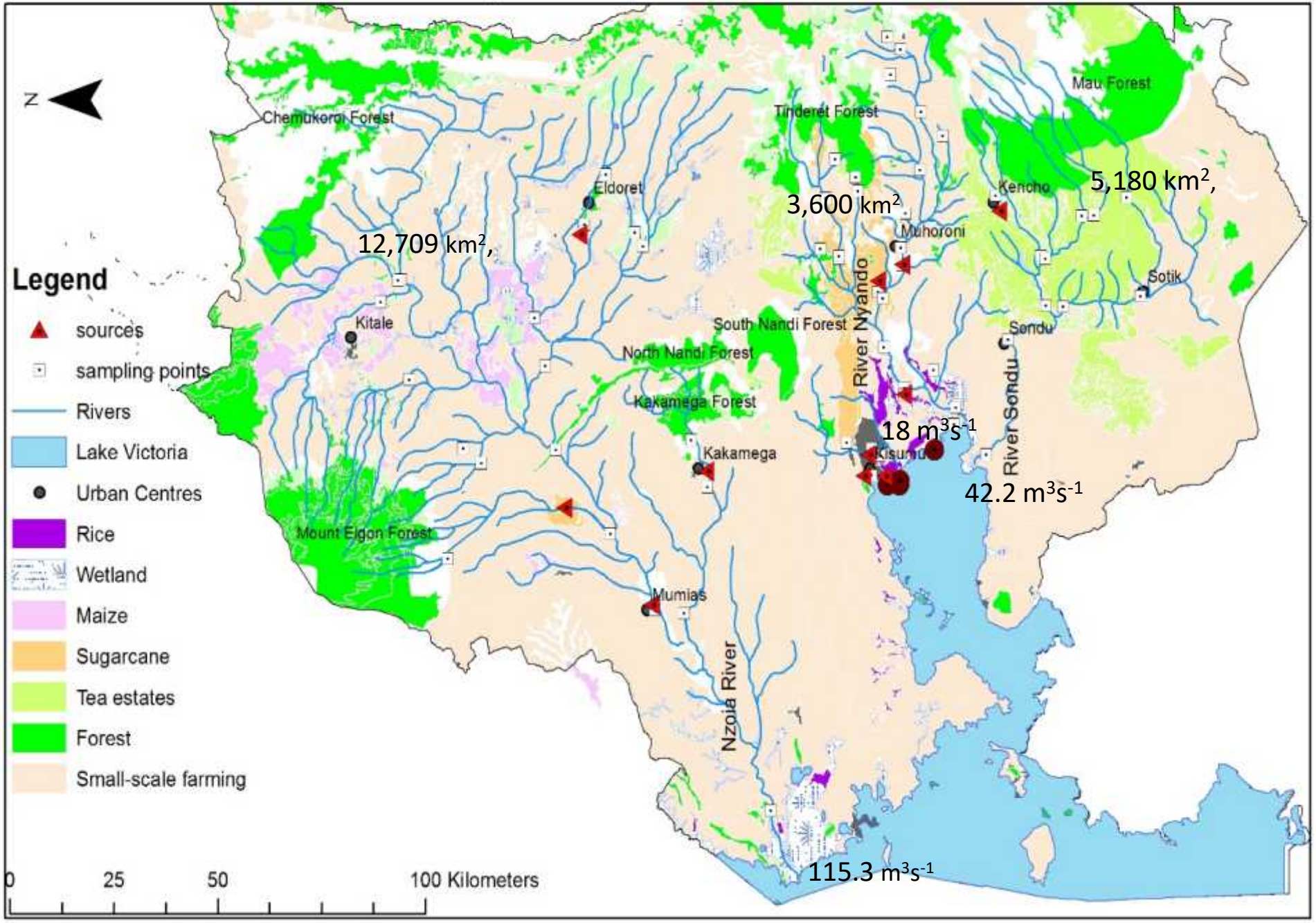
<u>Information Gap</u>

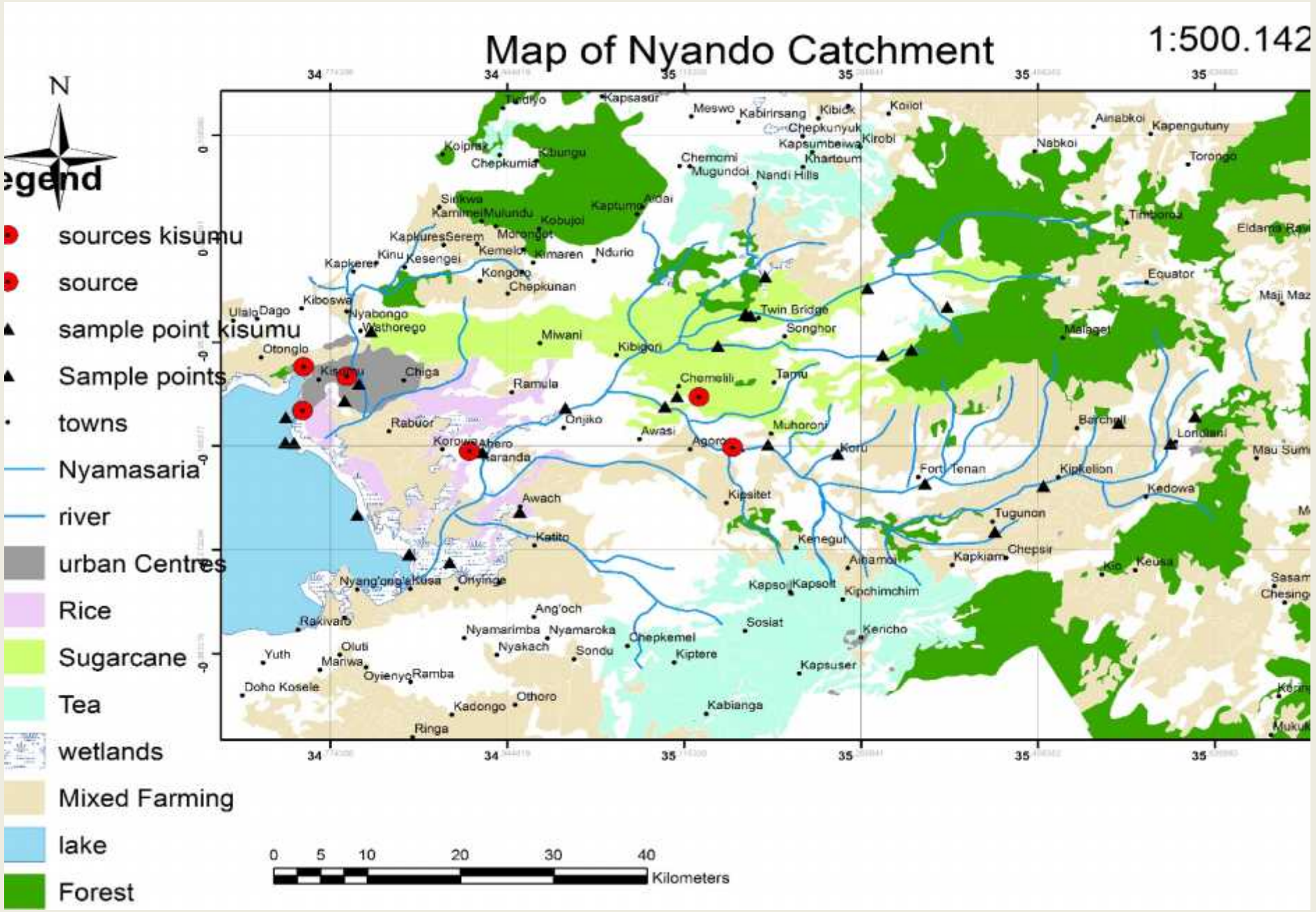
- Amount of nitrate each source contributes to the observed nitrate in the river/lake

Study objective

Apportion sources of nitrate discharged in major rivers (Nyando, Nzoia, Sondu) draining into Lake Victoria, Kenya, using isotopic ($\delta^{15}N$, $\delta^{18}O$ - NO_3^- , $\delta^{11}B$) techniques, hydrochemistry (NO_3^- , NO_2^-, NH_4^+) and mixSIAR

Landuse map of the study area - Nyando, Nzoia & Sondu river catchments

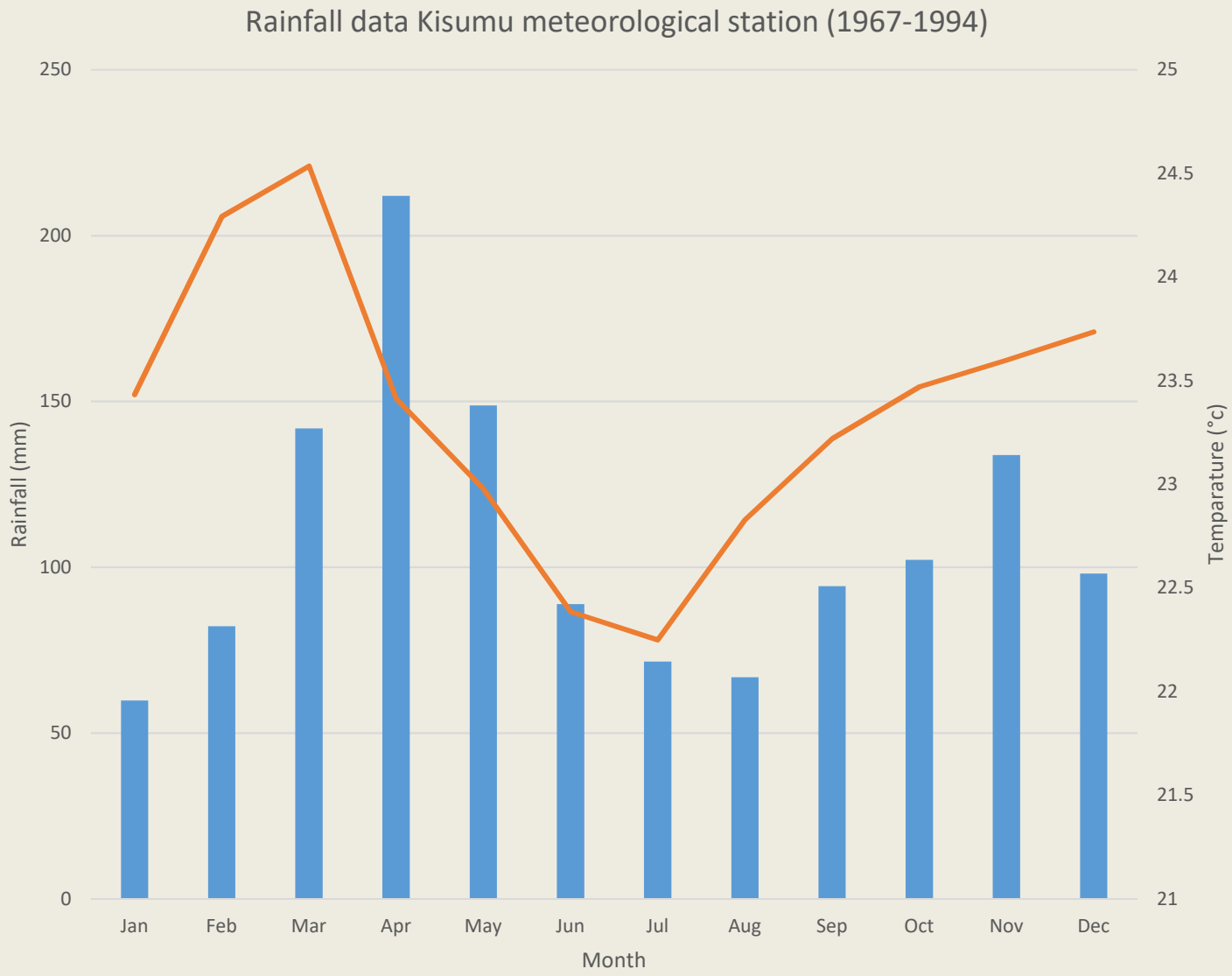




- **High population density, Fast growing towns, industries, subsistence farming, medium-large scale farms - tea, maize, sugarcane, rice, horticultural crops and livestock farming**

Study design

- **Bimodal rainfall pattern,**
- **Spatial & temporal sampling**



Results

Nitrate (mgL^{-1}) show seasonal variation:

	July_2016 (wet)	Sep_2016 (dry)
Range	0.53 – 2.7	0.61 – 4.4
Mean	0.85 ± 0.45	1.1 ± 0.85

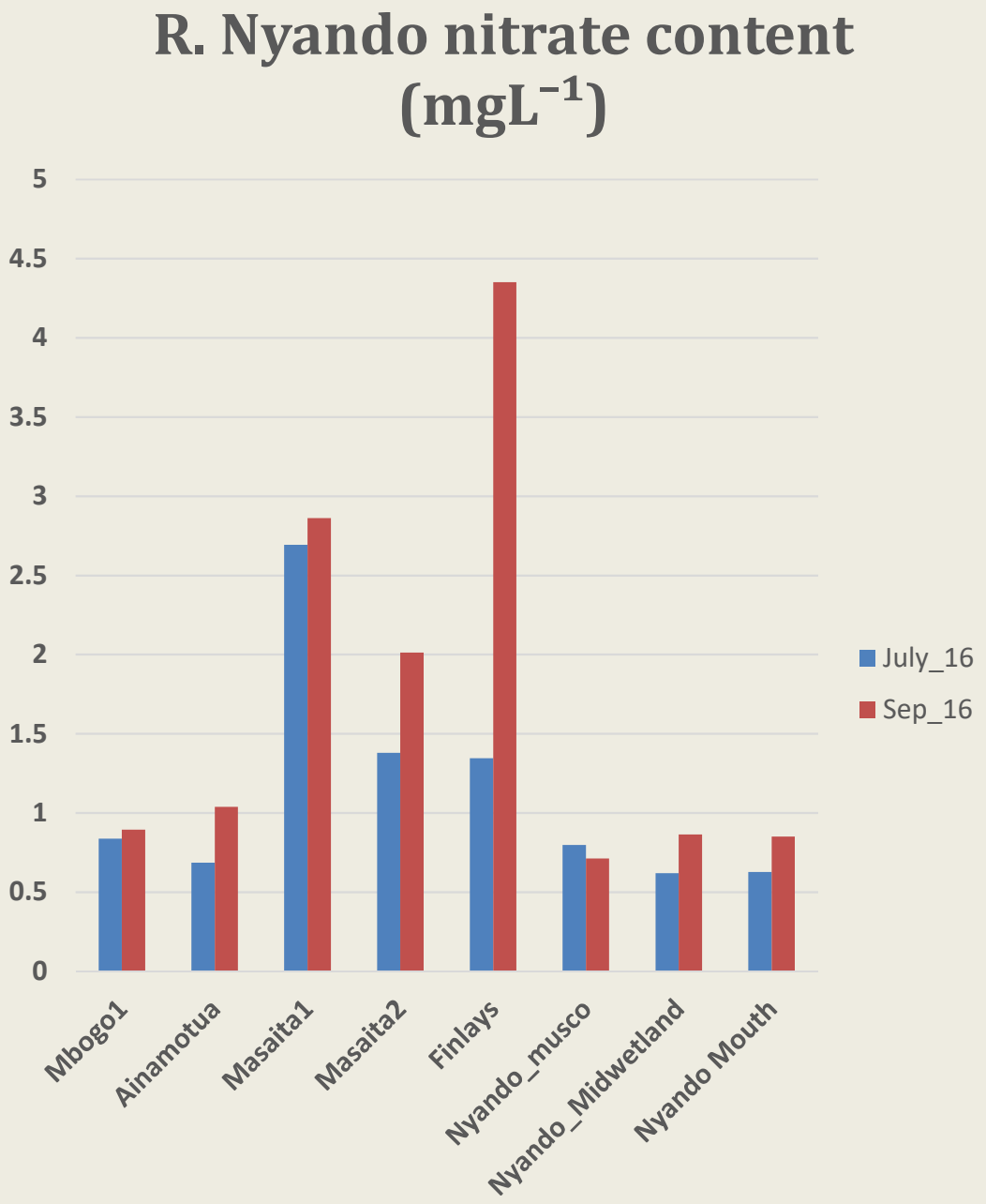
- **Nitrate discharge at river mouth**
  July_2016 = 21778 mgS^{-1}

  Sep_2016 = 6806 mgS^{-1}

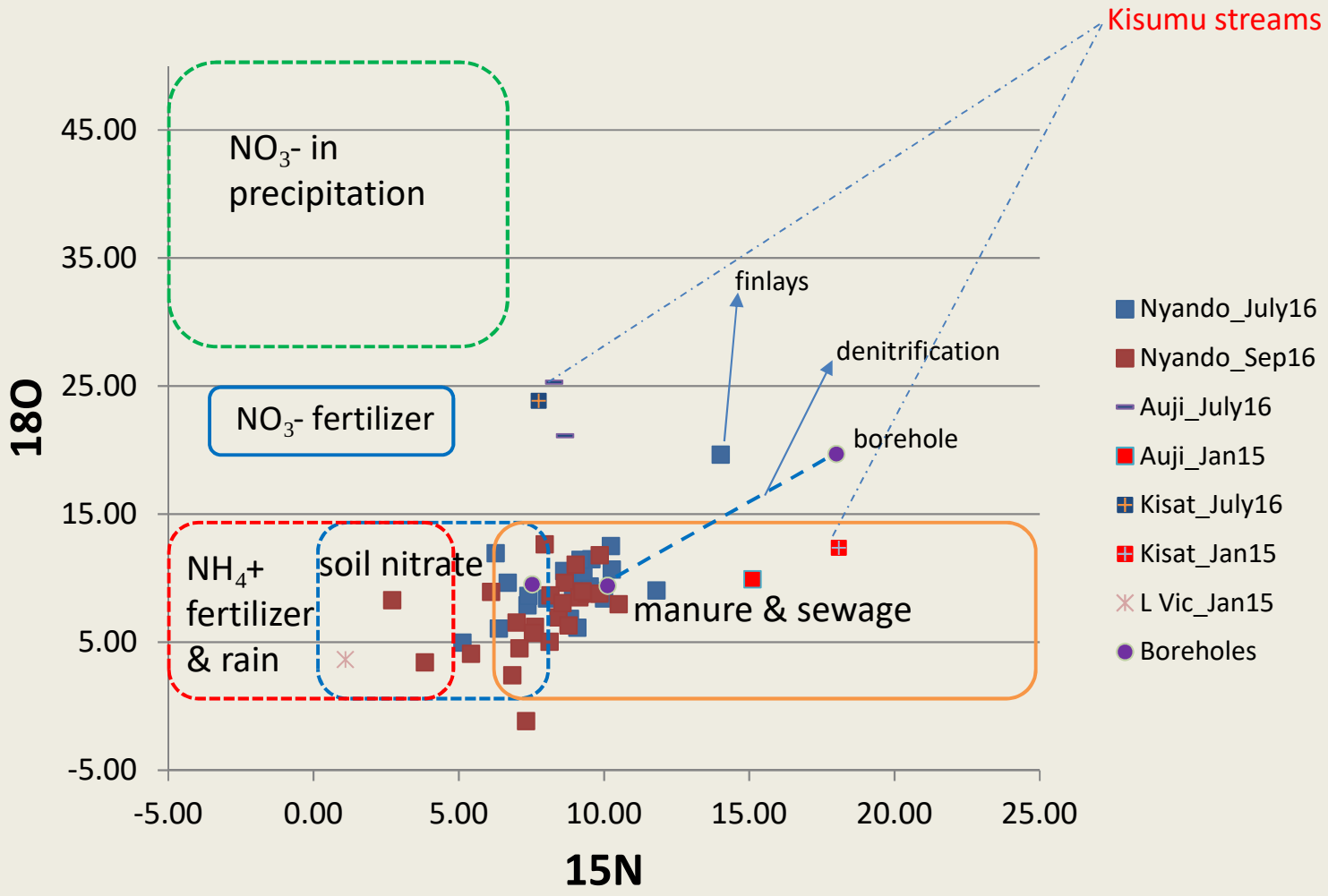
- **High N discharge during wet seasons-**

Spatial variation:

- **Mbogo – Forest tributary**
- **Finlays flower farm- commercial flower farm under irrigation**
- **Masaita - densely populated (Londiani) area, intense mixed farms & livestock**

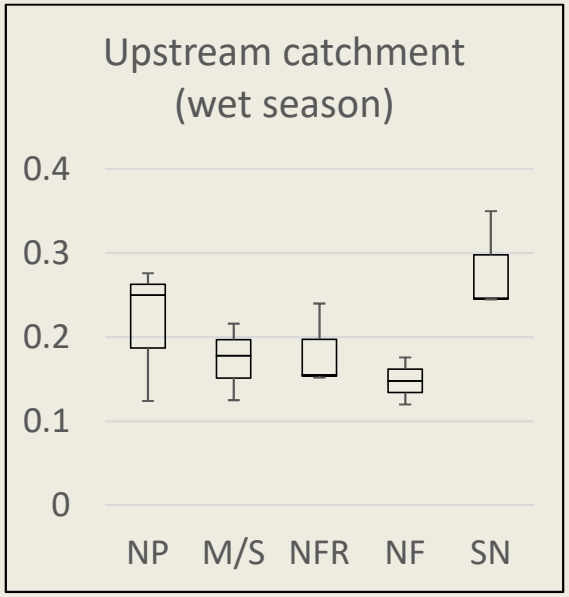


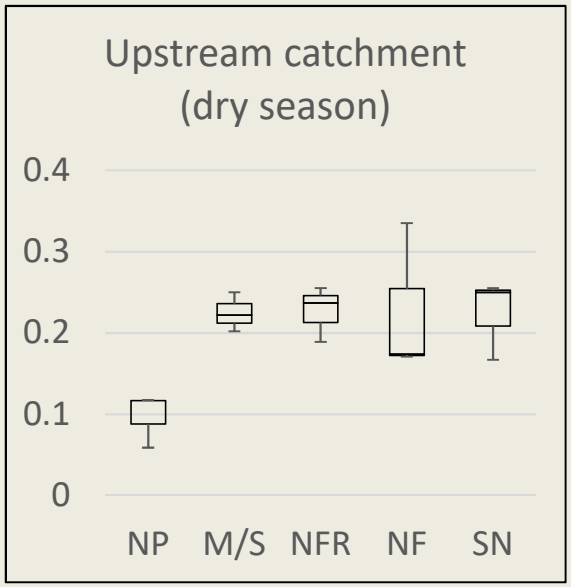
Nitrate source identification



Most samples - manure & sewage, soil nitrate
Seasonal variation- enrichment in wet season, kisumu streams
Denitrification- vector for borehole - 0.6 mgL^{-1}

Nitrate source apportionment

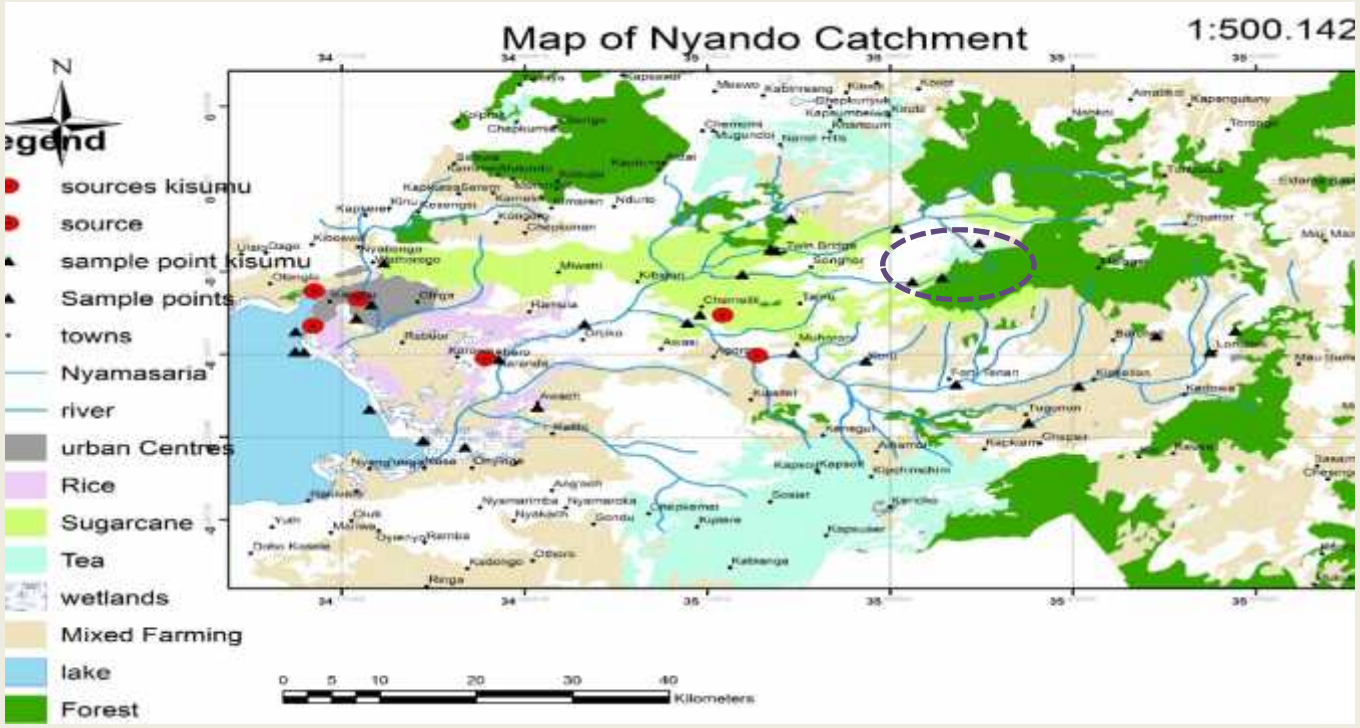




mixSIAR derived box plot of proportional contribution of 5 potential sources of nitrate discharged in river nyando

Upstream catchment

- **Natural forest** and **commercial tea** growing zone
- **Main source = soil N;** 25- 35%; highest in the forest site
- NO_3- **F:** low contribution in wet =low fertilizer application
- **NO_3- F:** major source in dry season = foliar fertilizers for tea are applied in dry season.

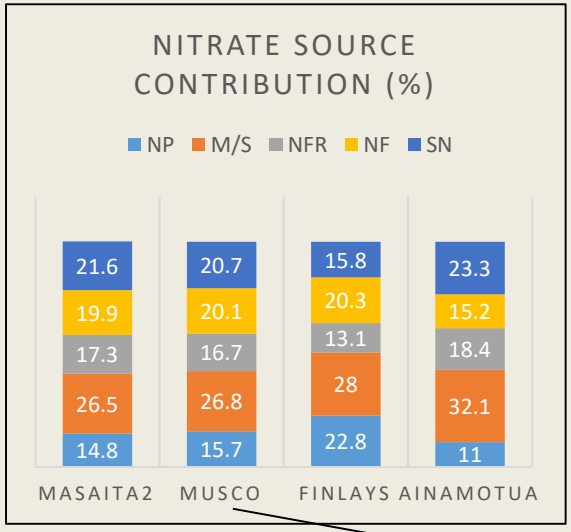


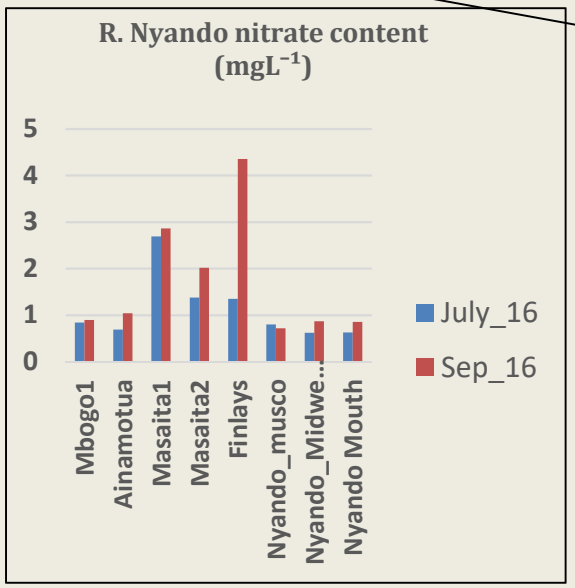
Nitrate Source apportionment- Midstream

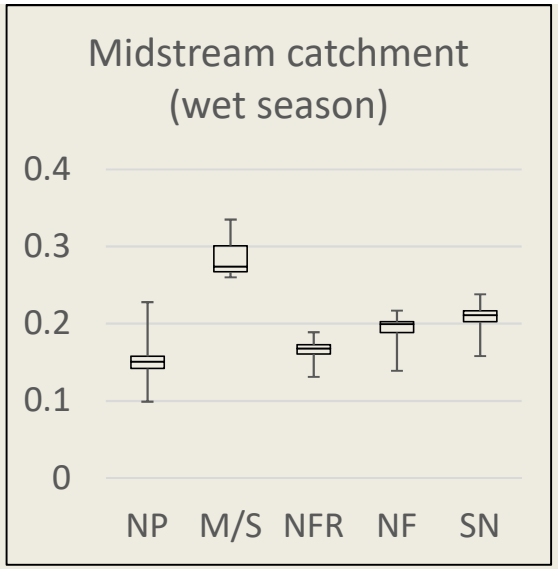
M/S dominates: 27- 35% wet season

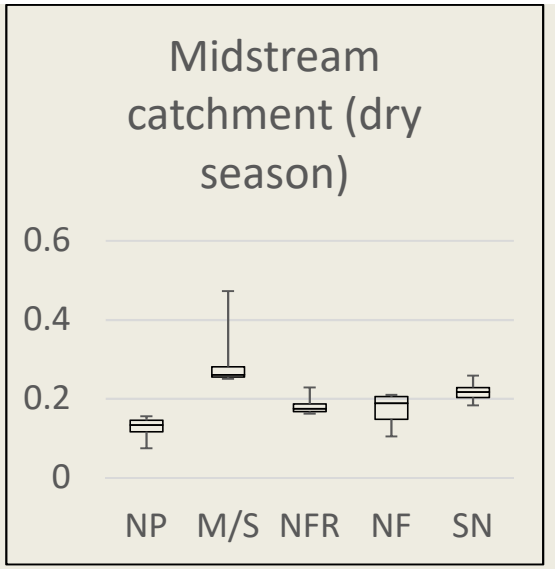
25 – 47% dry season

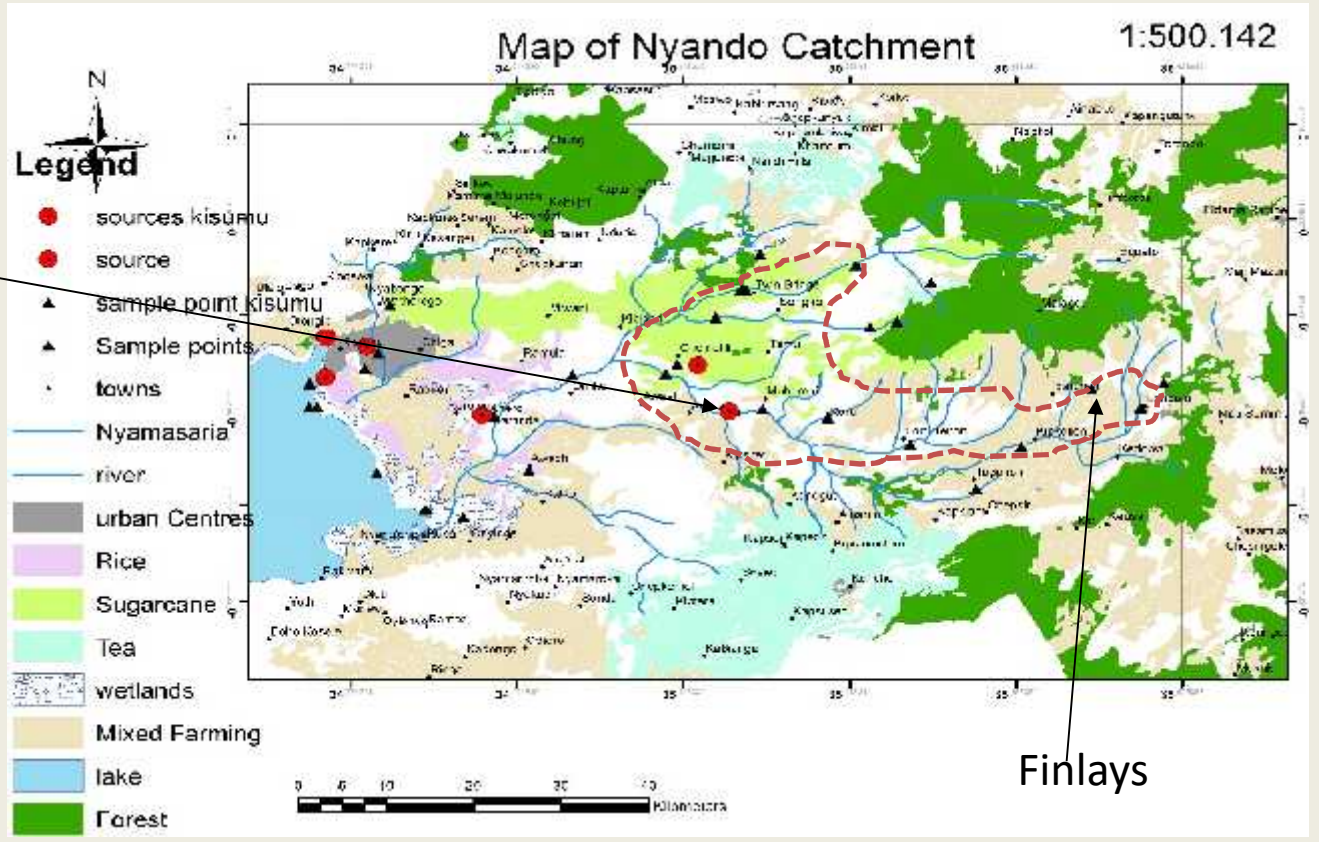
Soil N: 20 – 28%, esp. wet season







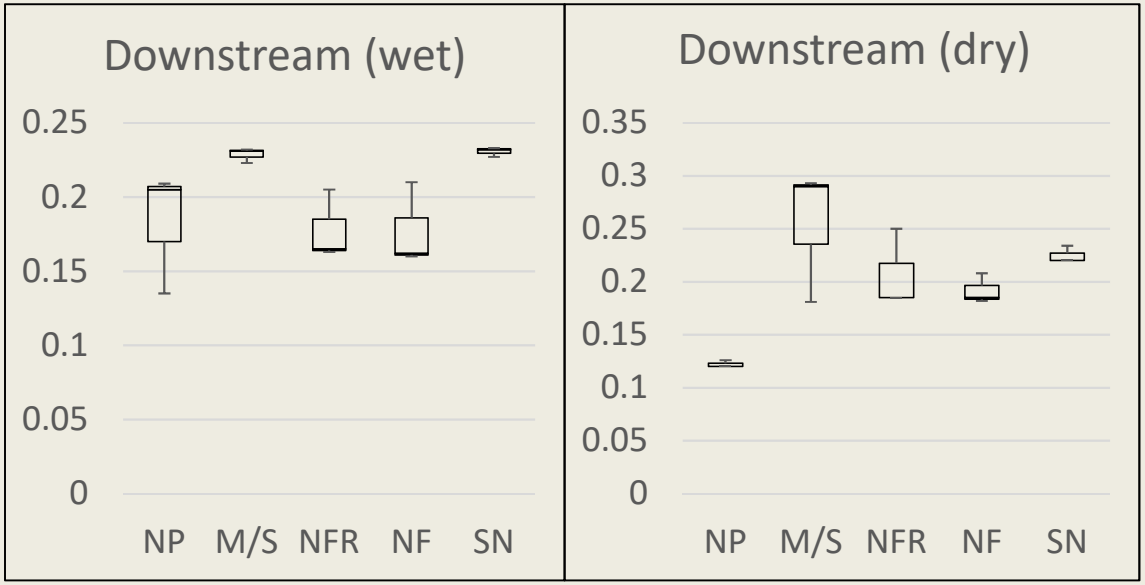


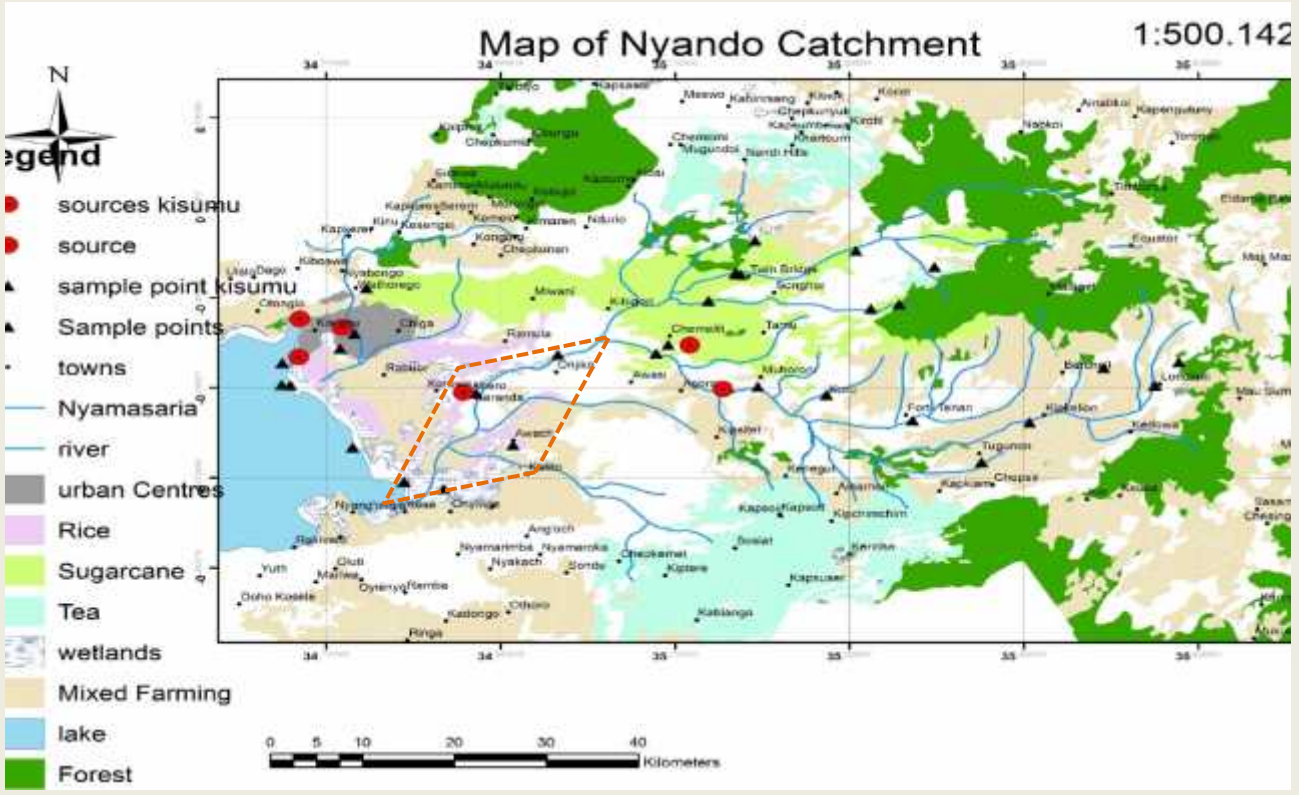


Nitrate Source apportionment-

<u>Downstream catchment</u>

- Flat land (kano plains)
- M/S and SN had similar contribution =23%
- Turbid (> 500 ntu) water





Key observations & further studies

1. Several sources of nitrate *discharge into river nyando*: **mixture**

a) manure & sewage main source in midstream catchments - high population density, mixed farms and sugar industry

b) Significant nitrate fertilizer contribution from commercial farms – Sugar, flower farms.

To be Studied

- Nitrate fate and dynamics in the rivers
- Apportionment of manure and sewage sources **($\delta^{11}B$)**
- Long term seasonal/ spatial trend of nitrate sources
- Groundwater nitrate source apportionment and susceptibility to surface water pollution

THANK YOU