Understanding the Environment, Promoting Health in Lake Baringo and Bogoria Drainage Basin

RIFT VALLEY LAKES-LEVEL RISE AND FLOOD CHALLENGES

Lakes Nakuru, Bogoria, Baringo

Onywere, et al
Kenyatta University
onywere.simon@ku.ac.ke
onywere@gmail.com

NACOSTI - Project participants

- **Prof. Simon M Onywere** – Kenyatta University and **Team Leader** (geospatial mapping and environmental health analysis)
- **Prof. Chris Shisanya** – Kenyatta University (Biodiversity assessment, irrigation agriculture and water quality)
- **Prof. Joy Obando** – Kenyatta University (Community livelihood systems and health)
- **Dr. Daniel Masiga** – ICIPE (Bacteriological analysis)
- **Mr. Zephania Irura** – Division of Diseases Surveillance and Response (DDSR), Ministry of Public Health and Sanitation – (health implications of consumption of contaminated waters)
- **Dr. Nicholas Mariita** – Kengen (geophysical survey and mapping of shallow aquifers)
- **Mr. Huron Maragia** - Mines and Geology (Chemical analysis, geochemistry and geohazards
- **Mr. Antony Oduya Ndubi** - FAO Somalia, SWALIM Project (Image Data analysis)

Unprecedented lakes level rise in the Rift Valley

- **Are we prepared for the consequences?**
- Recent events in the rift valley in Kenya and at least since the long rains of 2011 have seen a consistent and increased recharge into all the Rift Valley lakes
- This has lead to the lake levels rising to unprecedented levels since 1963 when the event was last observed.
- Historical records also indicate a flooded lake environment in 1901
- The effects of the increasing water volume in rift valley lakes are yet to be comprehensively evaluated and documented

Onywere et al (2013) - KU

Understanding the extent of spread of the flooding lakes

- Remote sensing images for January 2010 (dry season), May 2013 and September 2013 show a drastic increase in water volume and the area flooded in 3 popular lakes in the Rift Valley (Nakuru, Bogoria and Baringo)
- The detrimental effects on the ecosystem, the settlements, the infrastructure and the biodiversity is immense as witnessed from a ground truth survey that followed the Landsat image interpretation conducted by the Kenyatta University team
- Notably, the increase in water volumes between the month of May and September 2013 has been significantly high indicating that the situation will not cease soon

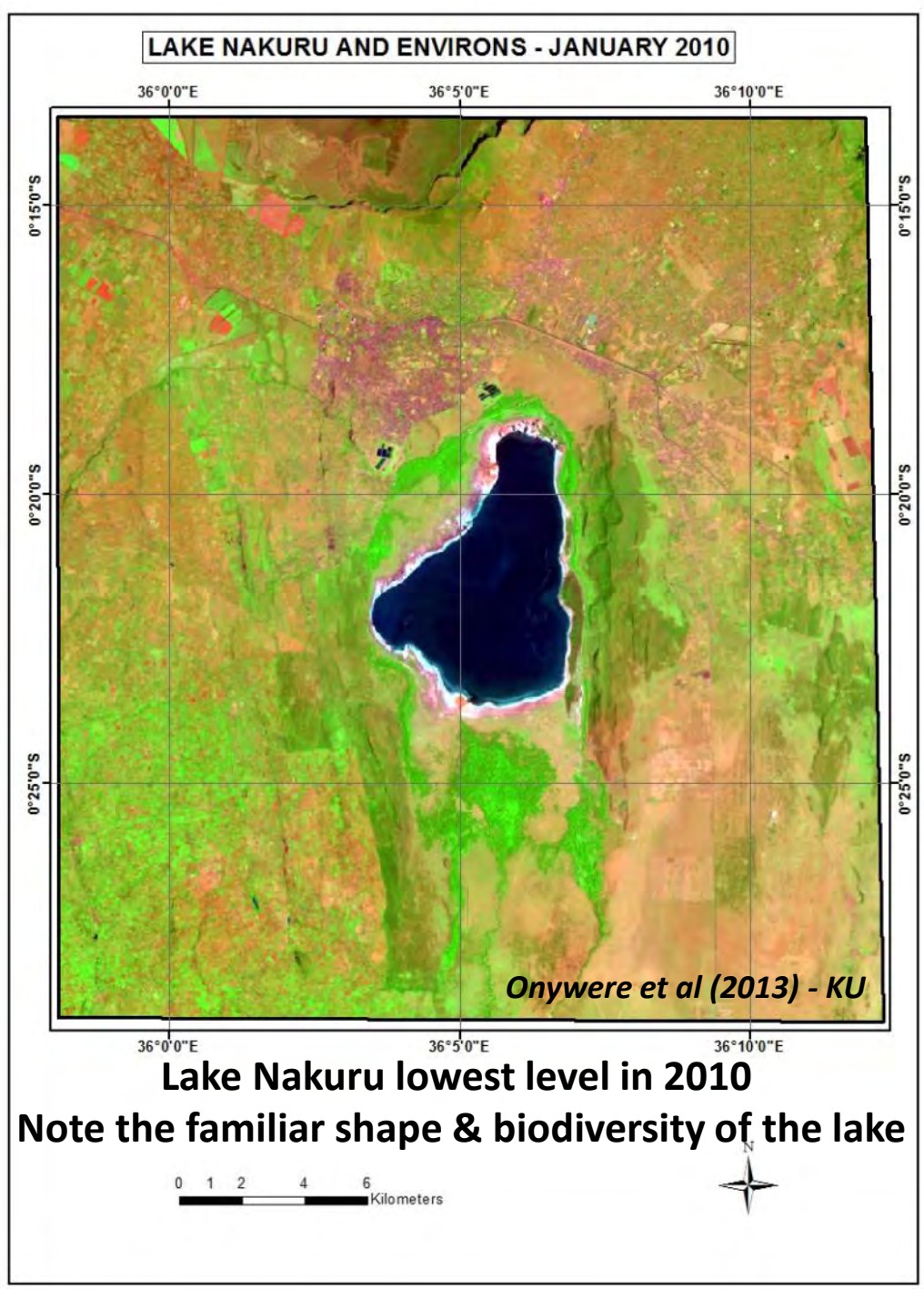
Onywere et al (2013) - KU

Lake Nakuru

- The lake has shown increasing water levels since the long rains of 2011 and was the first of the rift valley lakes to burst its bank.
- Increasing its flood area from a low area of 31.8 Sq. Km in January 2010 to a high of 54.67 Sq. Km in Sept 2013, an increase of 22.87 Sq. Km (71.92% increase by area)
- The changes are illustrated in the image data and digitize maps that follow:

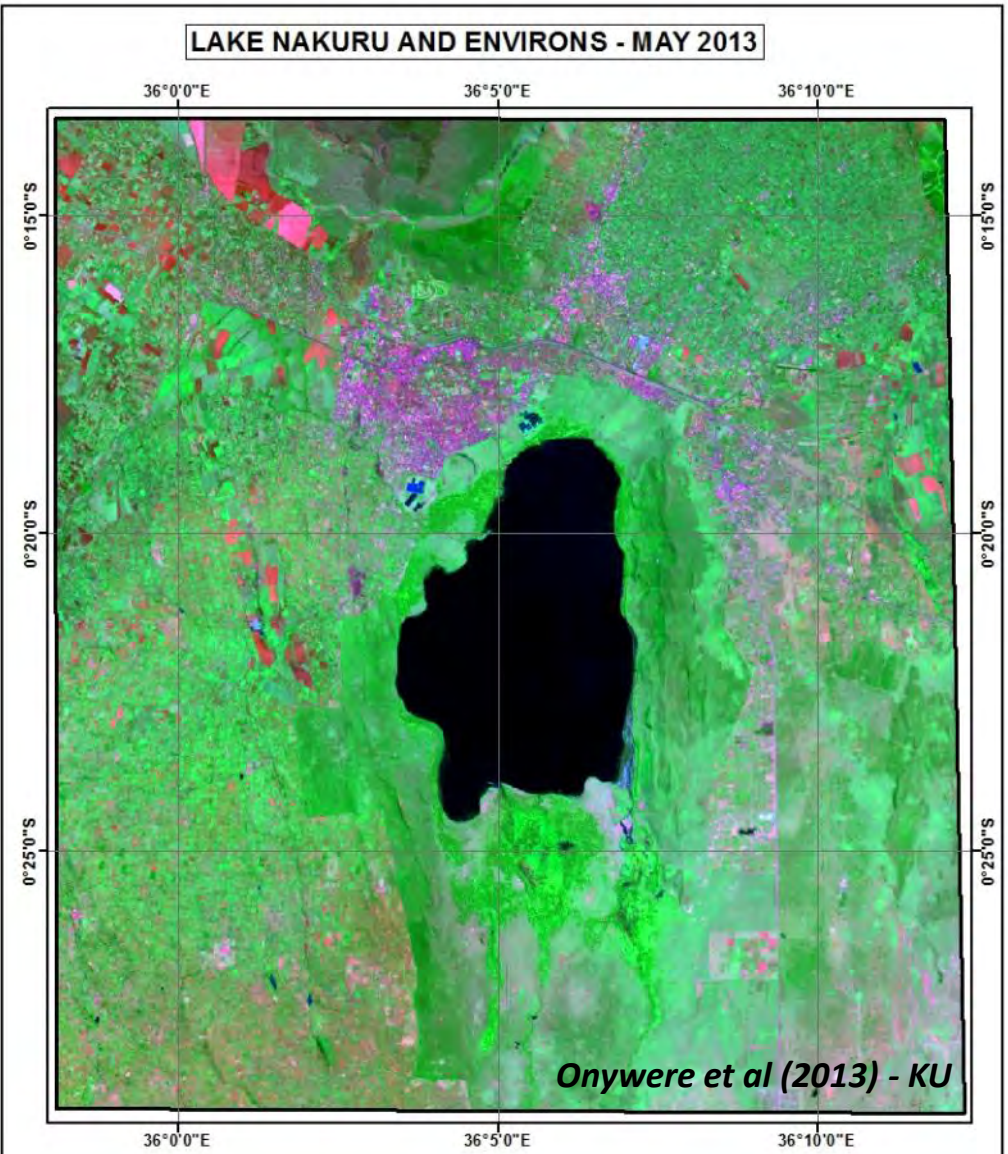
Nakuru	Sq. Km	Dif.	% incr.
Jan. 2010	31.80		
May, 2013	52.79	20.99	66.01
Sept., 2013	54.67	22.87	71.92

Onywere et al (2013) - KU

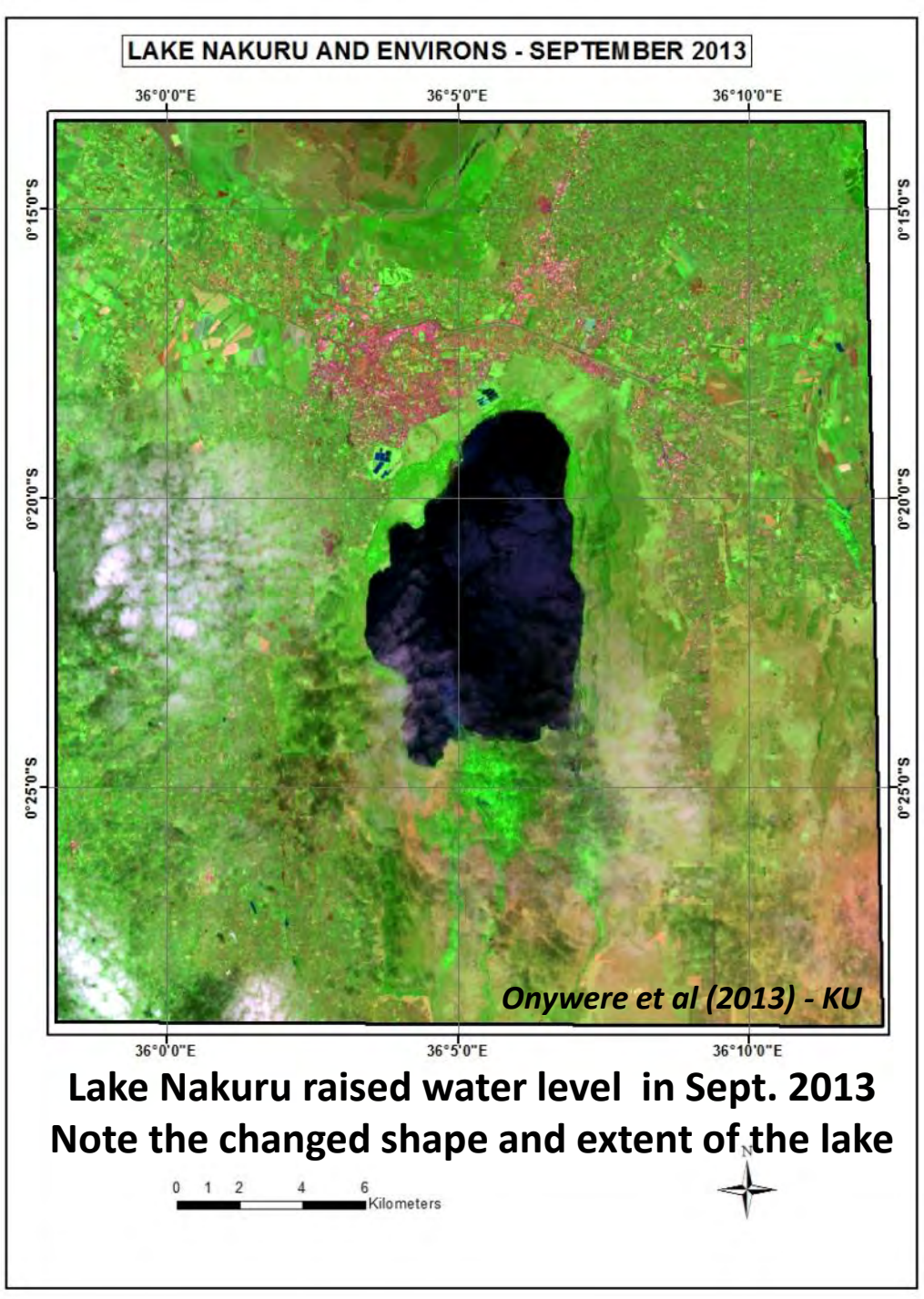


Lake Nakuru lowest level in 2010

Note the familiar shape & biodiversity of the lake



Lake Nakuru raised water level in May 2013
Note the changed shape and extent of the lake



Lake Nakuru raised water level in Sept. 2013

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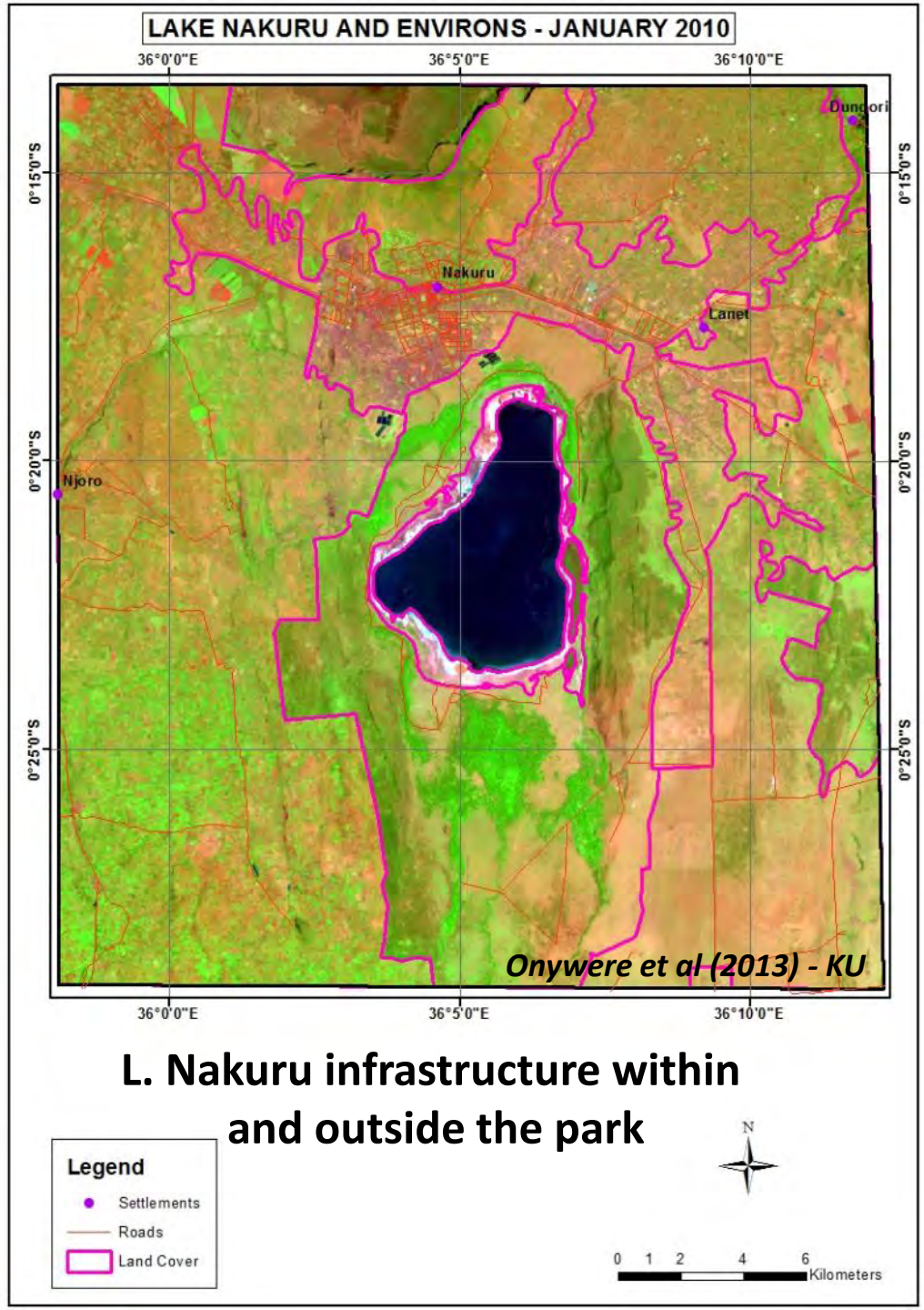
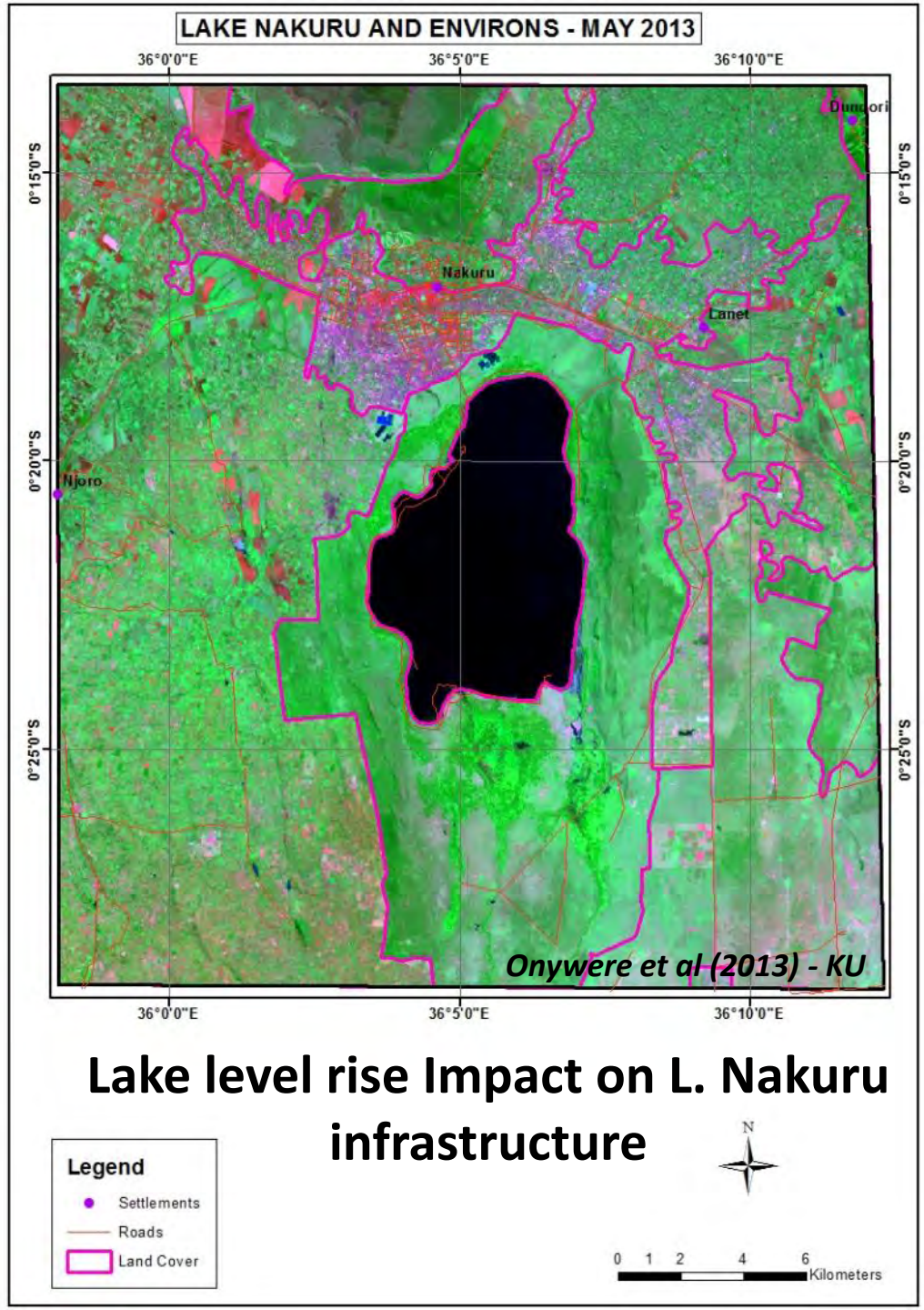


L. Nakuru infrastructure within and outside the park

Nakuru	Sq. Km
Jan. 2010	31.80



Lake level rise Impact on L. Nakuru infrastructure

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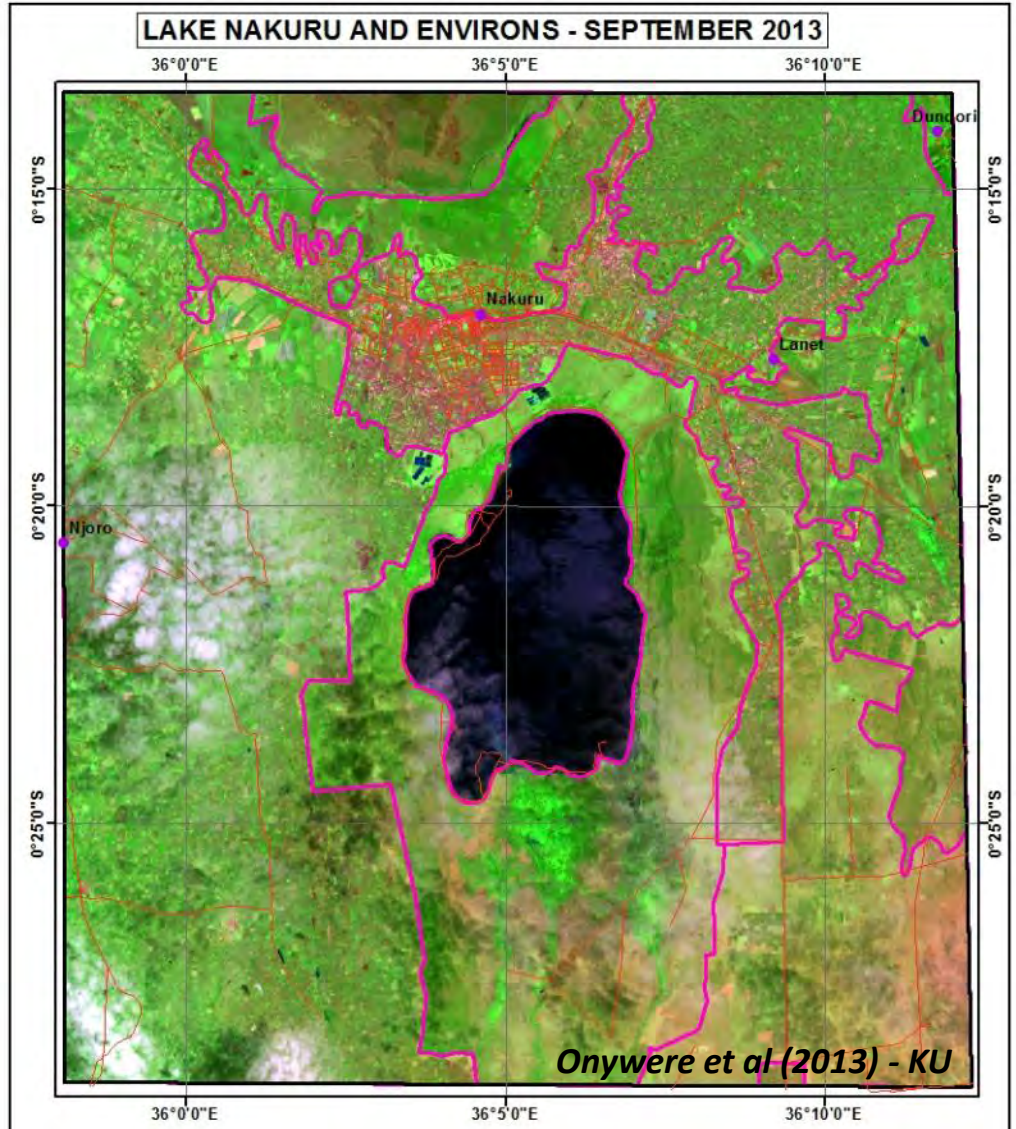

Lake level rise Impact on L. Nakuru Tourism Resources & infrastructure

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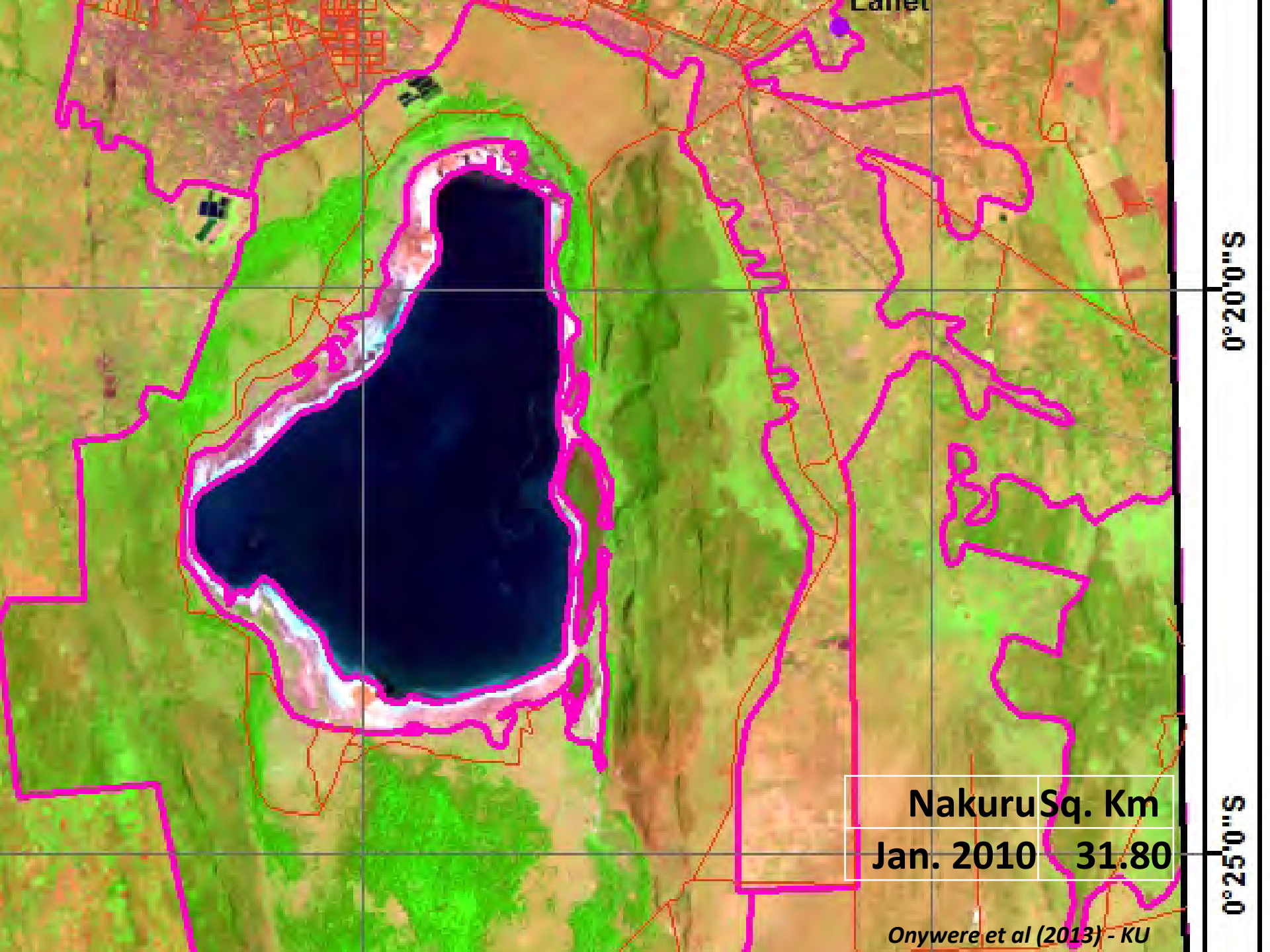
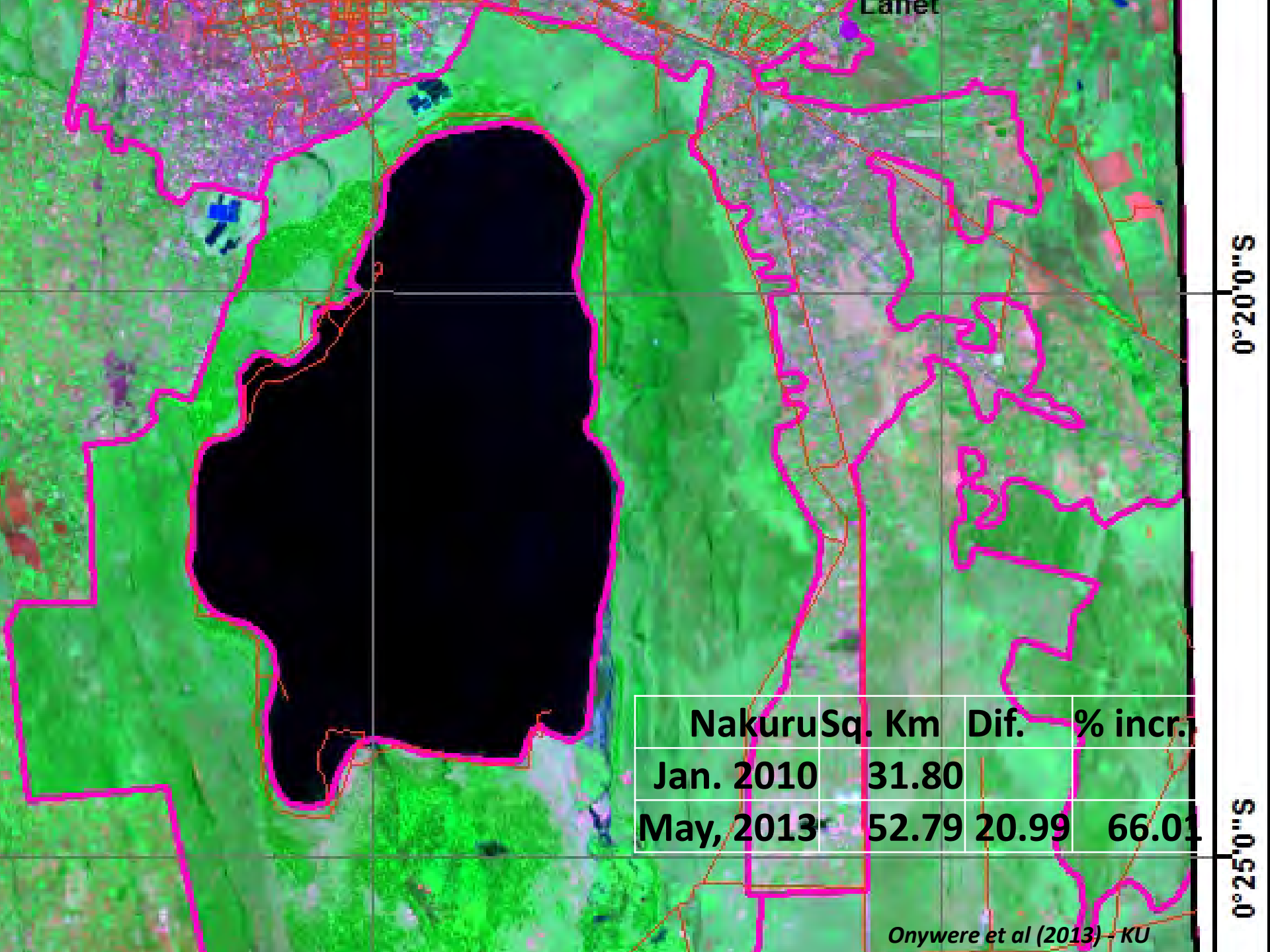

Lanet
0°20'0"S
0°25'0"S
Nakuru Sq. Km
Jan. 2010 31.80
Onywere et al (2013) - KU



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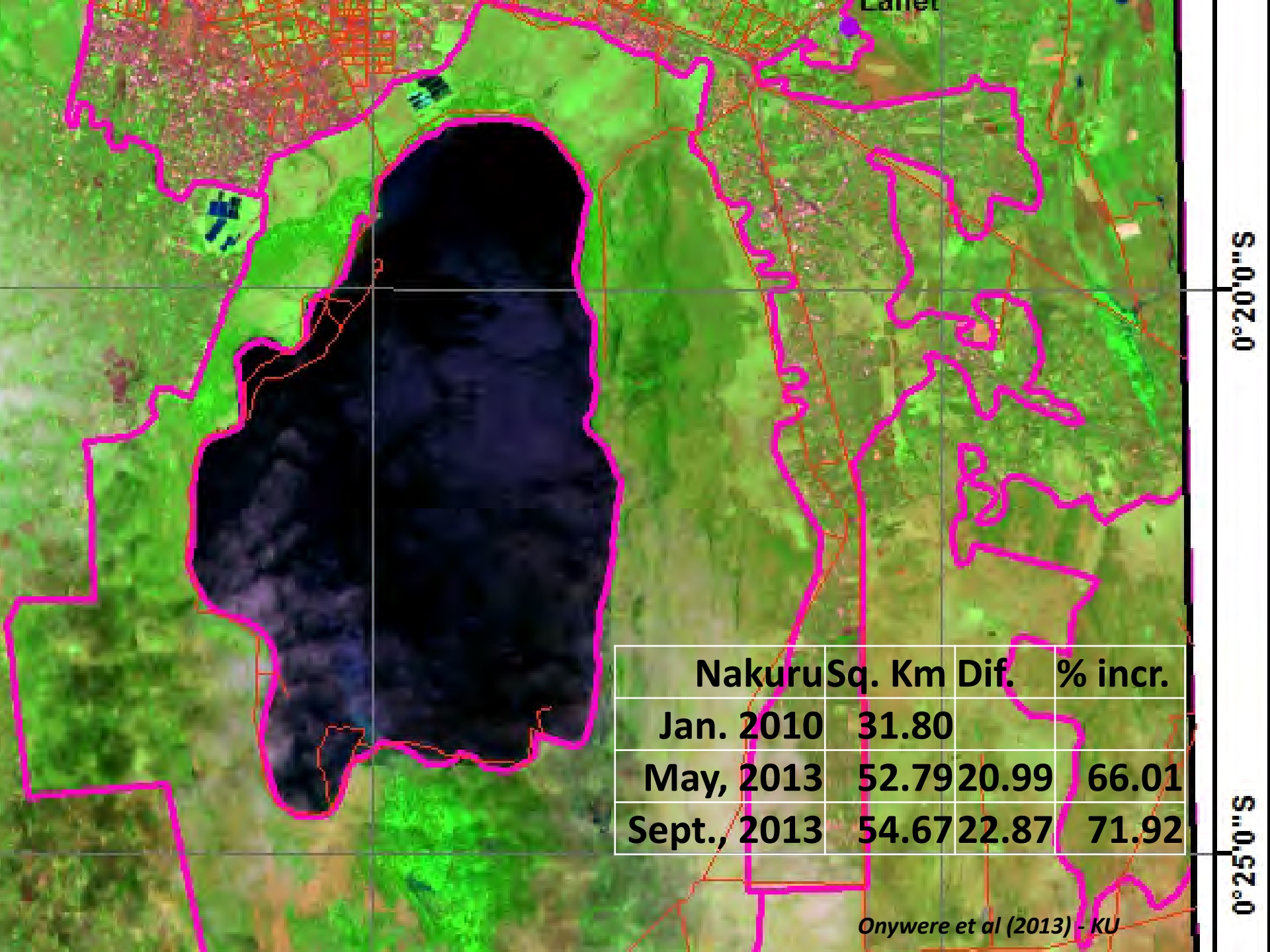

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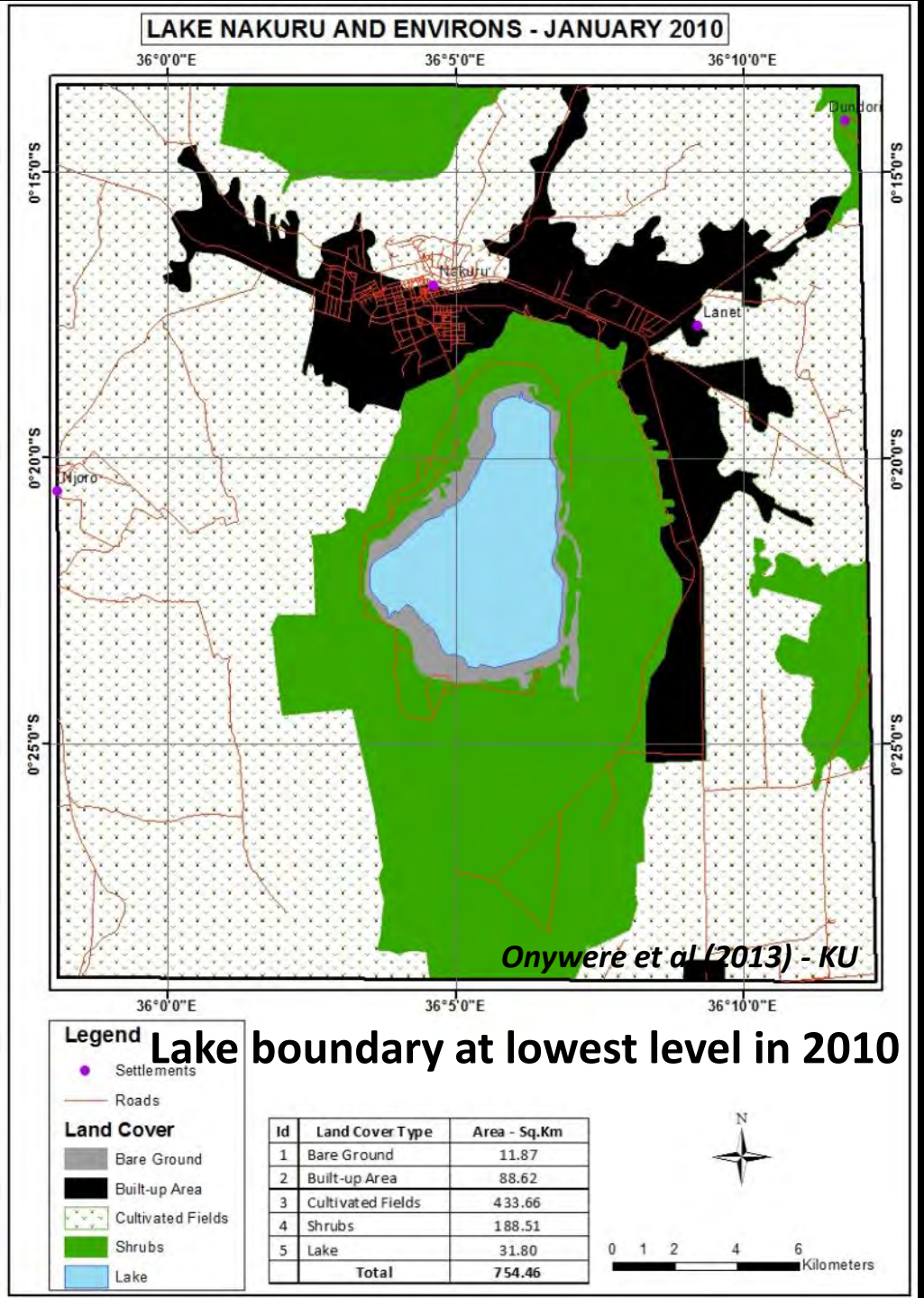
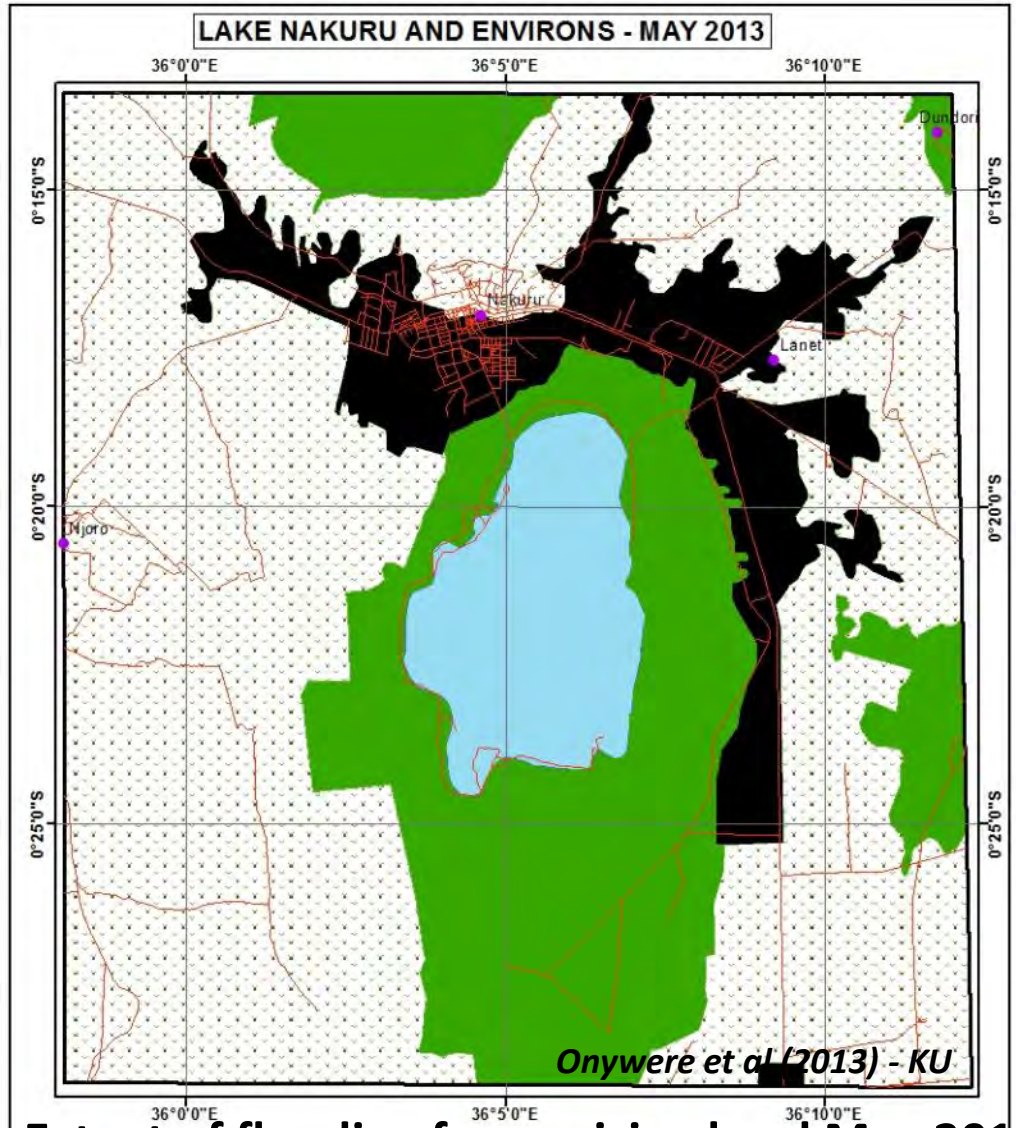

LAKE NAKURU AND ENVIRONS - JANUARY 2010
36°0'0"E
36°5'0"E
36°10'0"E
0°15'0"S
0°20'0"S
0°25'0"S
Dundori
Nakuru
Lanet
Njoro
Onywere et al (2013) - KU
Legend
Settlements
Roads
Land Cover
Bare Ground
Built-up Area
Cultivated Fields
Shrubs
Lake
Lake boundary at lowest level in 2010
Id | Land Cover Type | Area - Sq.Km
1 | Bare Ground | 11.87
2 | Built-up Area | 88.62
3 | Cultivated Fields | 433.66
4 | Shrubs | 188.51
5 | Lake | 31.80
Total | 754.46
N
0 1 2 4 6
Kilometers


smo


smo


Nakuru Sq. Km
Jan. 2010 31.80



Extent of flooding from raising level May 2013

Legend

- Settlements
- Roads

Land Cover

- Built-up Area
- Cultivated Fields
- Shrubs
- Lake

Id	Land Cover Type	Area - Sq.Km
1	Built-up Area	92.53
2	Cultivated Fields	431.53
3	Shrubs	177.62
4	Lake	52.79
	Total	754.46

N

0 1 2 4 6 Kilometers

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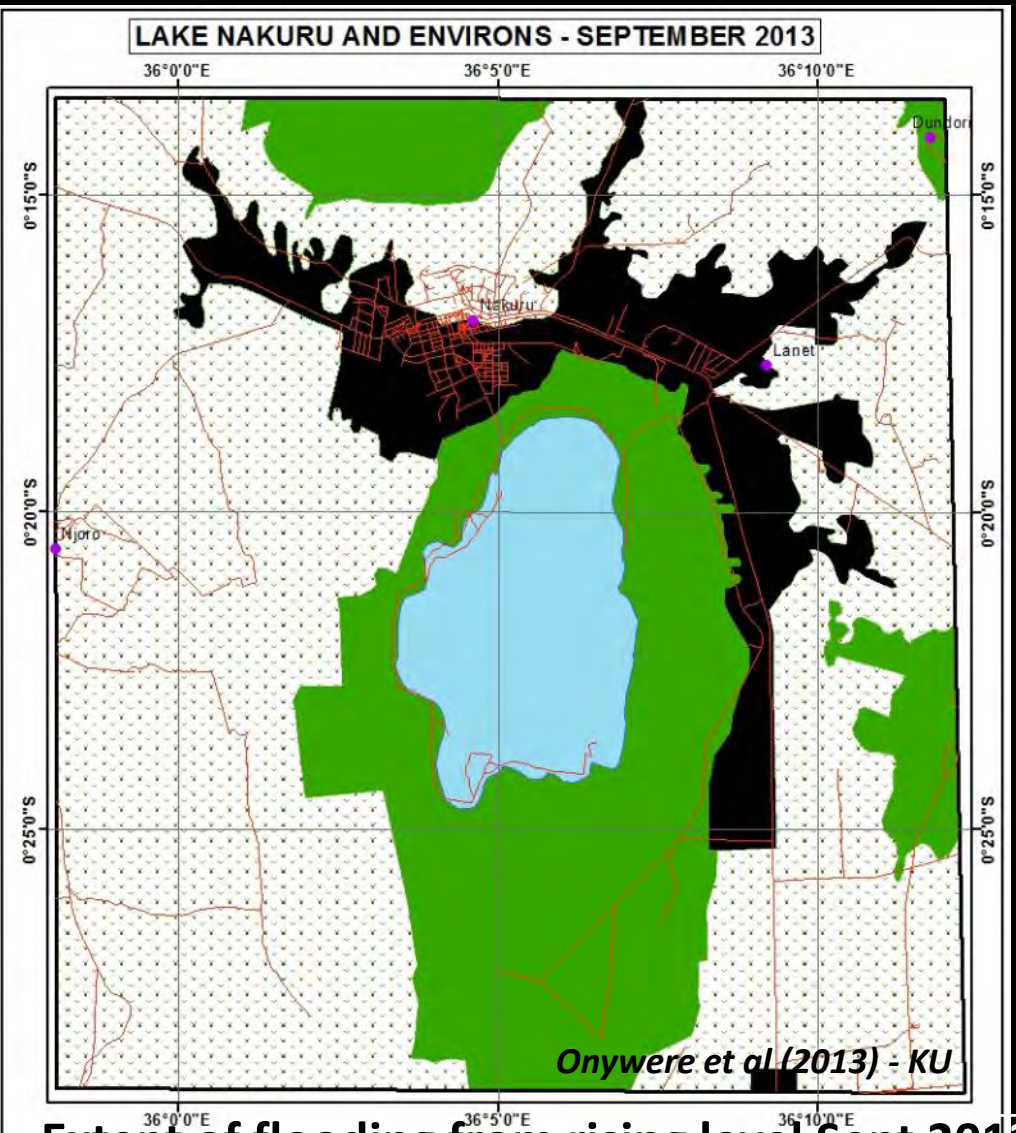
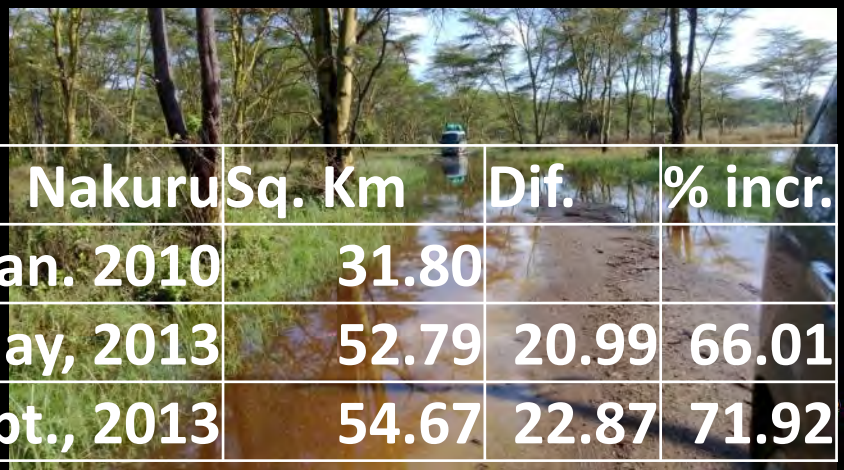


Id	Land Cover Type	Area - Sq.Km
1	Built-up Area	92.53
2	Cultivated Fields	431.53
3	Shrubs	175.74
4	Lake	54.67
	Total	754.46

Extent of flooding from rising level Sept 2013



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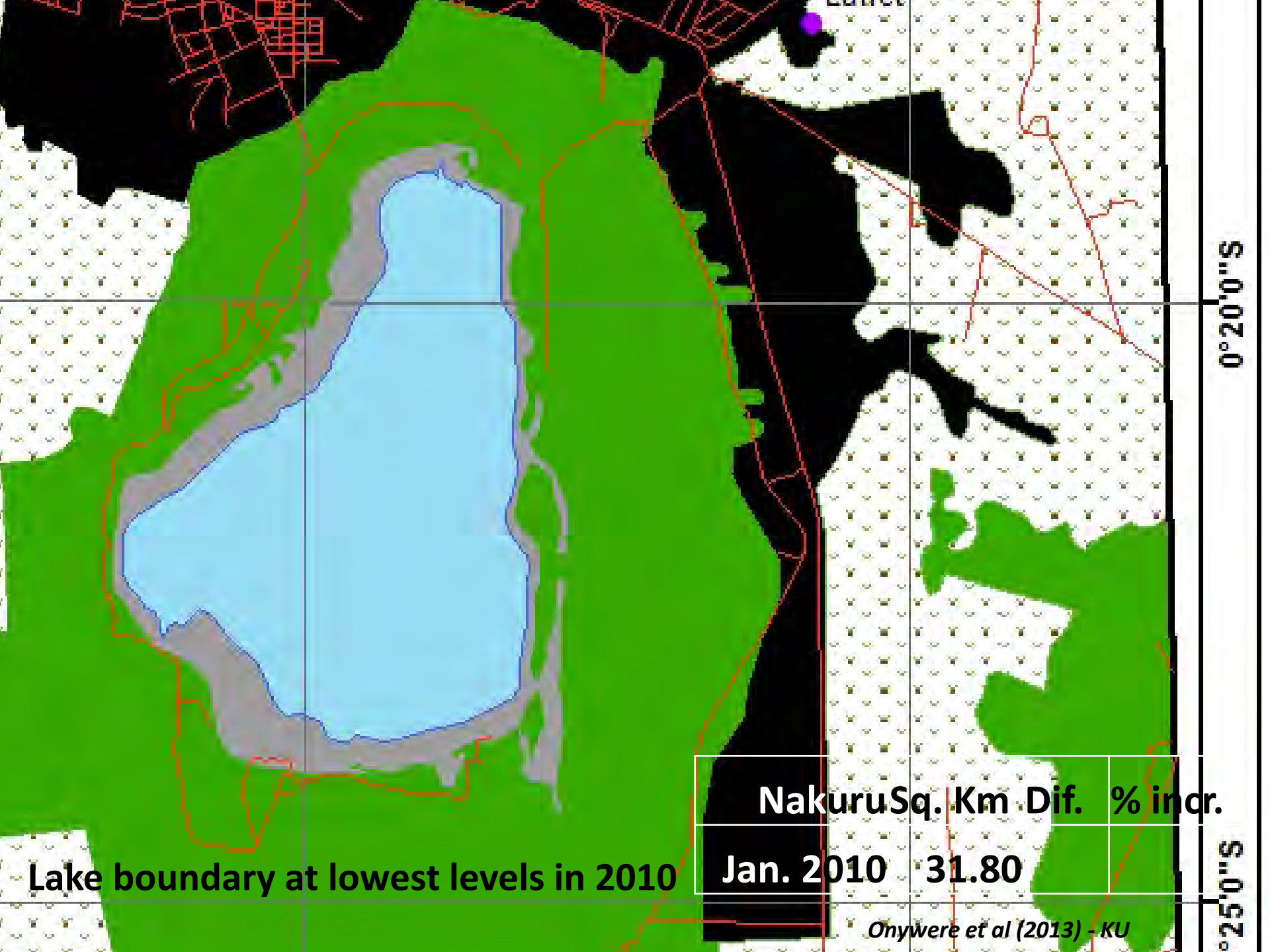
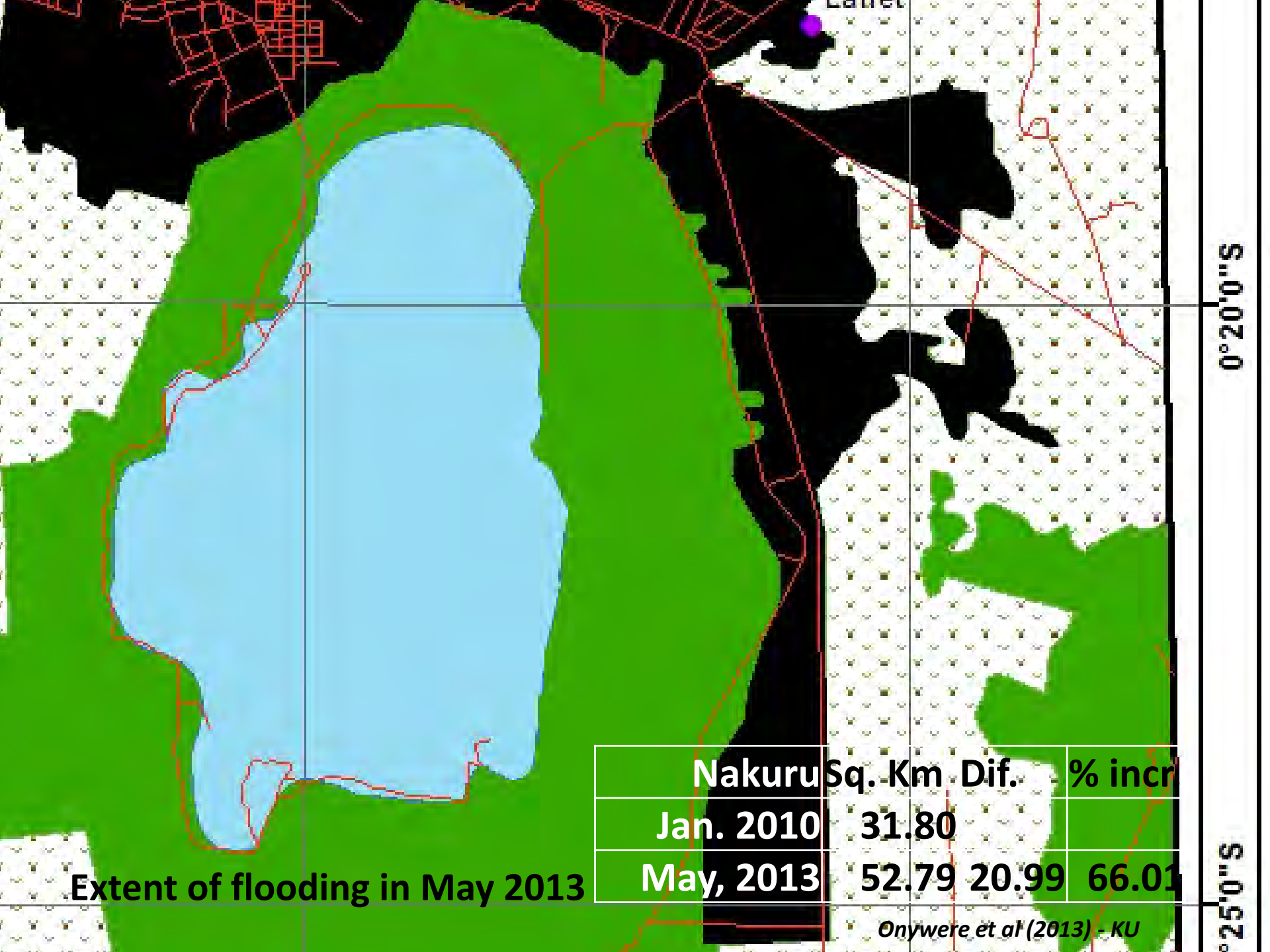

Lake boundary at lowest levels in 2010
Nakuru Sq. Km Dif. % incr.
Jan. 2010 31.80
Onywere et al (2013) - KU
0°20'0"S
0°25'0"S



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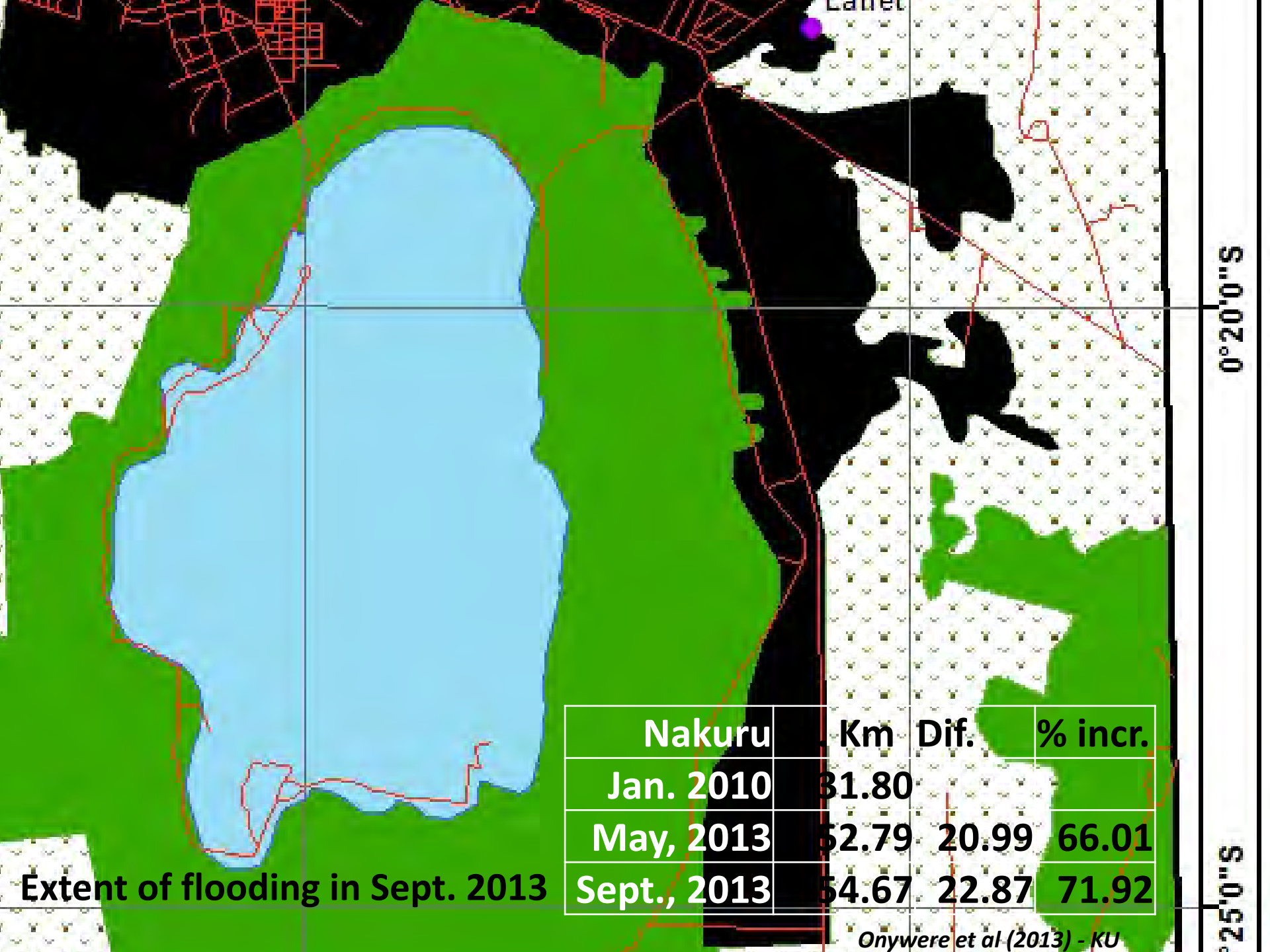
Extent of flooding in May 2013

Onywere et al (2013) - KU



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Extent of flooding in Sept. 2013

Onywere et al (2013) - KU

Lake Nakuru – Impacts from flood waters

- The increased recharge of the lake from Enjoro, Makalia, larmidiak, and Enderit Rivers has led to dilution of the lake water thus decreasing its salinity
- Low salinity and siltation has led to loss of algae on which the flamingoes feed
- All flamingoes have left the lake
- There is change in aquatic life with increased presence of birds of the duck family
- Most of the length of the inner circuit road around the lake is submerged and therefore destroyed.
- Loss of road infrastructure is making it increasingly difficult and dangerous to access the park
- Destruction of development infrastructure including the office facilities at the main gate from flooding
- Loss of biodiversity e.g. loss of acacia trees and other vegetation due to submergence and/or introduction of saline water from the rising level of the lake.

Onywere et al (2013) - KU

Lake Nakuru – Impacts from flood waters

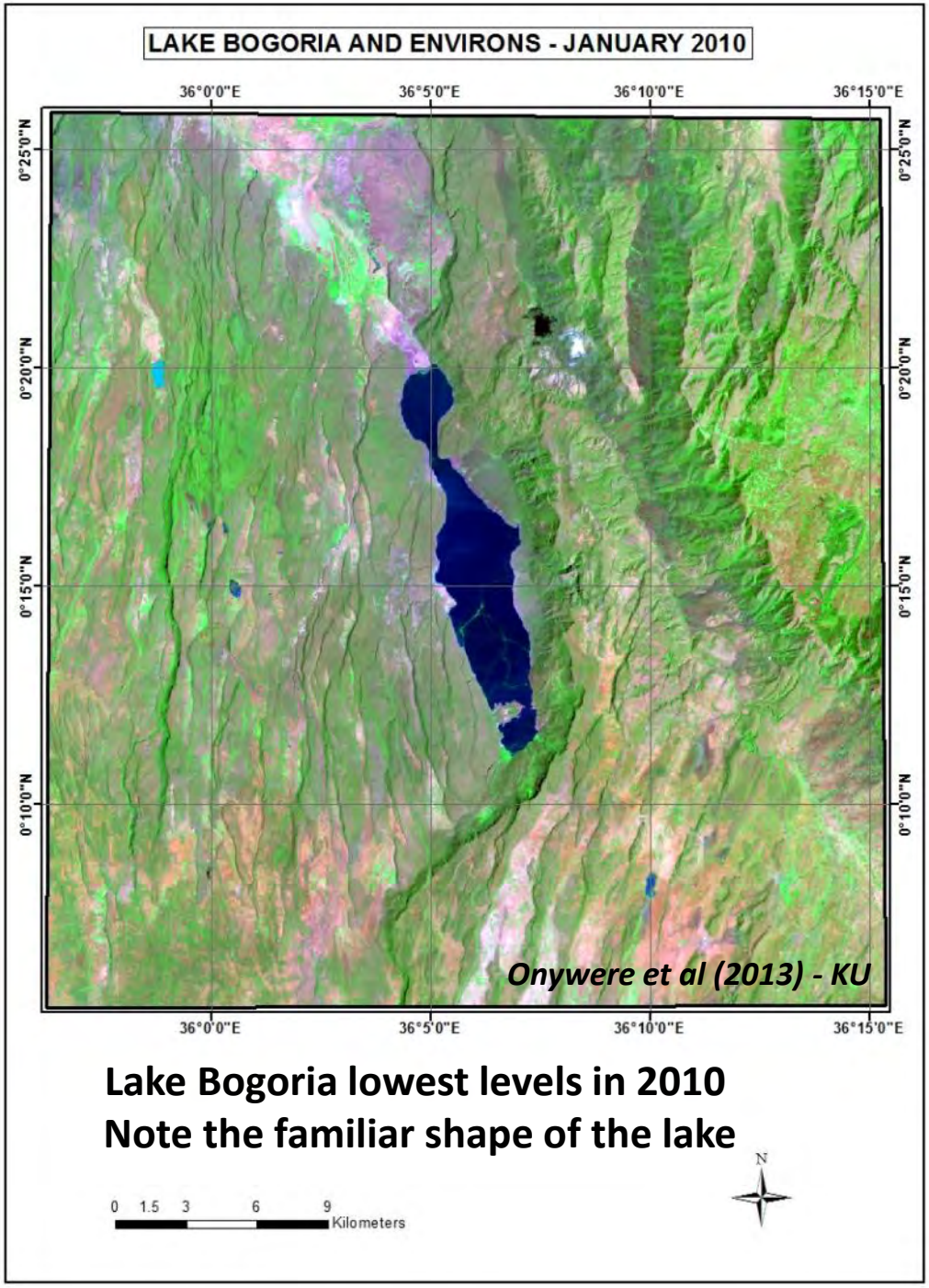
- The flood water could be attributed to the 50 year climatic cycle that was witnessed in 1963 and in 1901
- There is need to put in place research teams to document and monitor the changing ecology of the lake
- Also to monitor and document its effect on biodiversity and regeneration of vegetation
- The flood water is likely to remain for some time and thus pose new challenges that that now require preparedness in the following key areas:
  - Rethinking the planning of infrastructure location
  - Risk of malaria epidemic
  - Risk of rift valley fever
  - Contamination of groundwater in nearby boreholes
  - Decreased and/or loss of tourism potential & productivity

Onywere et al (2013) - KU

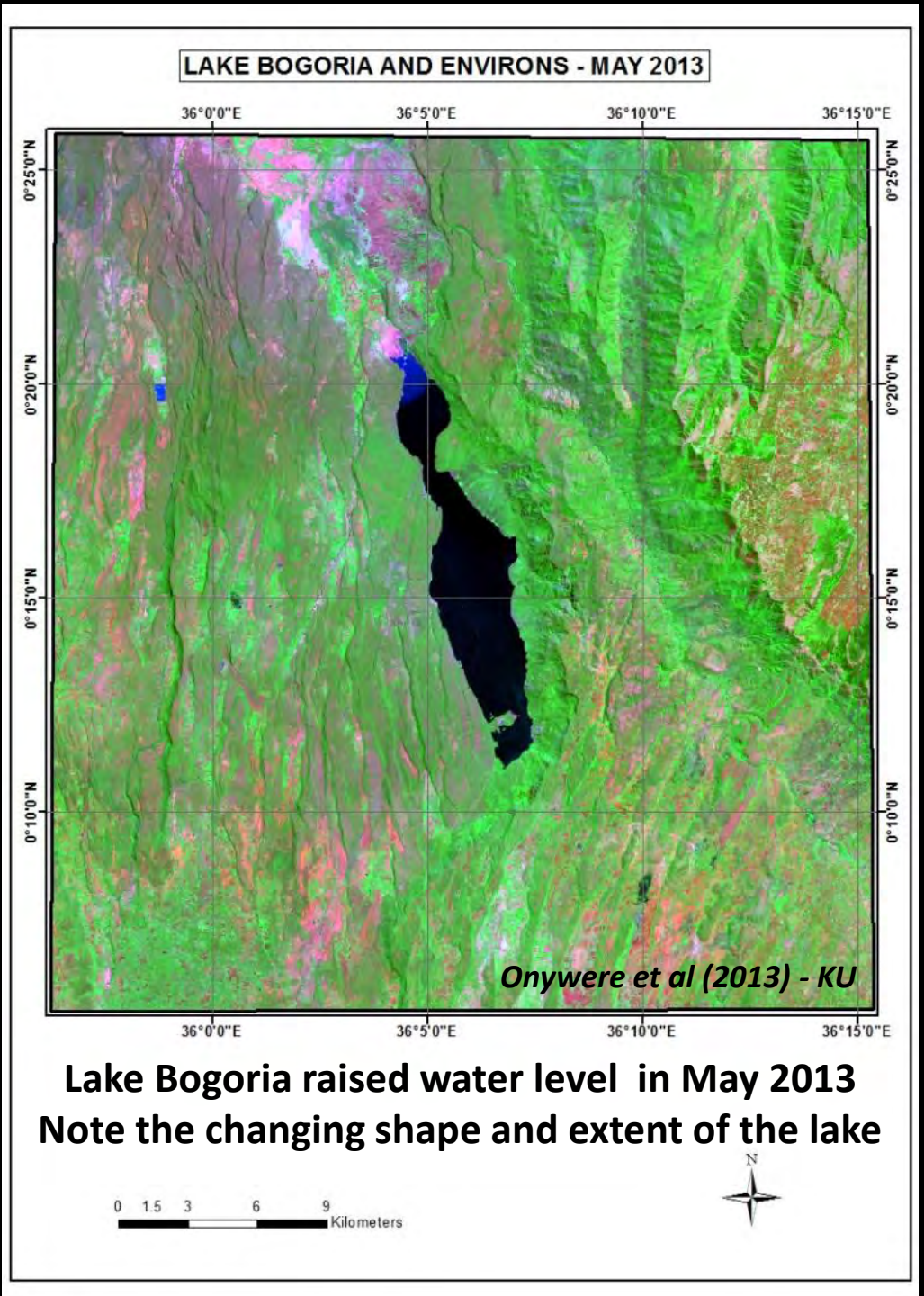
Lake Bogoria

- The lake has shown increasing water levels since 2011
- Lake Bogoria lies in a deep depression and the volume of the water increase has only flooded a small are compared to lake Baringo or lake Nakuru
- Increasing its flood area from **32.56 Sq. Km in January 2010 to 41.13 Sq. Km in Sept. 2013 an increase of 8.57 Sq. Km (26.32% increase by area)**
- The changes are illustrated from the image data and digitize maps that follow:

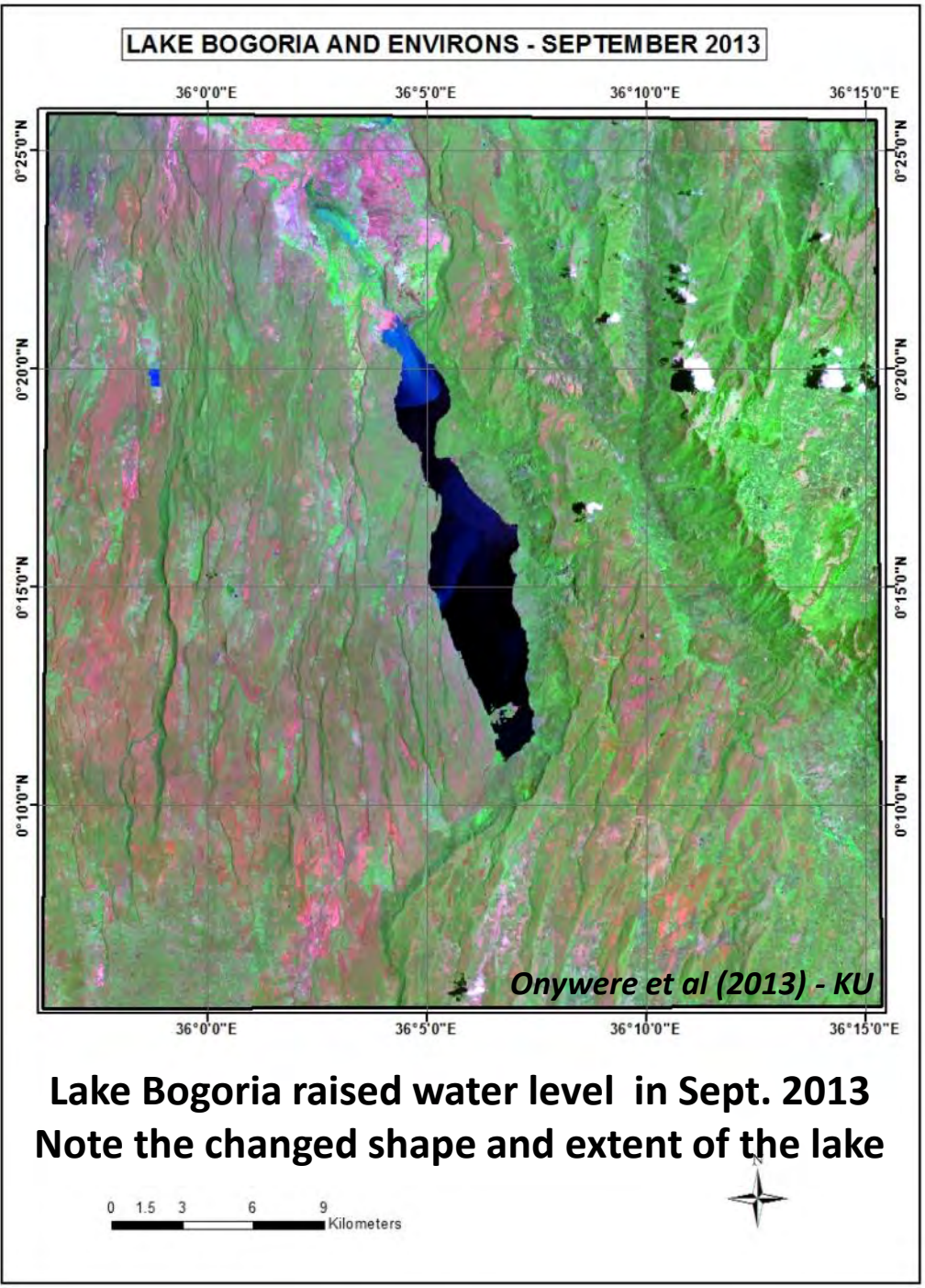
Bogoria	Sq. Km	Dif.	% Incr.
Jan. 2010	32.56		
May, 2013	39.52	6.96	21.38
Sept., 2013	41.13	8.57	26.32



Lake Bogoria lowest levels in 2010
Note the familiar shape of the lake



Lake Bogoria raised water level in May 2013
Note the changing shape and extent of the lake



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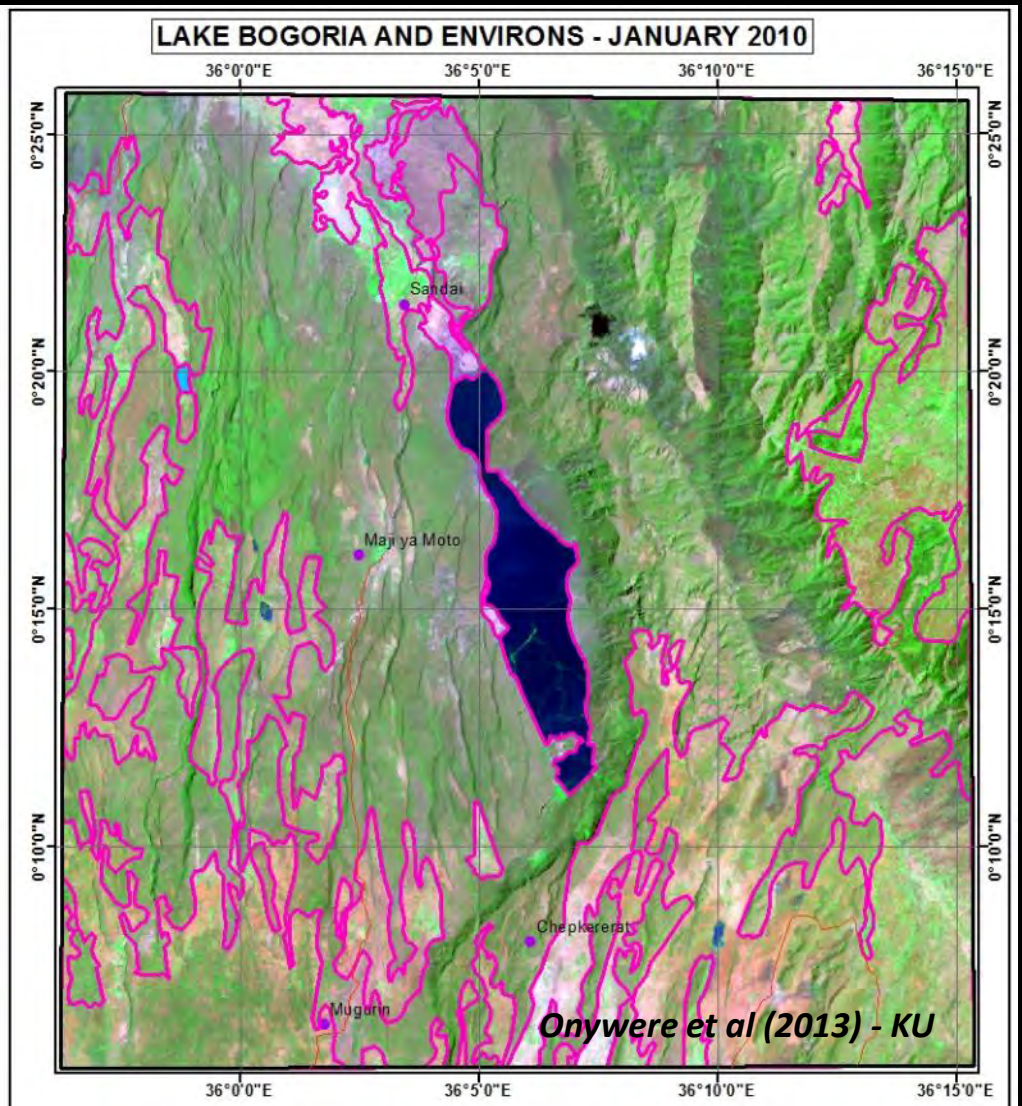
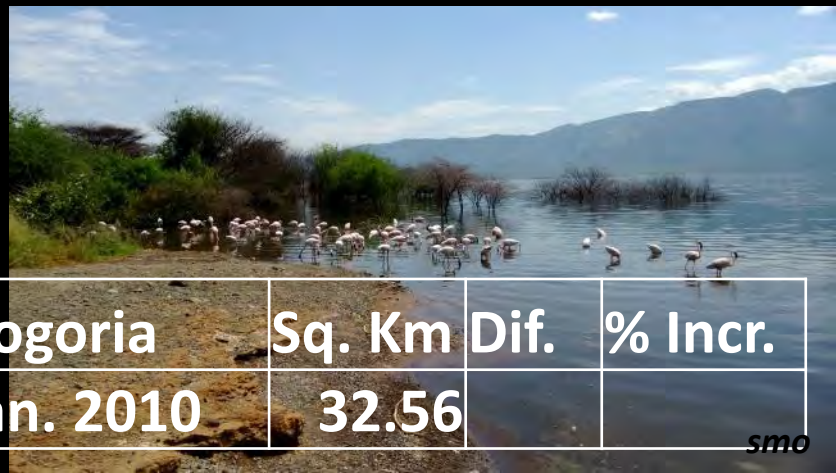


Impact on L. Bogoria infrastructure

Tourism Resources & settlements



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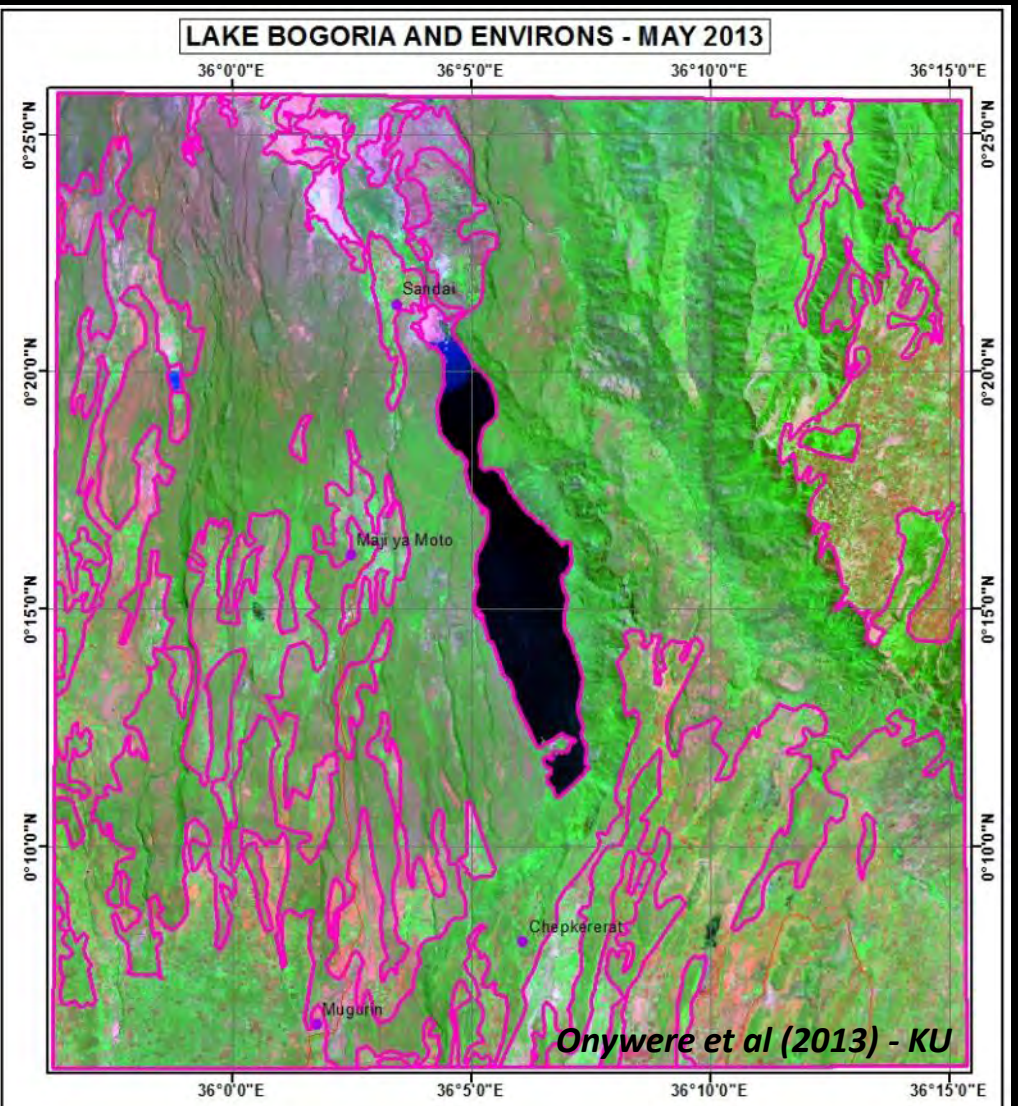
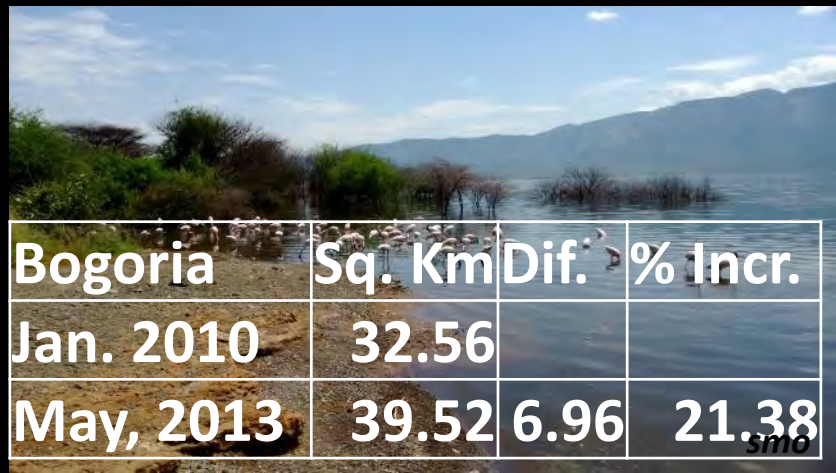


Impact on L. Bogoria infrastructure, Tourism Resources & settlements



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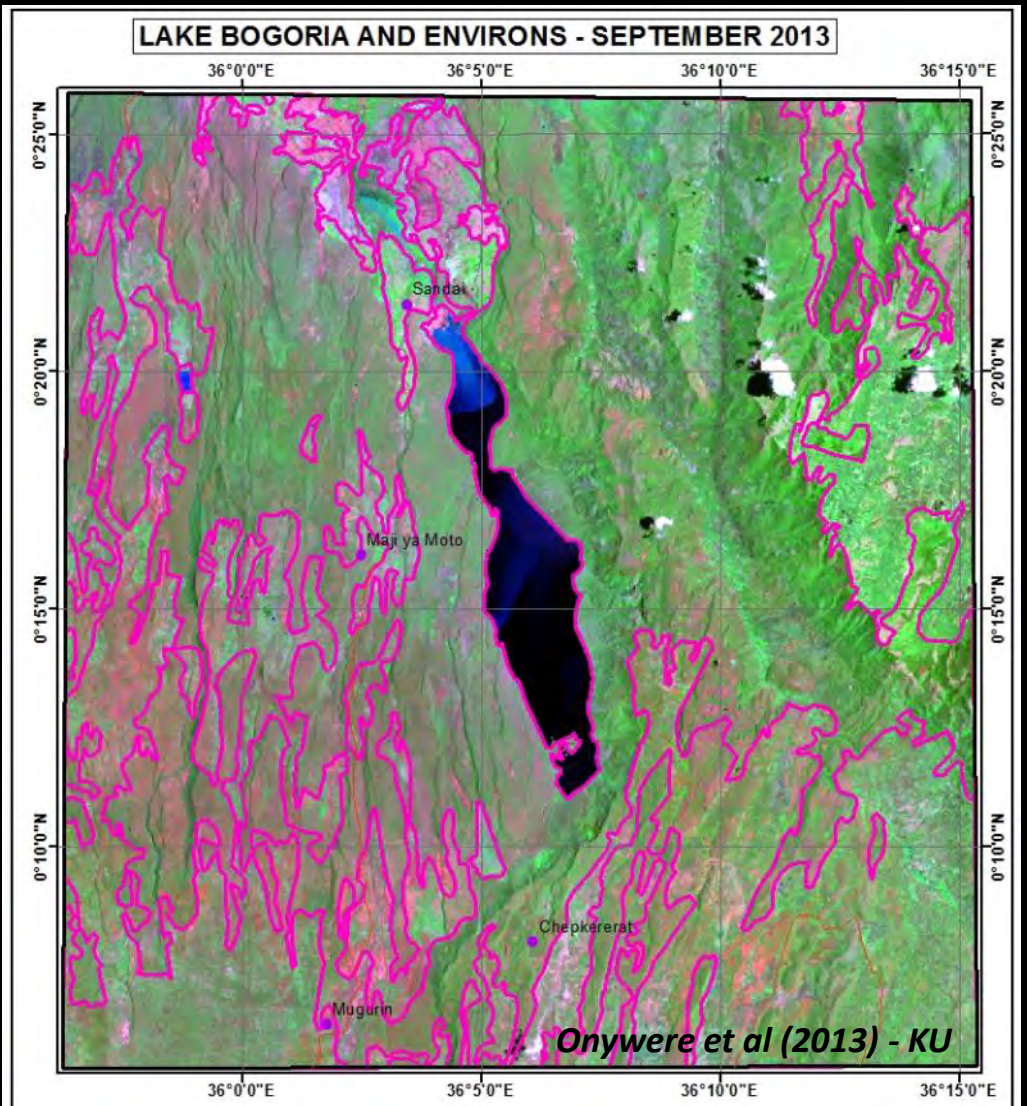

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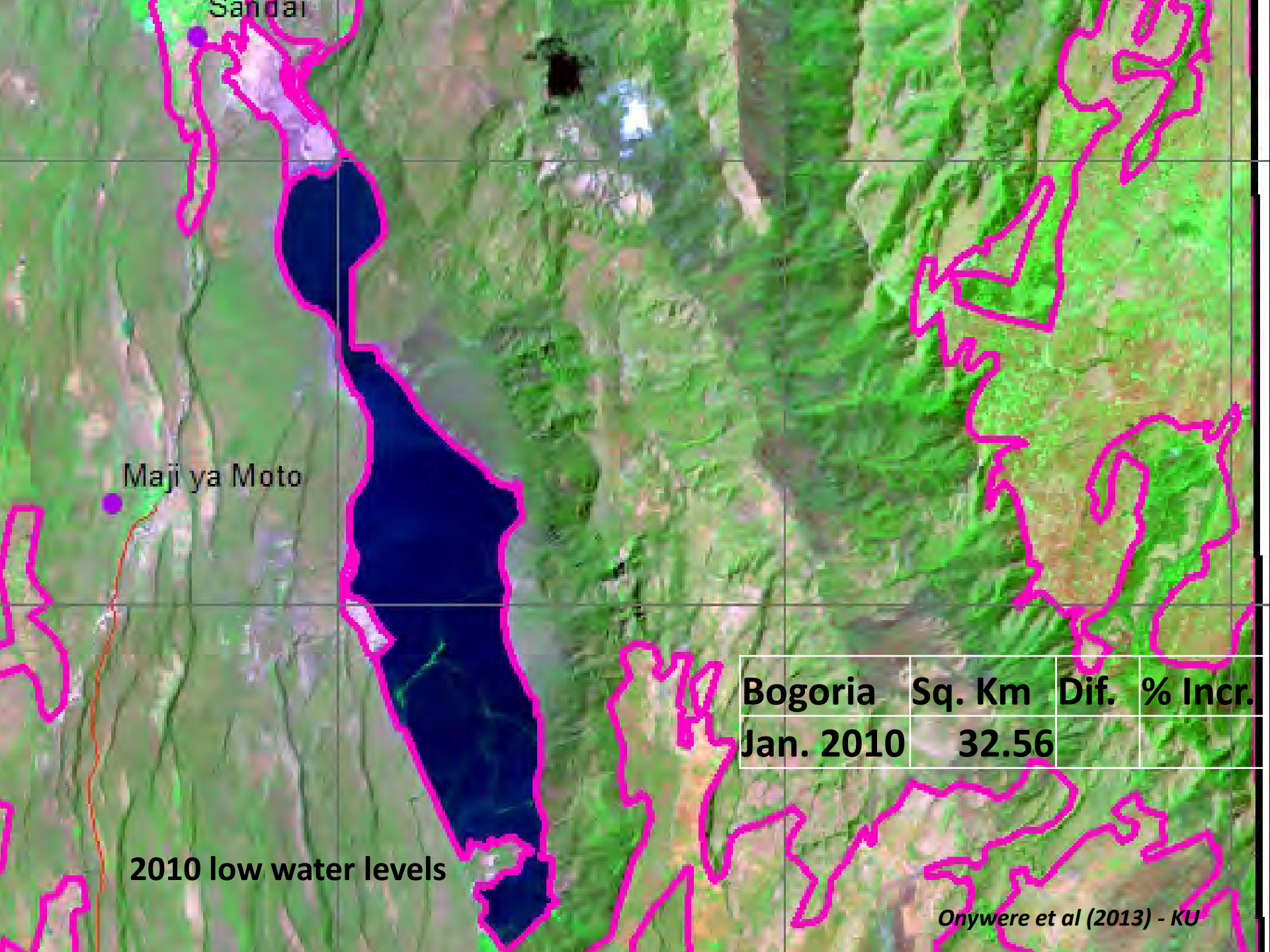
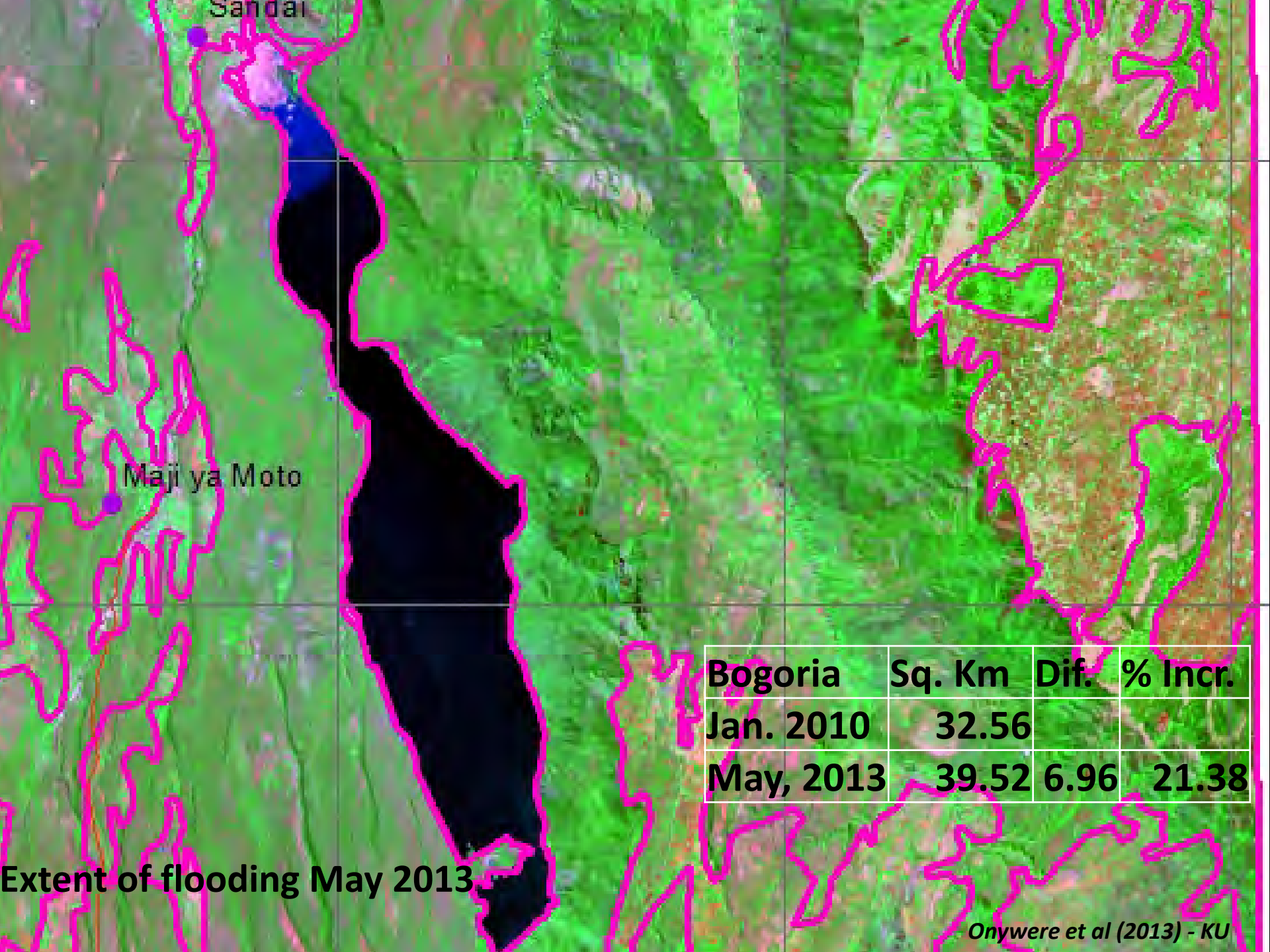

Sandai
Maji ya Moto
Bogoria
Sq. Km
Dif.
% Incr.
Jan. 2010
32.56
2010 low water levels
Onywere et al (2013) - KU



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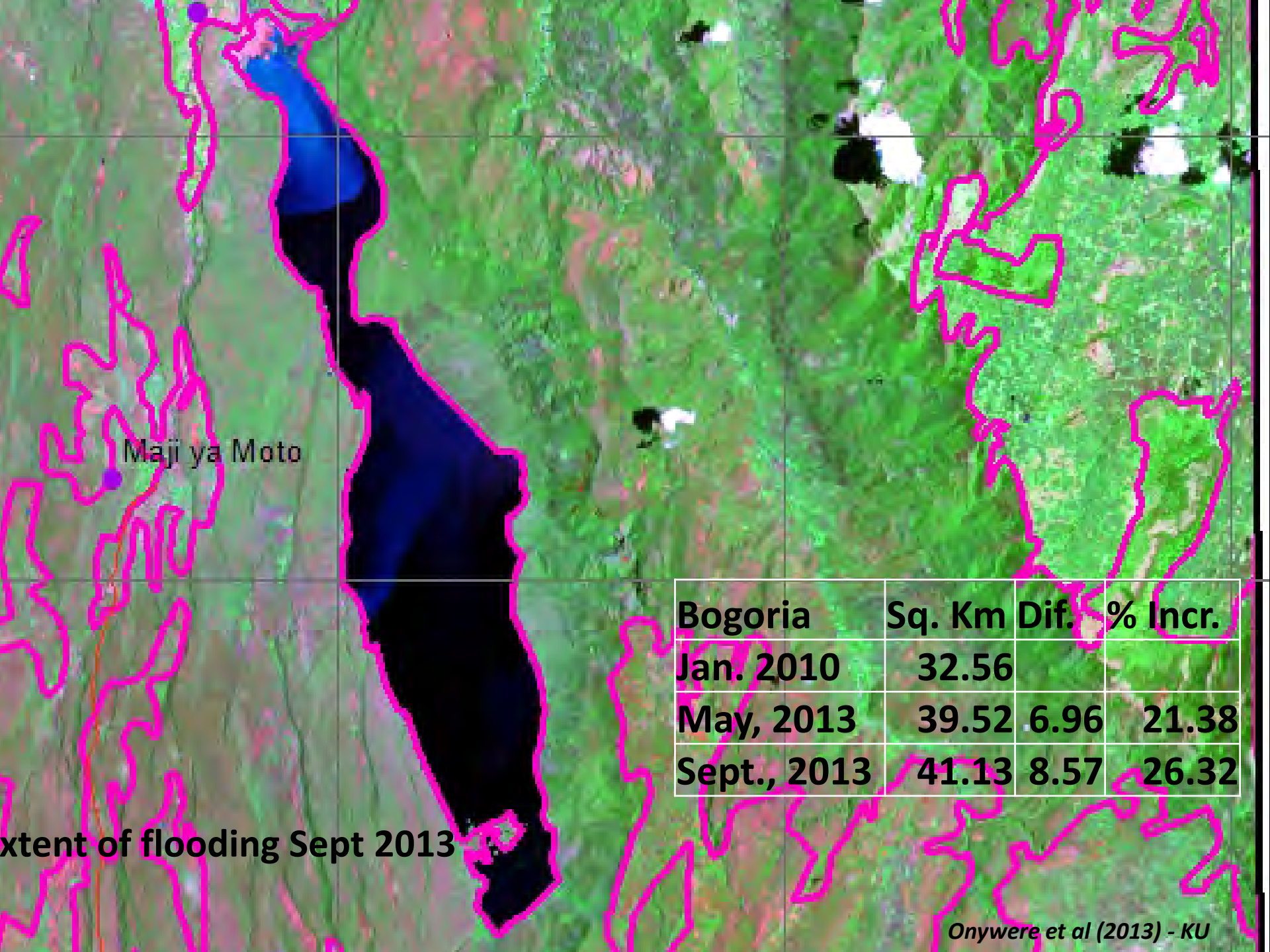
Extent of flooding May 2013

Onywere et al (2013) - KU



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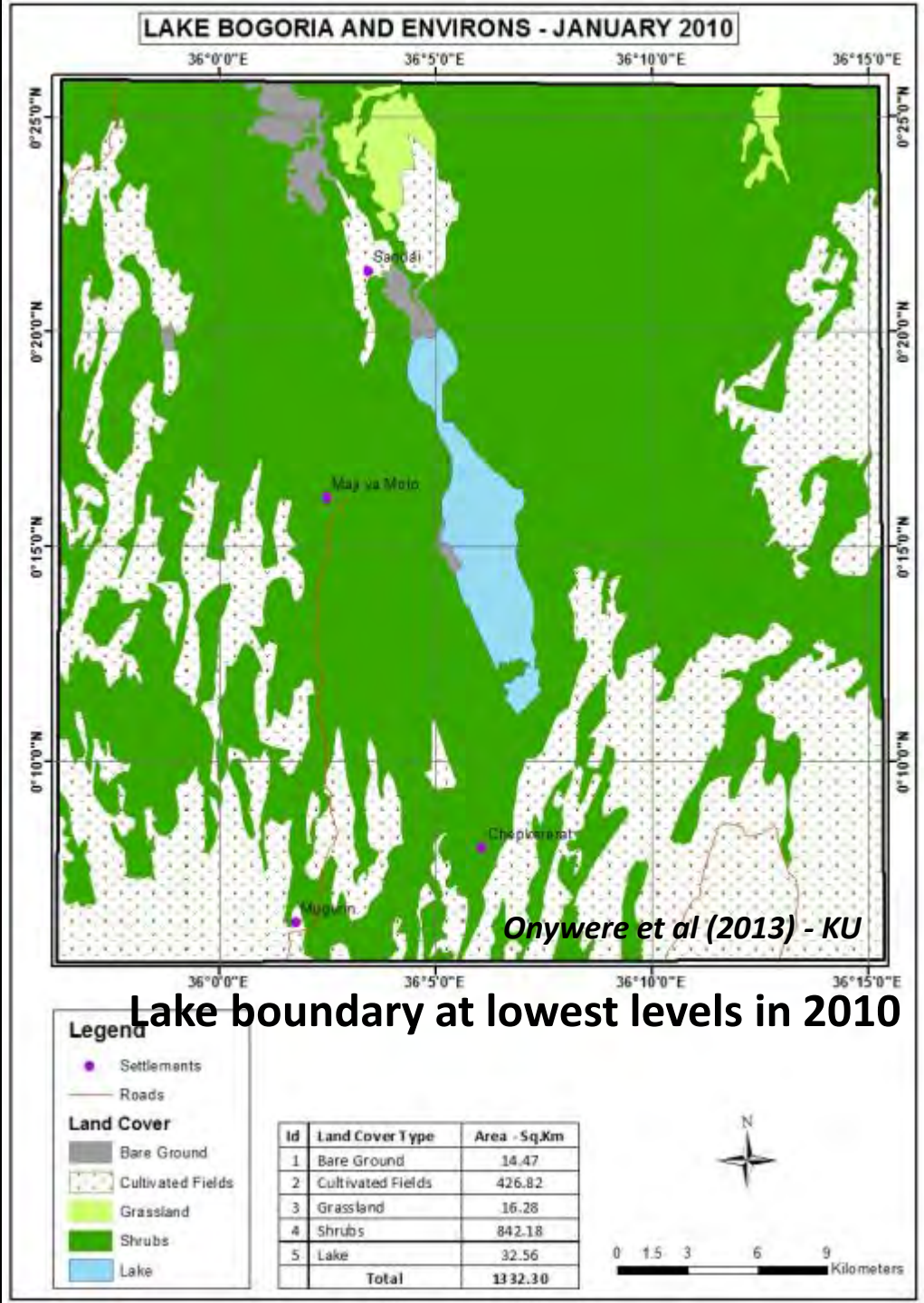

Lake boundary at lowest levels in 2010

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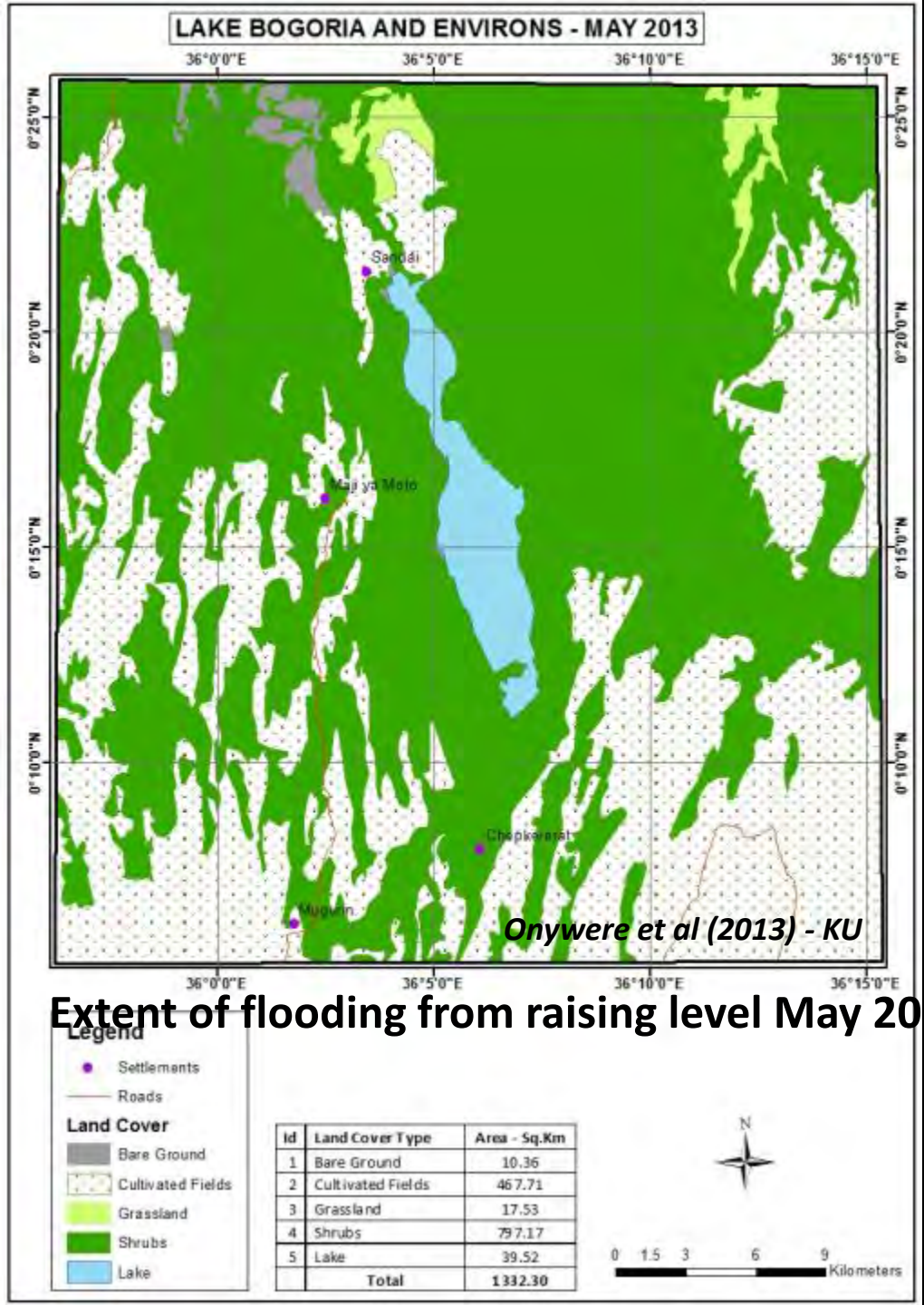
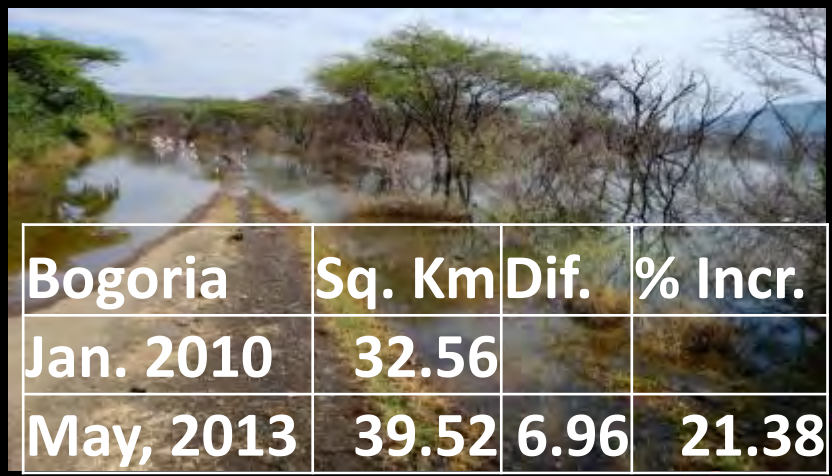


Extent of flooding from raising level May 2013



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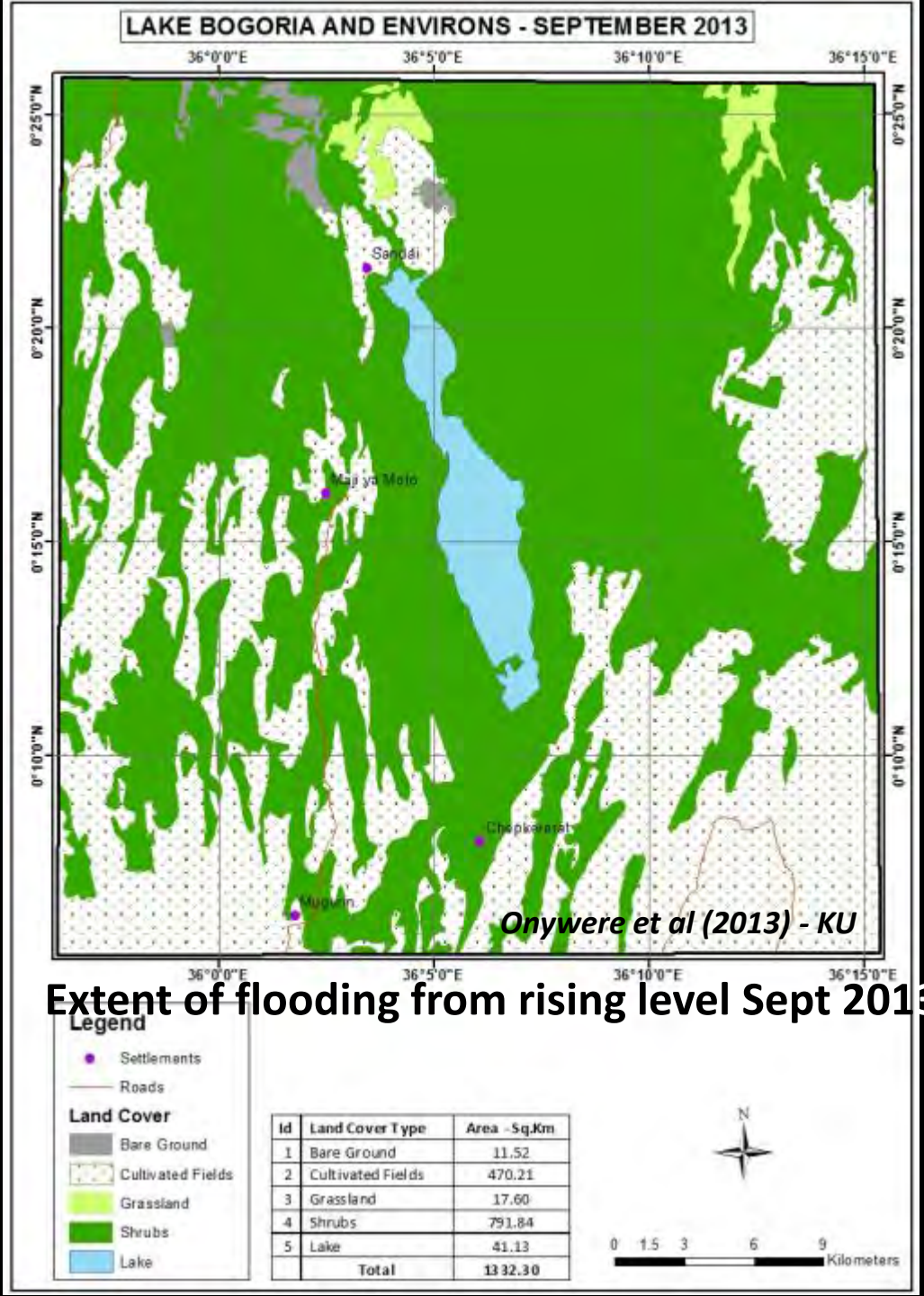

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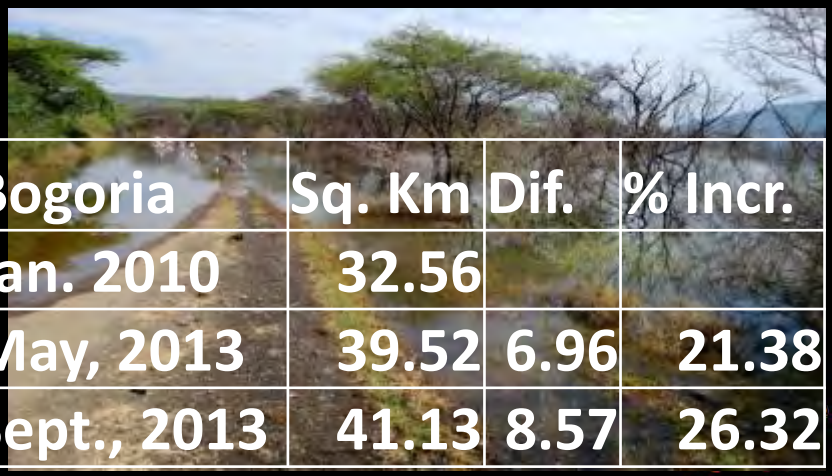

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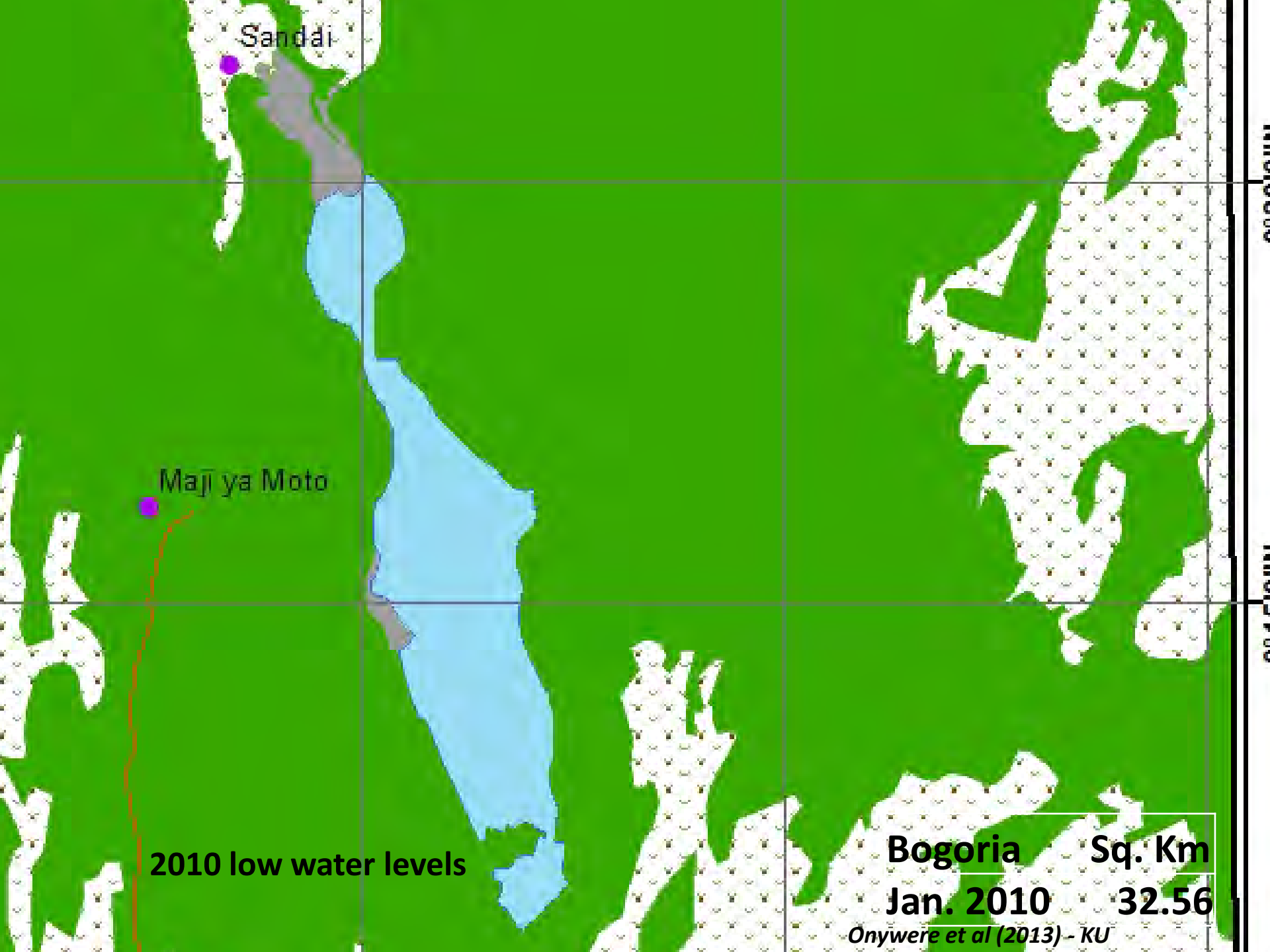
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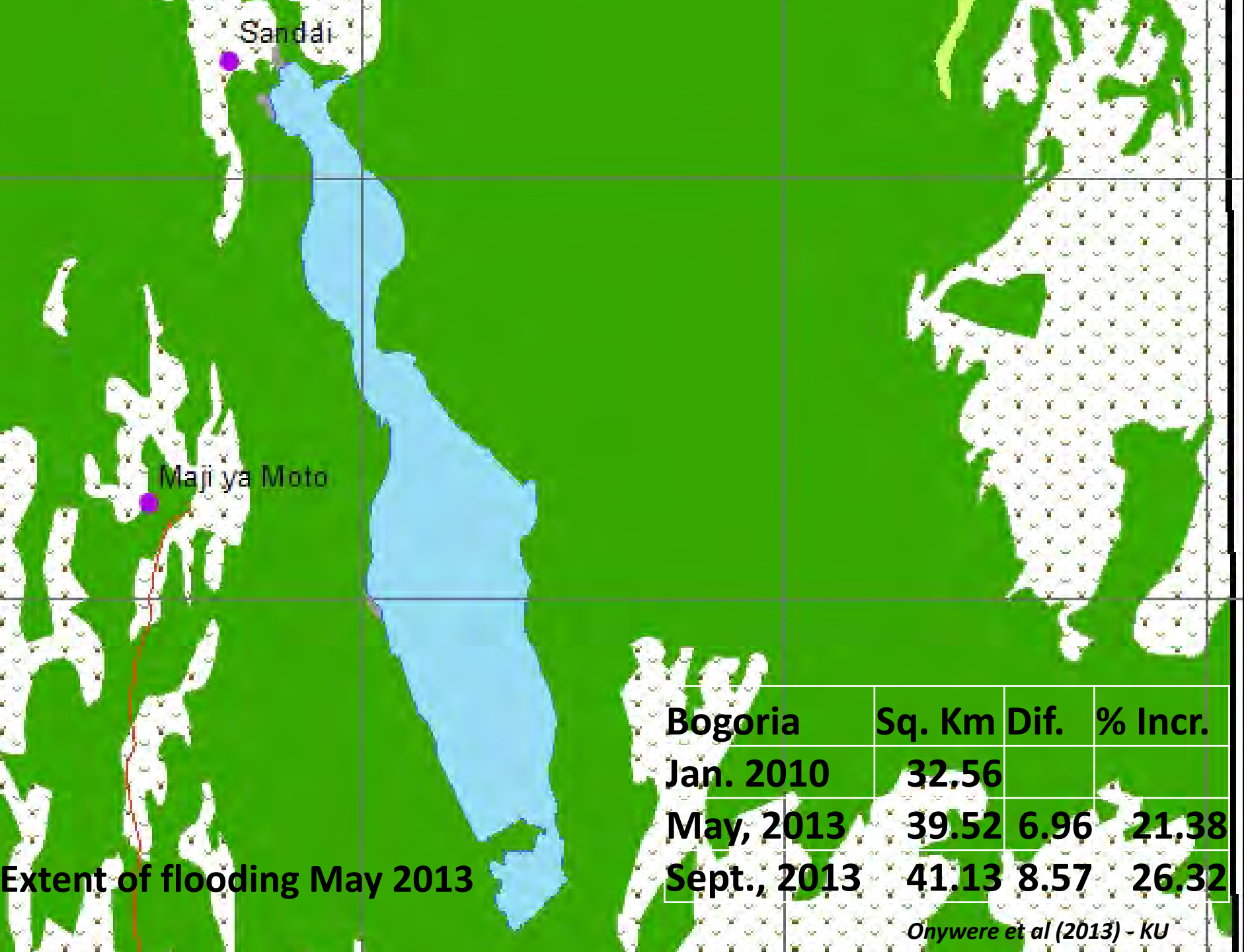

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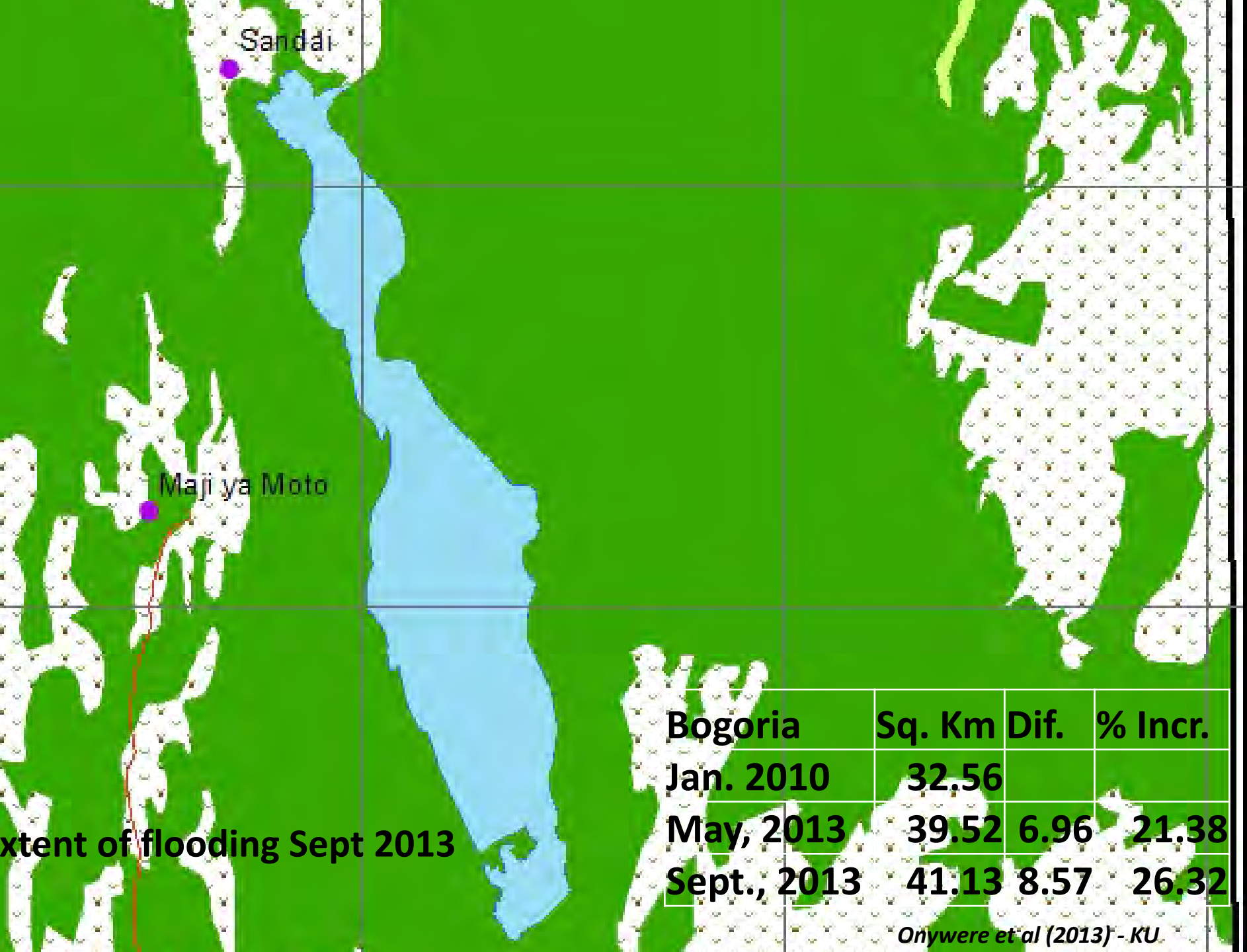

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Lake Bogoria – Impacts from flood waters

- The increased recharge of the lake from River Wasege, now reaching the lake directly through surface recharge has led to dilution of the lake water thus decreasing its salinity.
- The low salinity and siltation has led to loss of algae on the northern side of the lake leading to lack of food for the flamingoes
- The depth of the lake has increased compromising its ability to support any wading birds like flamingoes
- The flamingoes present are flocking the banks of the lake thus increasing the risk to be caught amongst the thorn trees as they fly off

Onywere et al (2013) - KU

Lake Bogoria – Impacts from flood waters

- The flood waters have displaced the community living along the northern shore of the lake within the River Waseges Flood plain
- The flood waters have affected the quality of the geysers located on the Western side of the southern half of the lake
- Most of the length of the inner circuit road around the lake is submerged and therefore destroyed.
- Loss of road infrastructure is making it increasingly difficult and dangerous to access the park and especially the hot springs
- Destruction of development infrastructure including the office facilities at the main gate from flooding
- Loss of biodiversity e.g. loss of acacia and other vegetation due to submergence and/or introduction of saline water from the rising level of the lake.
- Displacement of the people living in the low lying areas

Onywere et al (2013) - KU

Lake Bogoria – Impacts from flood waters

- The flood water is likely to remain for some time and thus pose new challenges that now require preparedness and monitoring in the following key areas:
  - Rethinking the planning of infrastructure location
  - Decreased and/or loss of tourism potential & productivity
  - Risk of malaria epidemic
  - Risk of rift valley fever
  - Contamination of groundwater in nearby boreholes
  - Water borne diseases such as schistosoma mansoni and intestinal worms

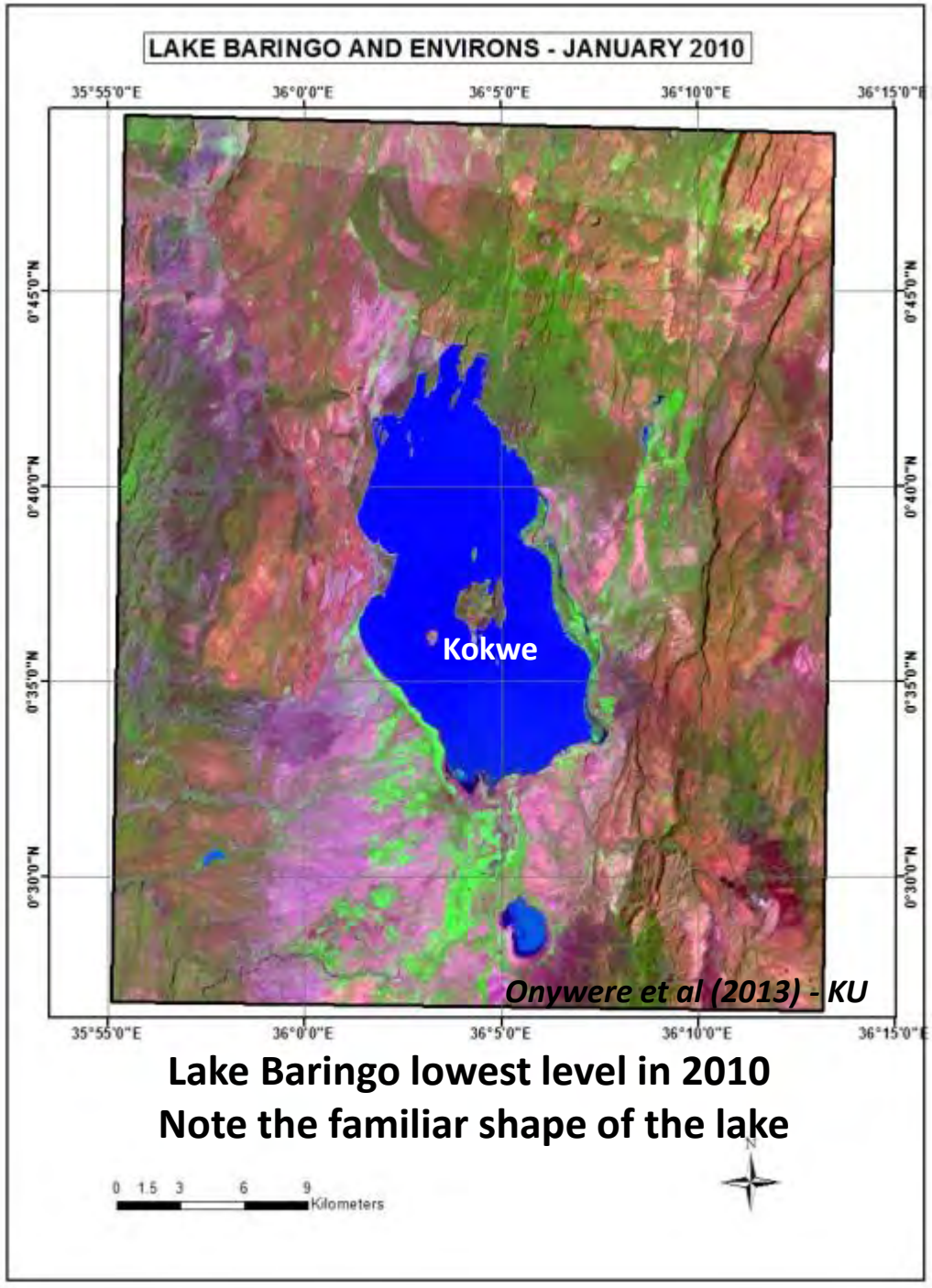
Onywere et al (2013) - KU

Lake Baringo

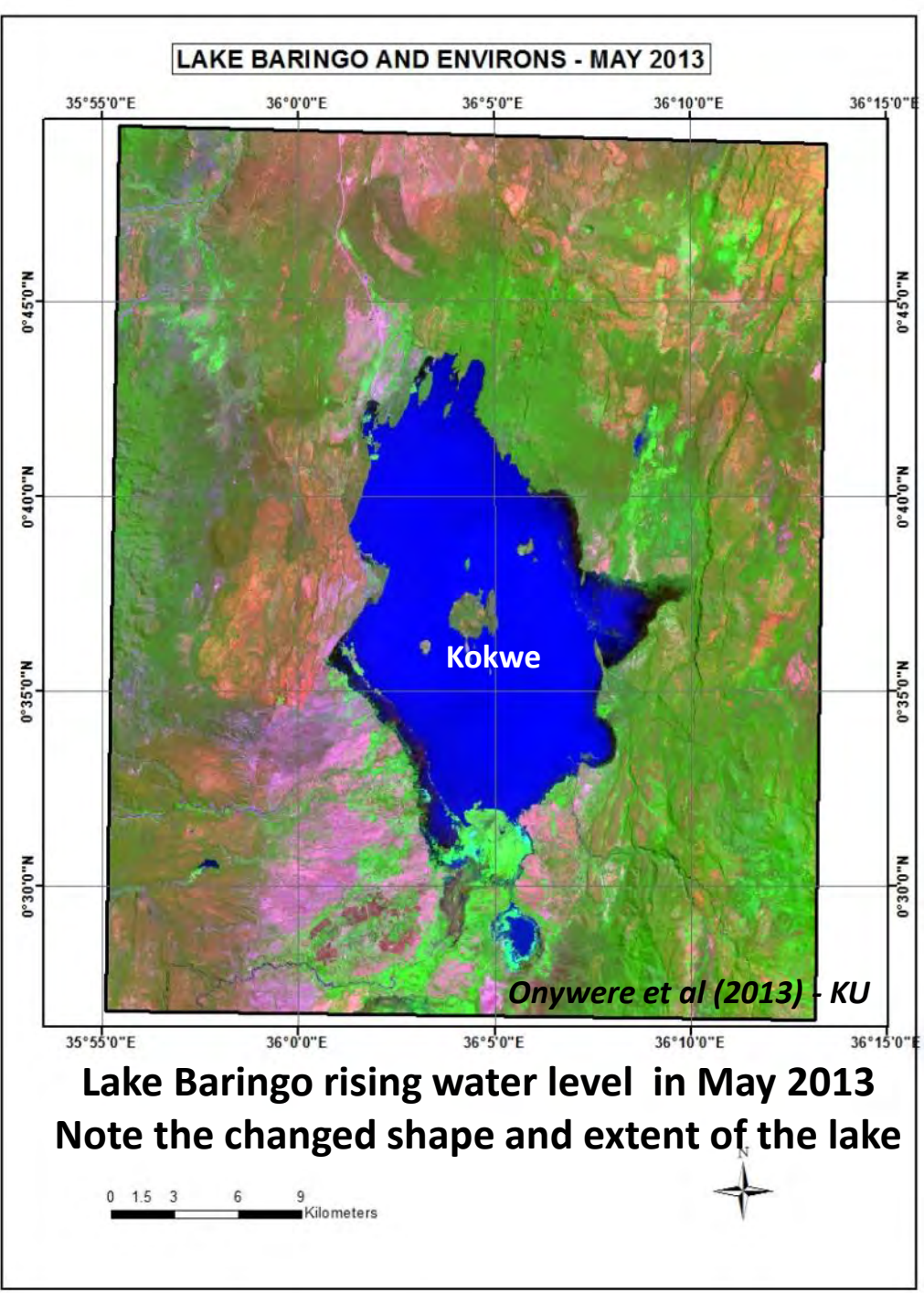
- Of the 3 lakes studies the most affected is Lake Baringo both from the point of view of the size of the population affected and the loss of infrastructure such as schools dispensaries and the size of the area under water.
- Much of the area surrounding the lake is a lowland area that is largely settled up to the shoreline
- The impact of the flooding in Lake Baringo has seen the area under water rise from 143.57 Sq. Km in January 2010 to a high of 231.57 Sq. Km in Sept. 2013, an increase of 88 Sq. Km (61.29% increase by area)
- The changes are illustrated from the image data and digitize maps that follow:
-

Baringo	Sq. Km	Dif.	% Incr.
Jan. 2010	143.57		
May, 2013	216.96	73.39	51.12
Sept., 2013	231.57	88.00	61.29

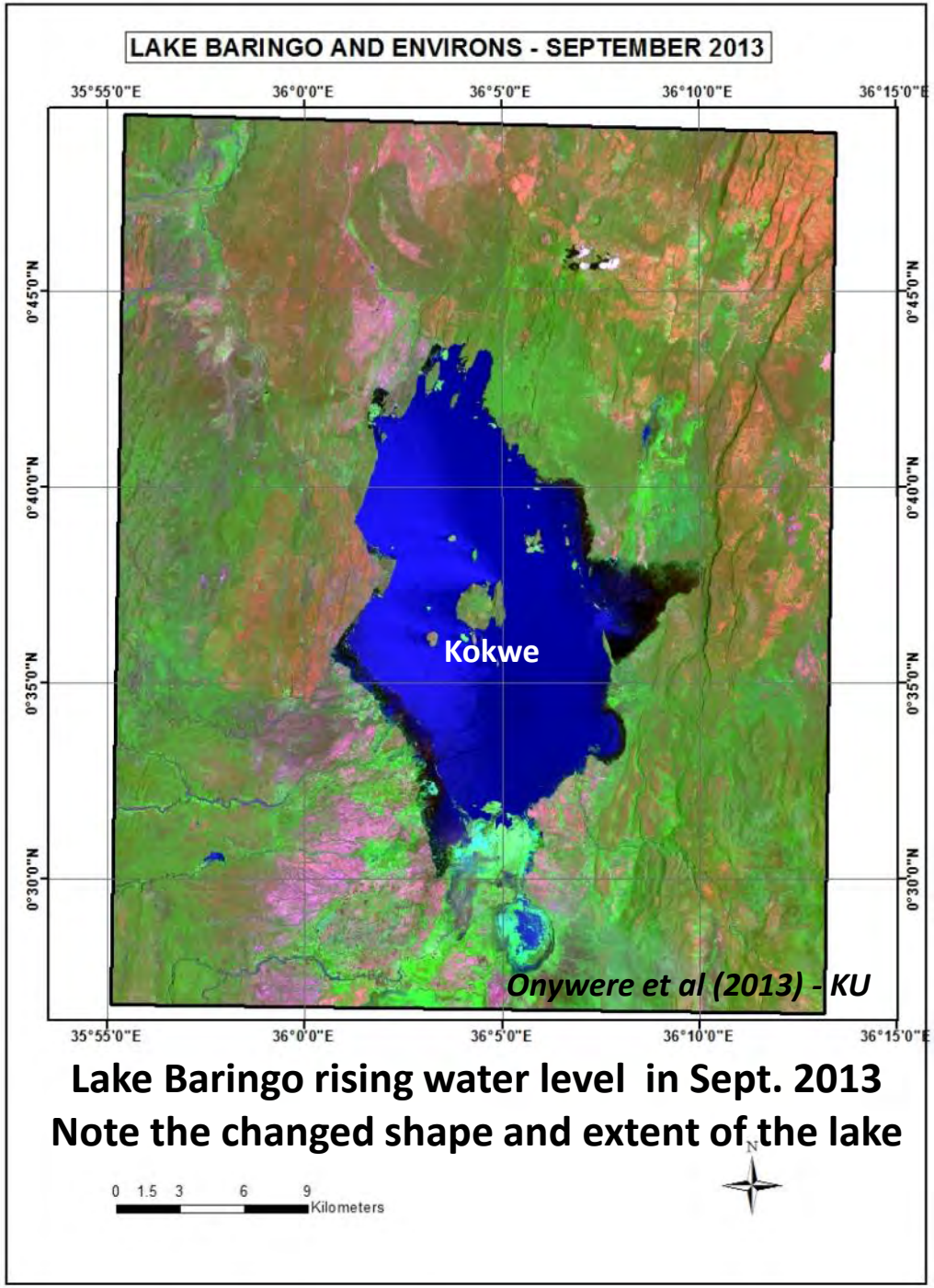
Onywere et al (2013) - KU



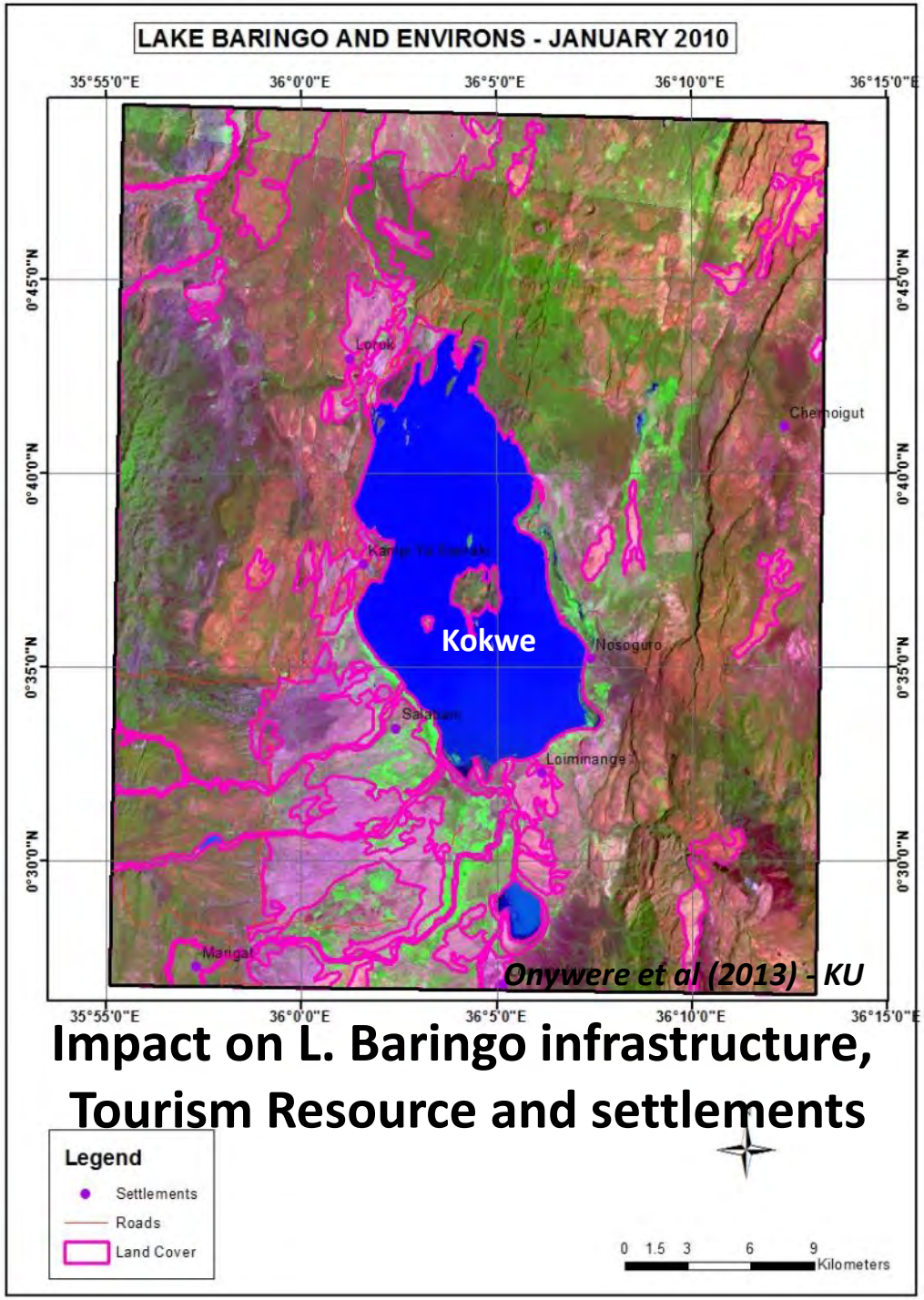
Lake Baringo lowest level in 2010
Note the familiar shape of the lake



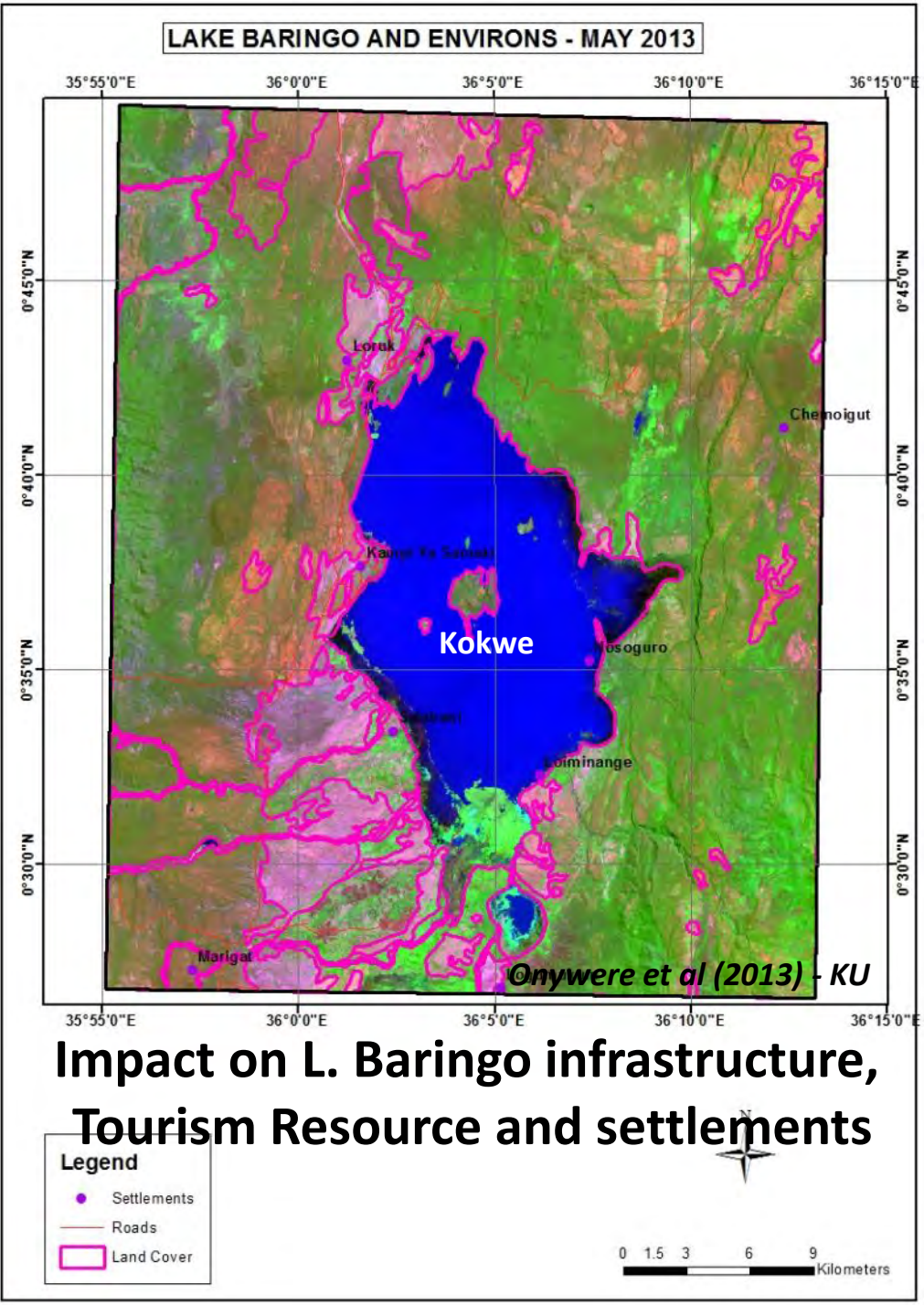
Lake Baringo rising water level in May 2013
Note the changed shape and extent of the lake



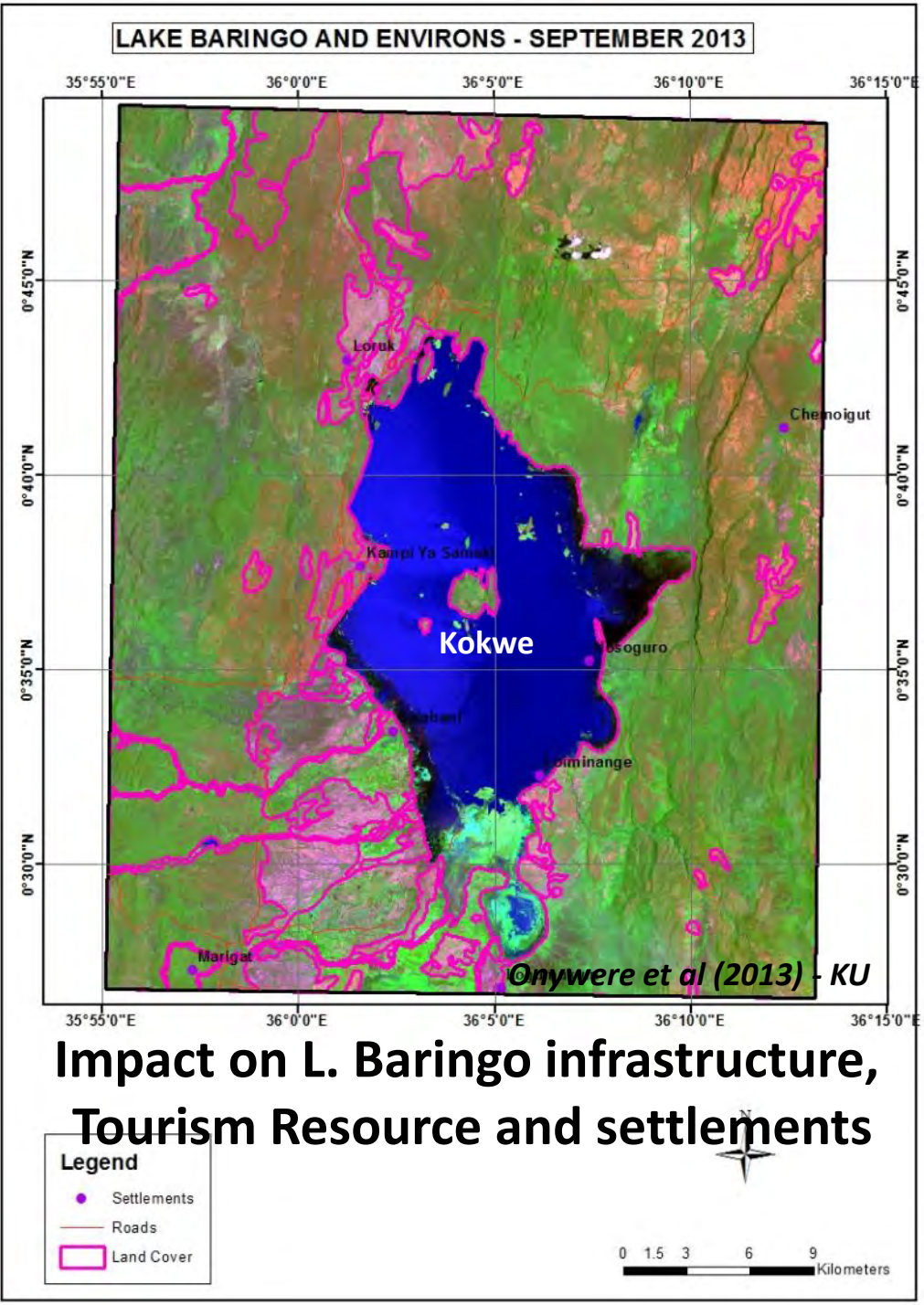
Lake Baringo rising water level in Sept. 2013
Note the changed shape and extent of the lake



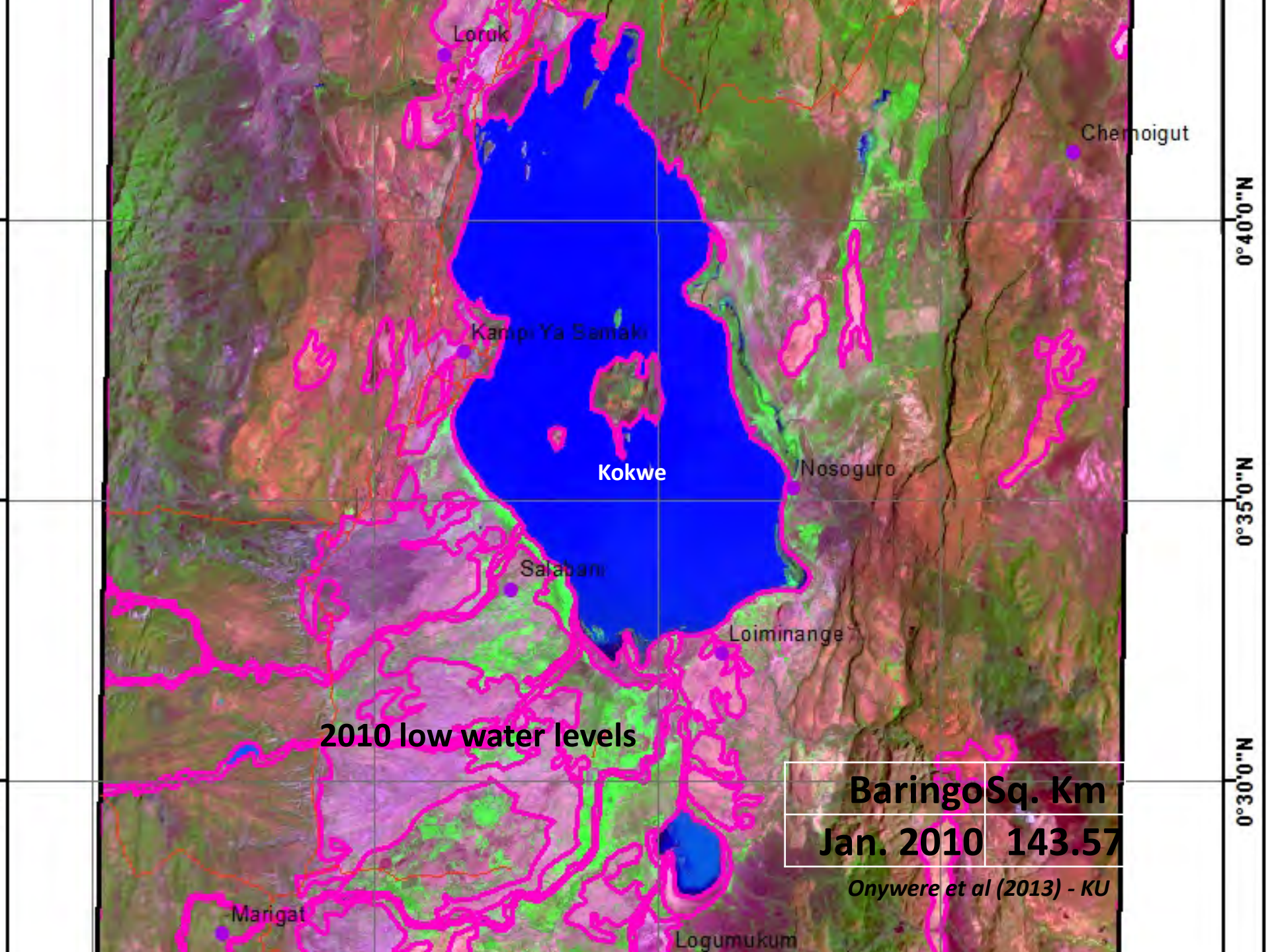
Impact on L. Baringo infrastructure, Tourism Resource and settlements



Impact on L. Baringo infrastructure, Tourism Resource and settlements



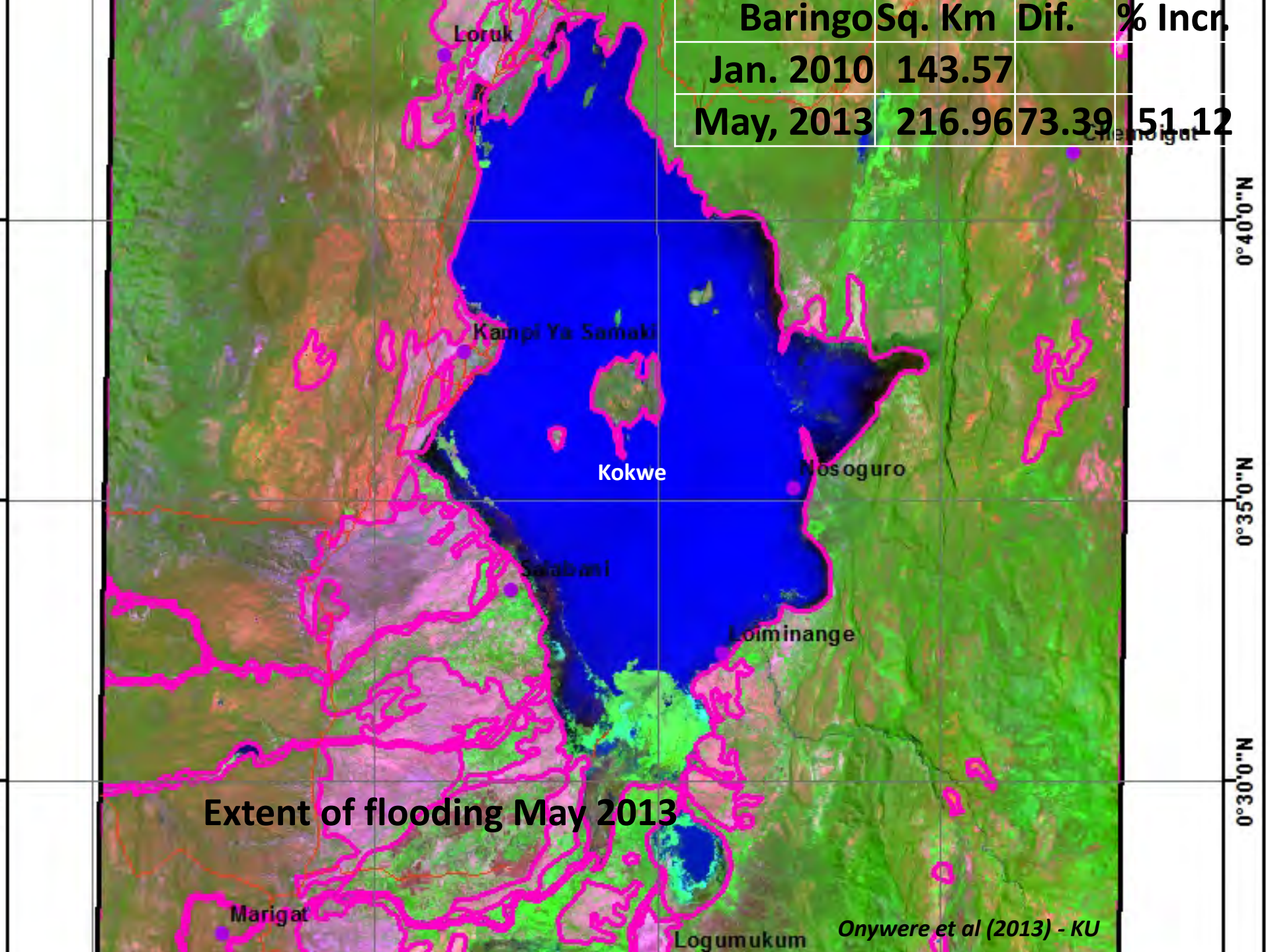
Impact on L. Baringo infrastructure, Tourism Resource and settlements

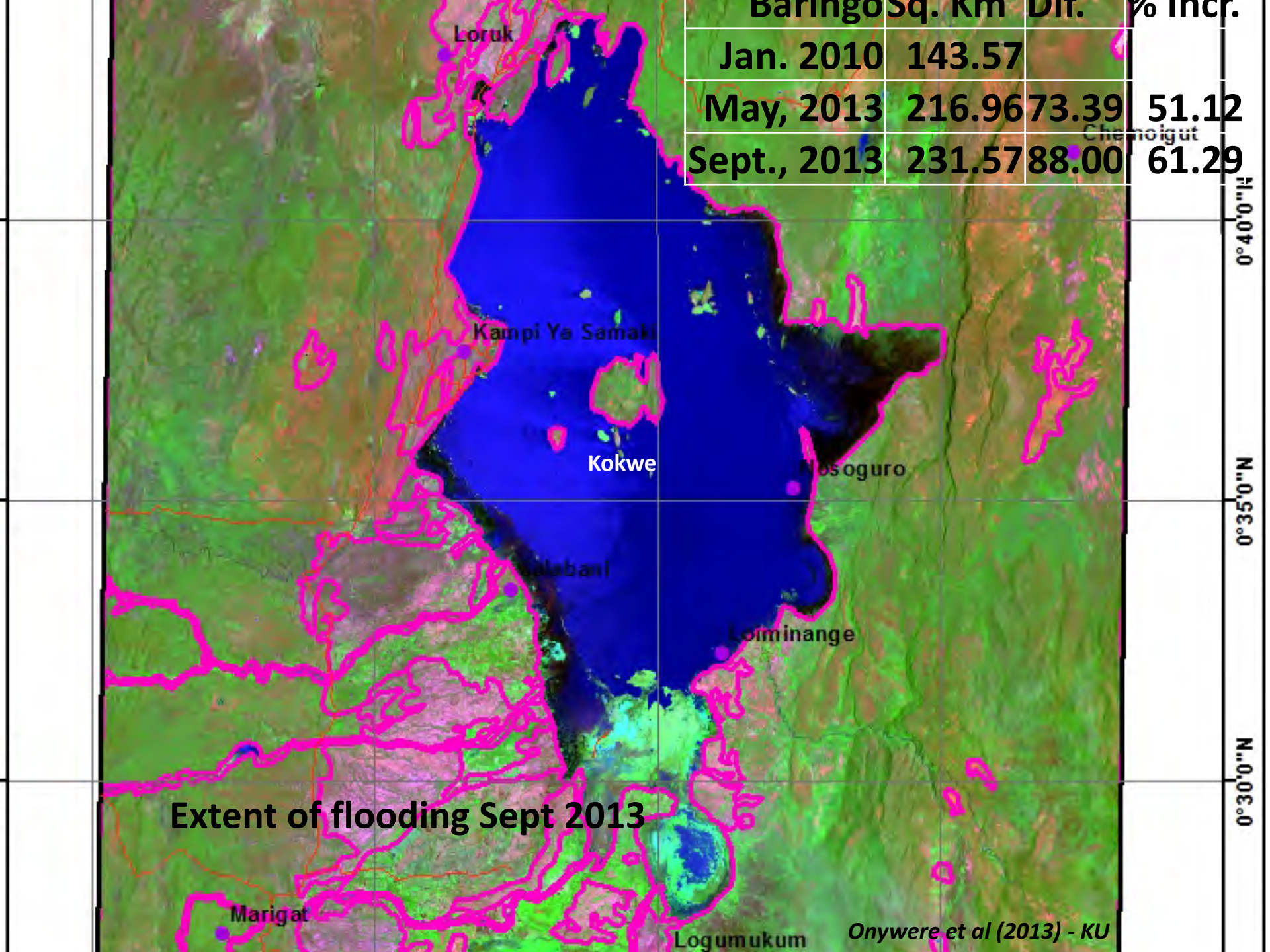


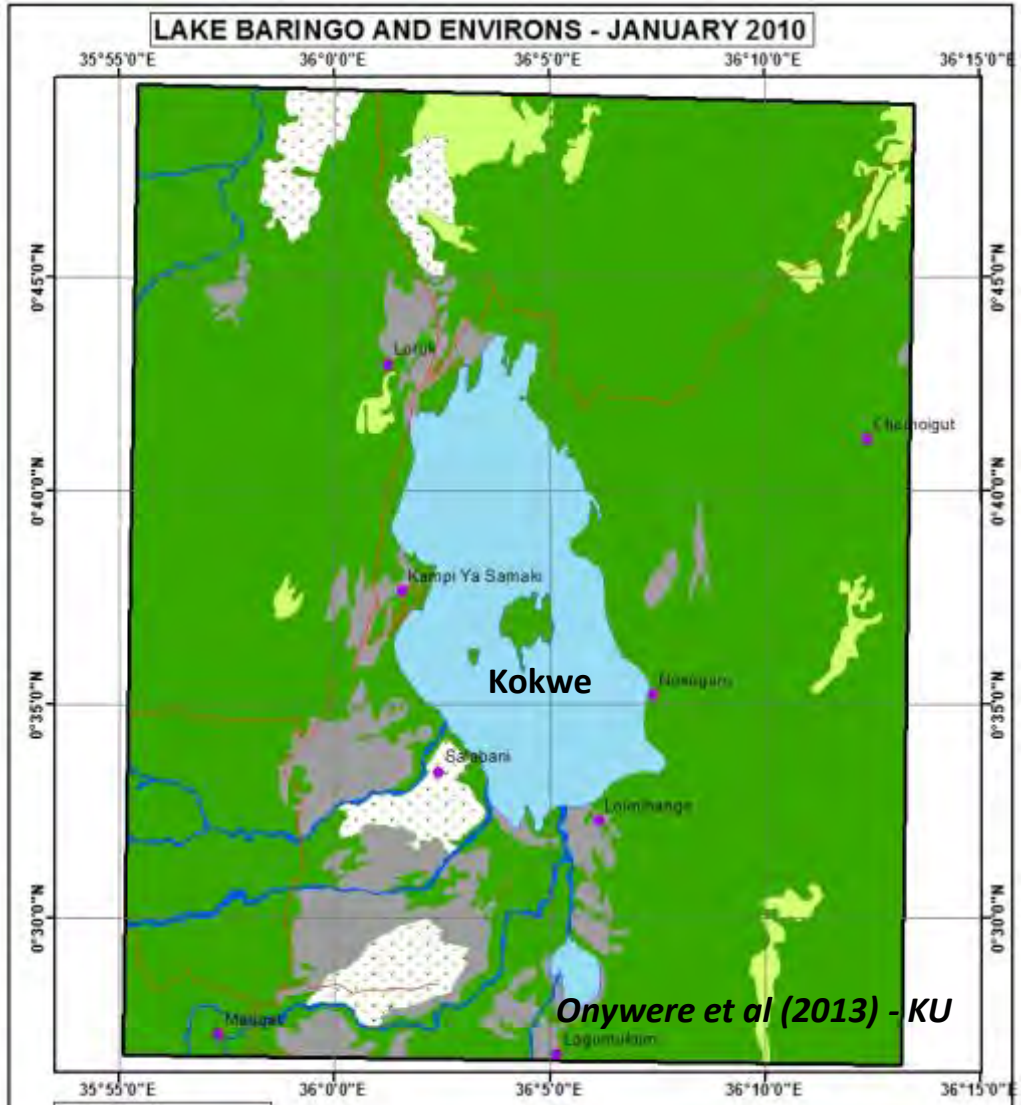
2010 low water levels

Baringo	Sq. Km
Jan. 2010	143.57

Onywere et al (2013) - KU


Baringo
Sq. Km
Dif.
% Incr.
Jan. 2010
143.57
May, 2013
216.96
73.39
51.12
Loruk
Kampi Ya Samaki
Kokwe
Nosoguro
Loiminange
Marigat
Logumukum
Extent of flooding May 2013
Onywere et al (2013) - KU
0°40'0"N
0°35'0"N
0°30'0"N

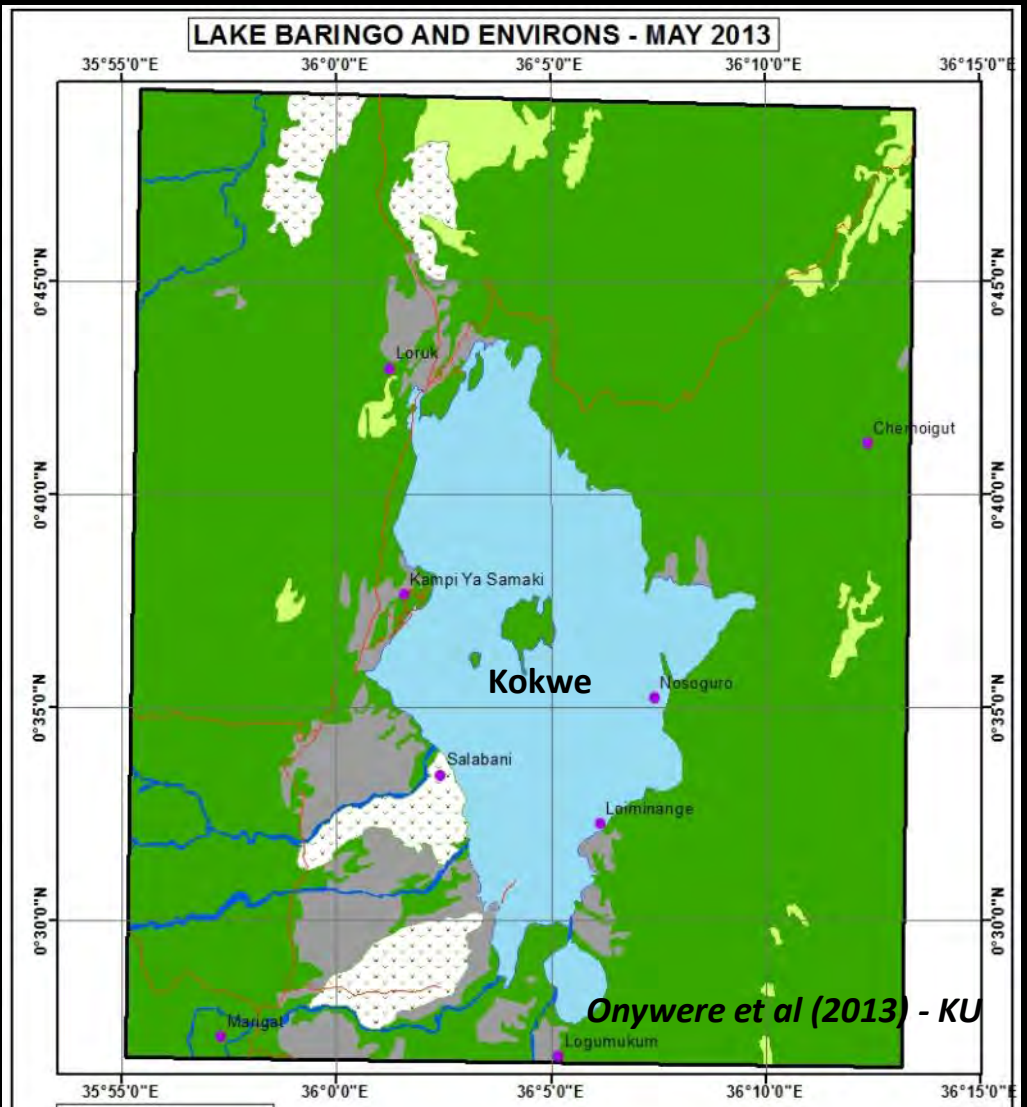

Baringo Sq. Km Dif. % Incr.
Jan. 2010 143.57
May, 2013 216.96 73.39 51.12
Sept., 2013 231.57 88.00 61.29
Loruk
Kampi Ya Samaki
Kokwe
Marigat
Logumukum
Extent of flooding Sept 2013
Onywere et al (2013) - KU
0°40'0"N
0°35'0"N
0°30'0"N


LAKE BARINGO AND ENVIRONS - JANUARY 2010
35°55'0"E
36°0'0"E
36°5'0"E
36°10'0"E
36°15'0"E
0°45'0"N
0°40'0"N
0°35'0"N
0°30'0"N
Lorok
Kampi Ya Samaki
Kokwe
Nosiguru
Salabani
Loiminange
Logumukum
Onywere et al (2013) - KU
Legend
Settlements
Roads
Land Cover
Bare Ground
Cultivated Fields
Grassland
Shrubs
River
Lake
Lake boundary at lowest level in 2010
Id | Land Cover Type | Area - Sq.Km
1 | Bare Ground | 103.44
2 | Cultivated Fields | 55.79
3 | Grassland | 41.06
4 | Shrubs | 1040.07
5 | Rivers | 15.40
6 | Lake | 143.57
Total | 1399.34
N
0 1.5 3 6 9
Kilometers


smo


Logumukum
smo

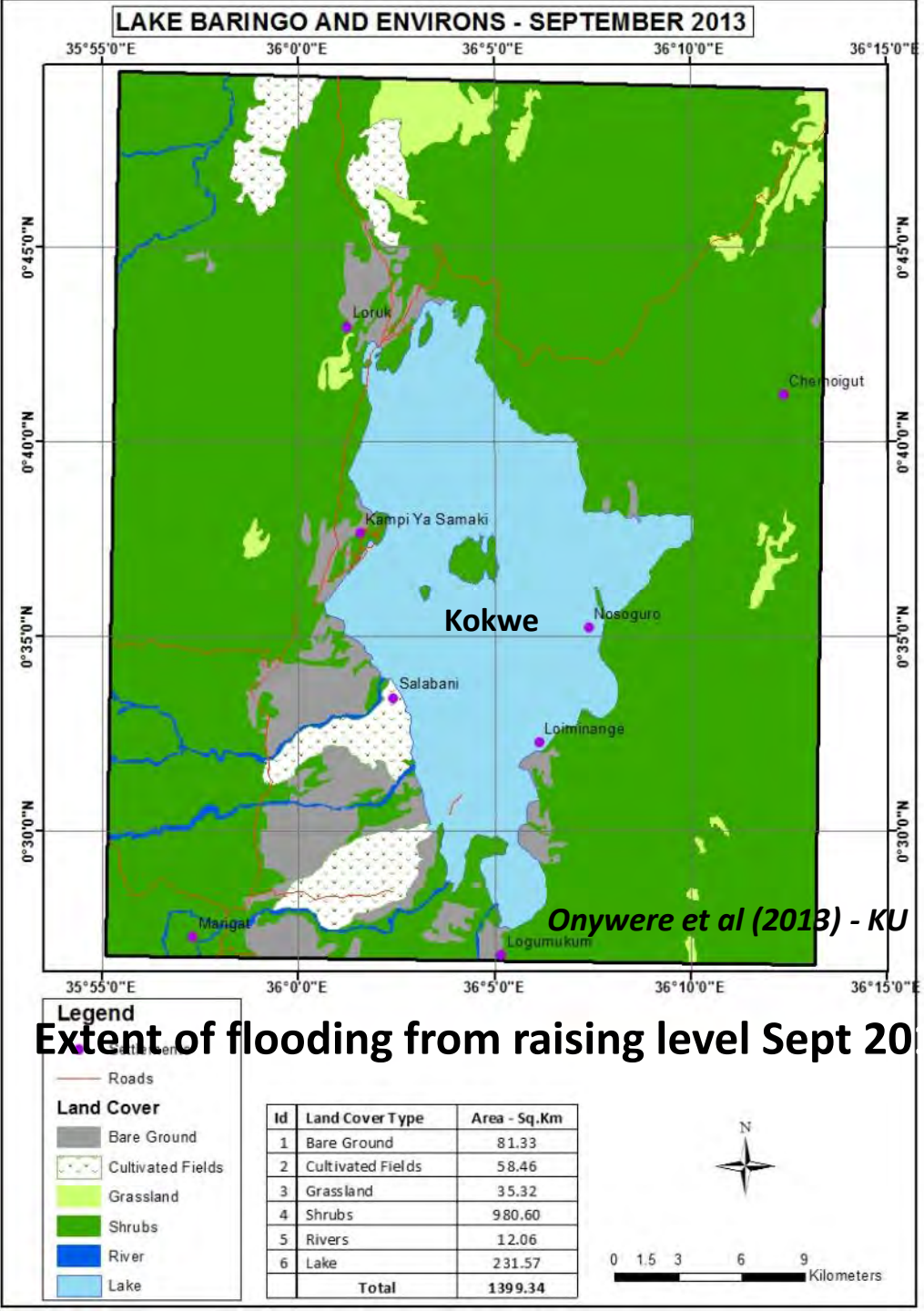

Baringo Sq. Km
Jan. 2010 143.57



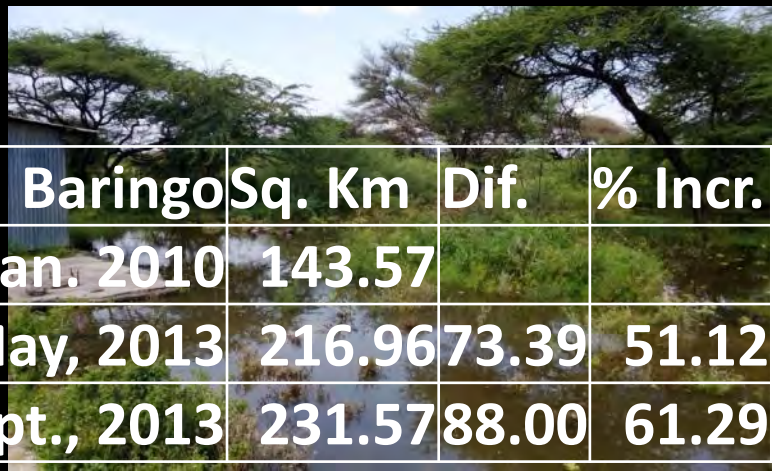
Id	Land Cover Type	Area - Sq.Km
1	Bare Ground	85.98
2	Cultivated Fields	59.39
3	Grassland	35.36
4	Shrubs	989.21
5	Rivers	12.45
6	Lake	216.95
	Total	1399.34

Extent of flooding from rising level May 2013

Baringo	Sq. Km	Dif.	% Incr.
Jan. 2010	143.57		
May, 2013	216.96	73.39	51.12



Extent of flooding from raising level Sept 2013



Baringo	Sq. Km	Dif.	% Incr.
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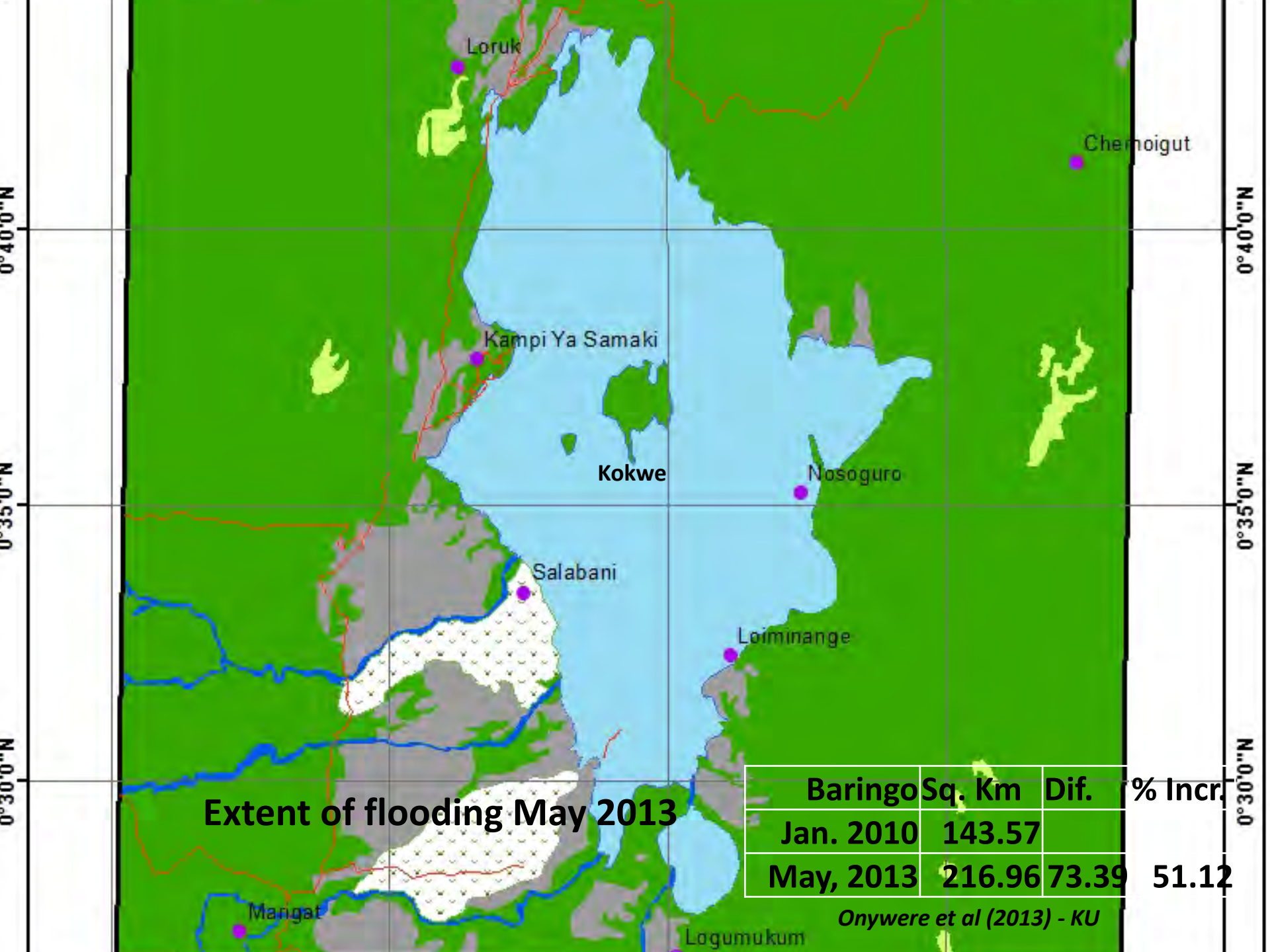
May, 2013	216.96	73.39	51.12
Sept., 2013	231.57	88.00	61.29

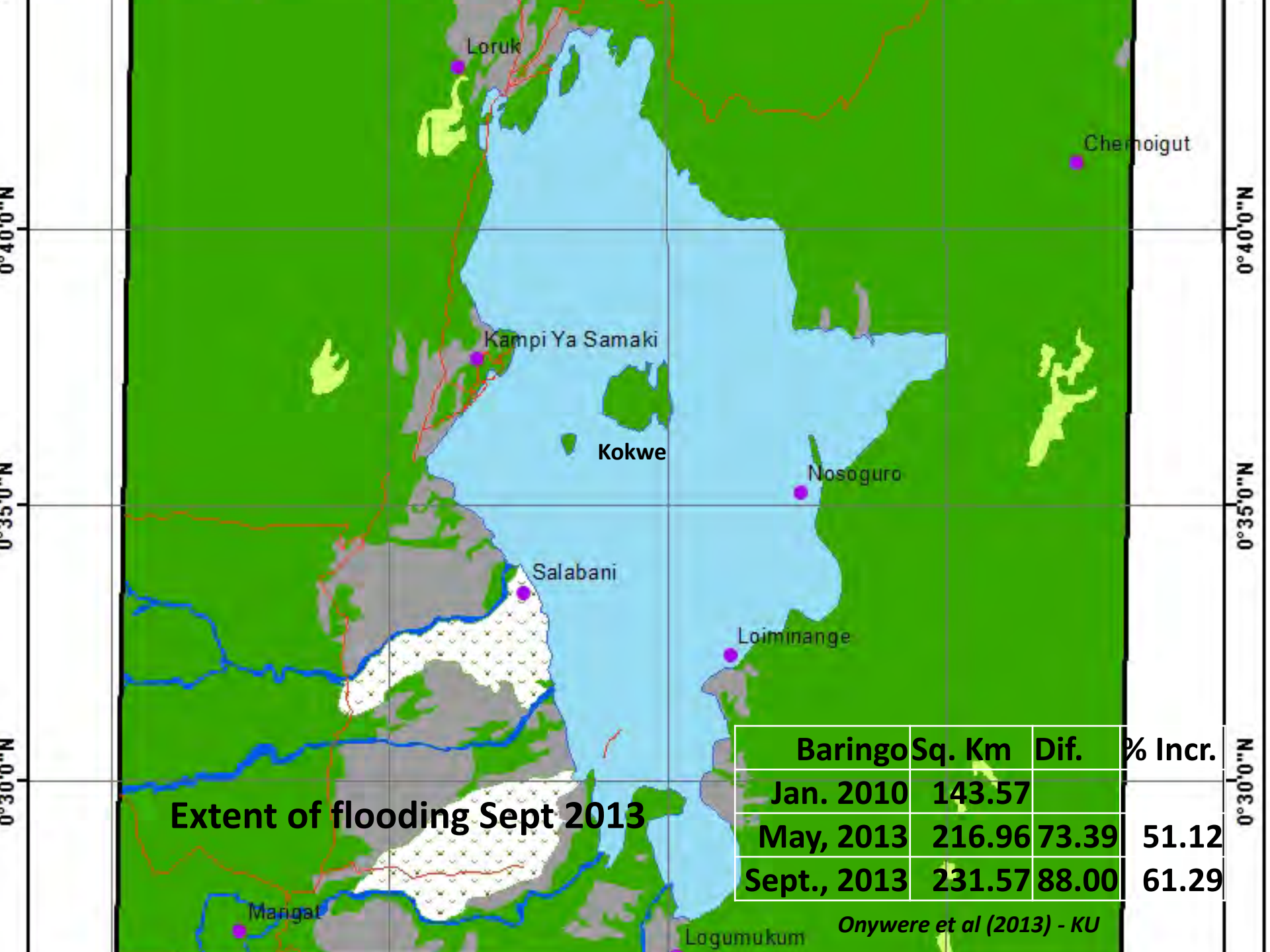

Loruk
Chemoigut
Kampi Ya Samaki
Kokwe
Nosoguro
Salabani
Loiminange
2010 low water levels
Marigat
Logumukum
0°40'0"N
0°35'0"N
0°30'0"N
0°40'0"N
0°35'0"N
0°30'0"N
Baringo Sq. Km
Jan. 2010 143.57
Onywere et al (2013) - KU



Extent of flooding May 2013

Baringo	Sq. Km	Dif.	% Incr.
Jan. 2010	143.57		
May, 2013	216.96	73.39	51.12

Onywere et al (2013) - KU



Extent of flooding Sept 2013

Baringo	Sq. Km	Dif.	% Incr.
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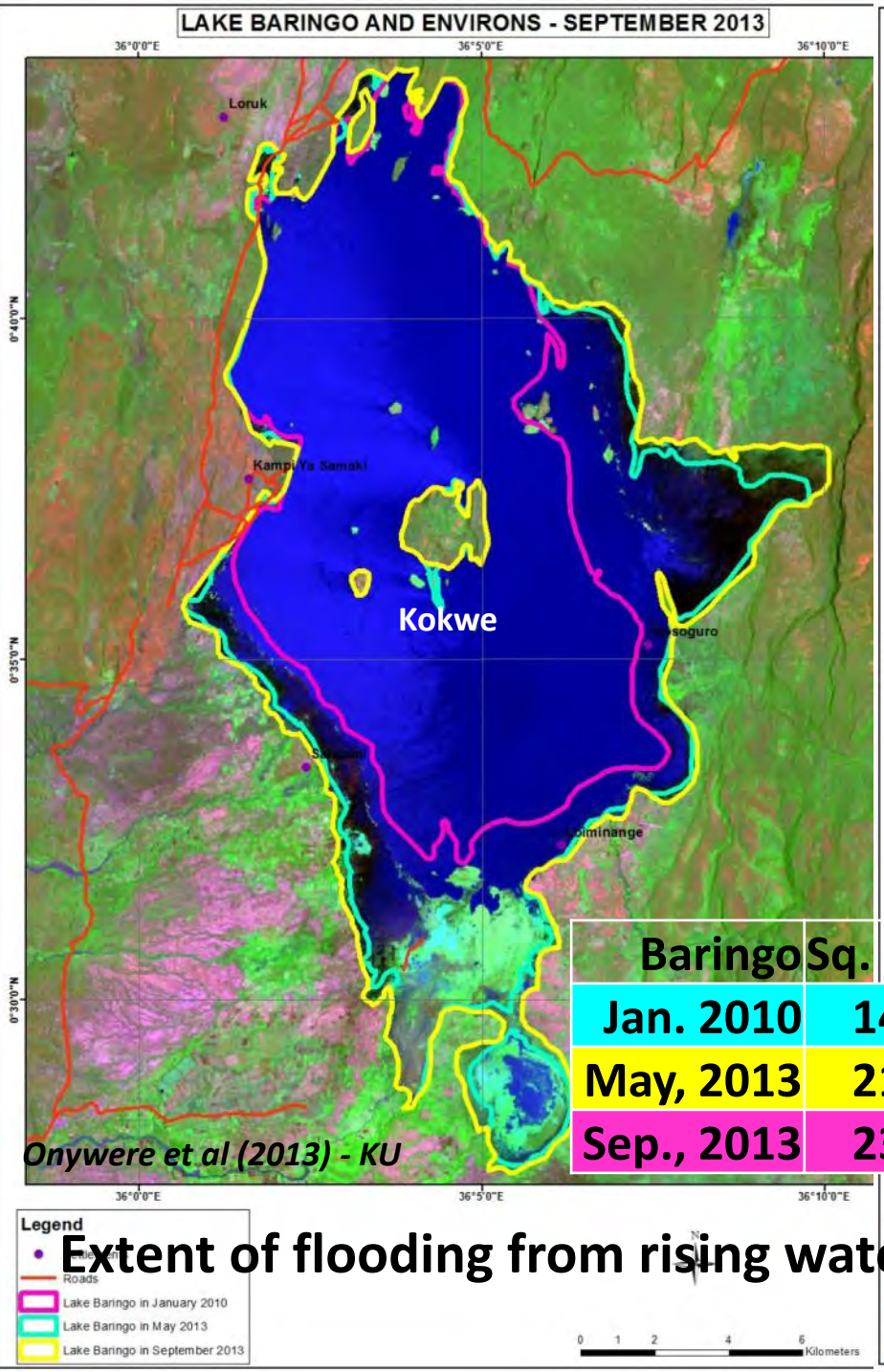
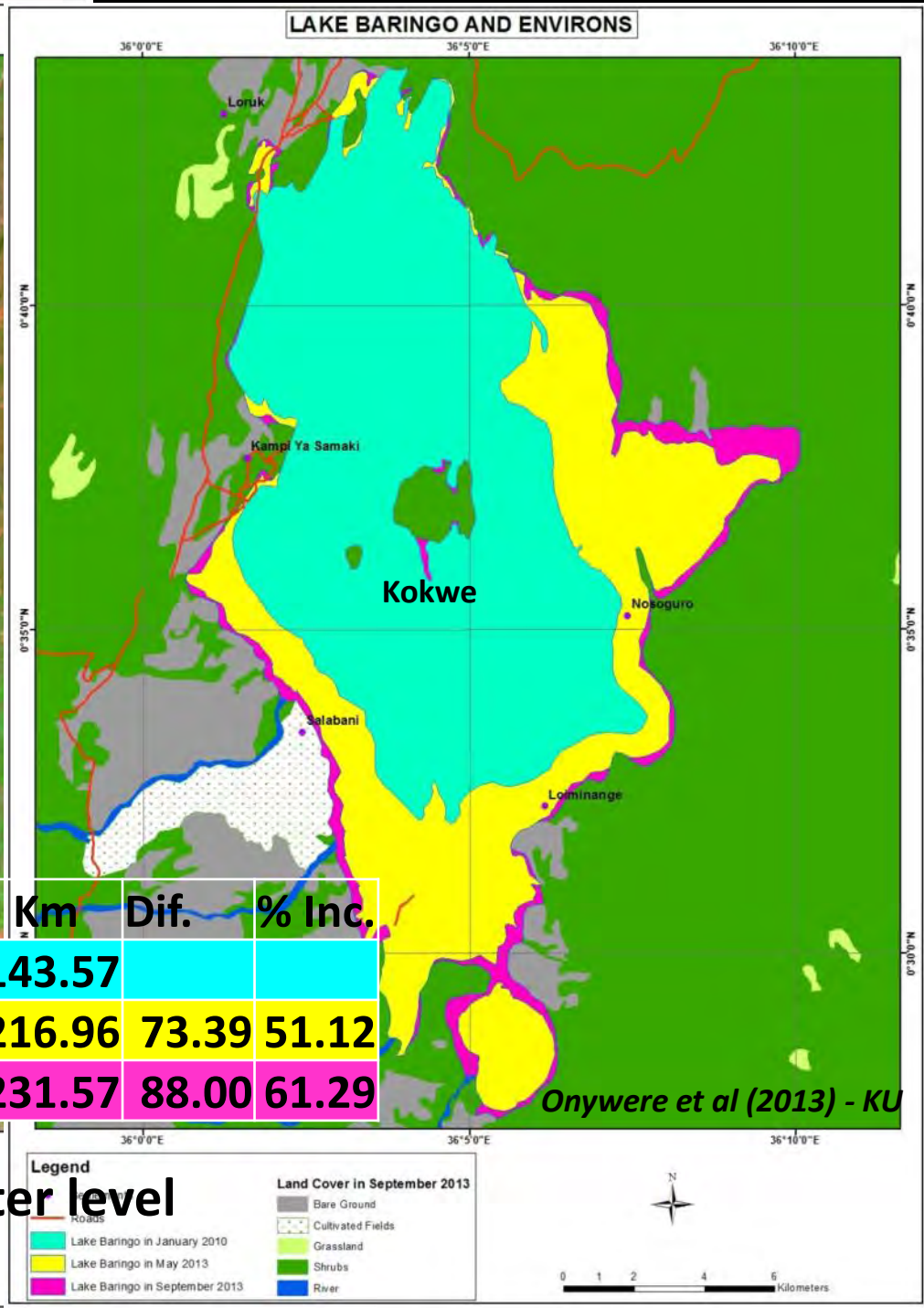
May, 2013	216.96	73.39	51.12
Sept., 2013	231.57	88.00	61.29

Onywere et al (2013) - KU





Baringo	Sq. Km	Dif.	% Inc.
Jan. 2010	143.57		
May, 2013	216.96	73.39	51.12
Sep., 2013	231.57	88.00	61.29

Extent of flooding from rising water level

Lake Baringo – Impacts from flood waters

- The increased recharge of the lake is from mainly Molo and Perkerra Rivers, now both reaching the lake directly through surface recharge and bringing I a large amount of sediments.
- The spread of the flood waters have seen the villages like Salabani, Logumukum, Loiminange, Ngamboni, Nosoguro and Loruk and Kokwe submerged displacing the communities living in those area along with their livestock
- There is an accompanied loss of cultivated land especially the irrigated areas within the flooded areas.
- At least 6 Schools in the villages listed above along with Health Centres are submerged
- All the Hotels and Lodges located at Kambi Samaki, notably Soy Lodge, Lake Baringo Lodge and Roberts Camps are submerged.

Onywere et al (2013) - KU

Lake Baringo – Impacts from flood waters

- 2 islands have a emerged as the flood waters fill the grabens marking the fault blocks on the northern side of the lake while Ol-Kokwe and the other regular islands on the lake have considerably shrunk
- .The fish in the lake has spread far and wide within the flooded areas and villagers are fishing from within the flood plains.
- The crocodiles in the lake are now not confined to the lake but are now coming out to the flood areas
- Snake that infest the lake Baringo area have migrated to dryer areas increasing the risk of snake bite
- Increased amount of floating mats of water weeds are seen as islands in the lake and now are the main undergrowth in the flooded areas
- Loss of biodiversity e.g. loss of acacia and other vegetation due to submergence.
- Prosopis juliflora (Mathenge) has prolifically increased in its growth, limiting accessibility

Onywere et al (2013) - KU

Lake Baringo – Impacts from flood waters

- The flood water is likely to remain for some time and thus pose new challenges that now require preparedness and monitoring in the following key areas:
  - Rethinking the planning of infrastructure especially settlement areas and location of public utilities such as schools
  - Risk of malaria epidemic
  - Risk of rift valley fever
  - Risk from snake bites
  - Risk from crocodile attacks
  - Contamination of lake waters that is largely consumed directly by the community
  - Water borne diseases such as schistosoma mansoni and intestinal worms
  - Change in biodiversity of the area
  - Loss of agricultural and grazing land

Onywere et al (2013) - KU

ACKNOWLEDGEMENTS

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- Warden Lake Nakuru National Park
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- The communities of the lake Baringo area

onyweres@gmail.com
onywere.simon@ku.ac.ke