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Land use changes in sub-Saharan Africa from local to continetal

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Land and Forest Governance:

Reconciling the Interests of Businesses and People Living in Poverty

Helsinki, 20.5.2010

Land cover

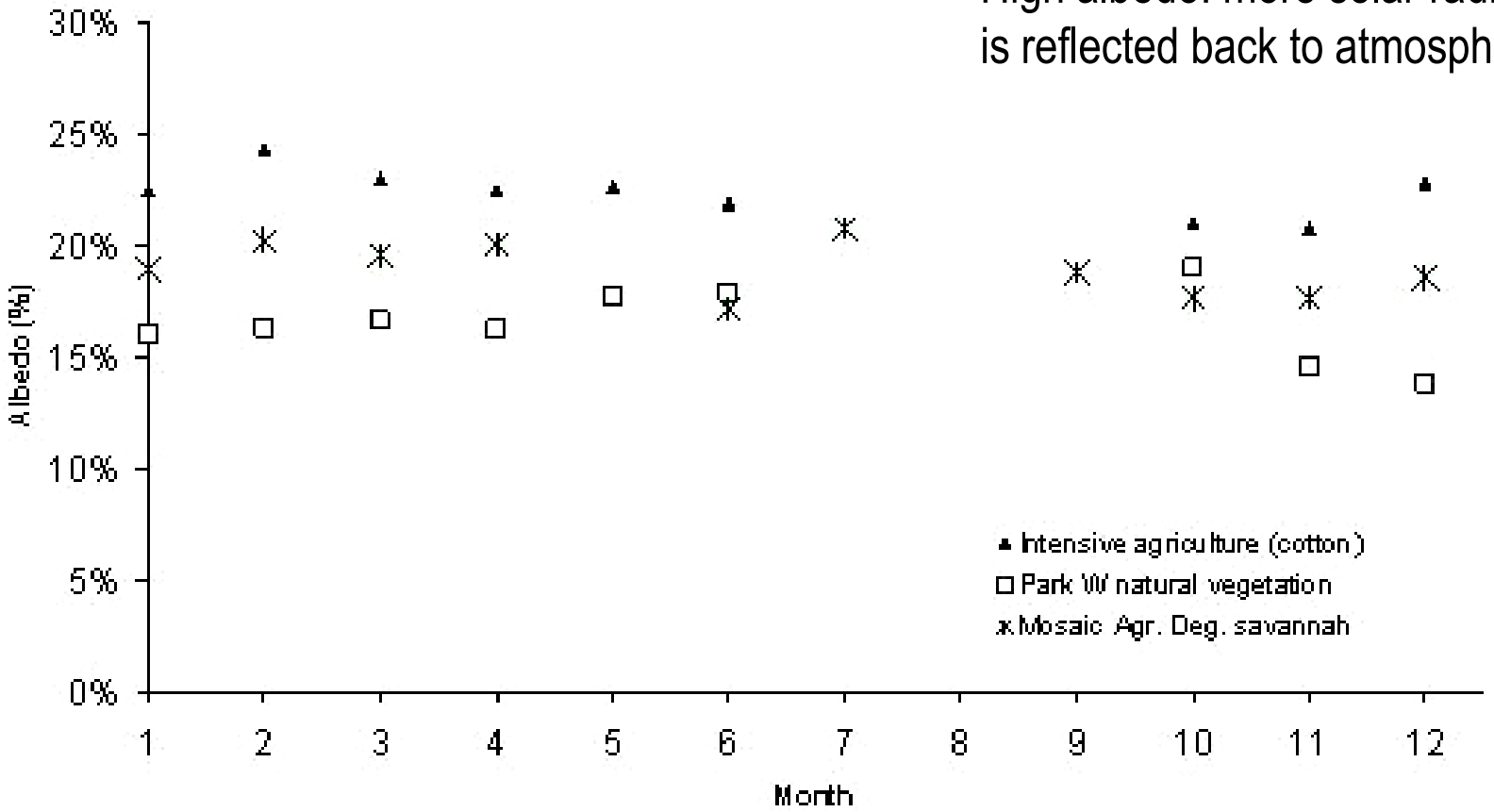
- Land cover is the main factor regulating water, carbon, aerosol, gas and heat exchange between land and atmosphere
- Increasing agricultural land decreases original vegetation and more land is barren at least part of the year
- Increasing albedo affects radiation and heat balance
- Decreasing vegetation cover captures less atmospheric moisture
- Decreasing vegetation cover retains less water and is vulnerable to soil erosion

Gully erosion in Kenya, 2004

Bushland cleared for sisal plantation in Kenya, 2005

Albedo (%) from various surface types

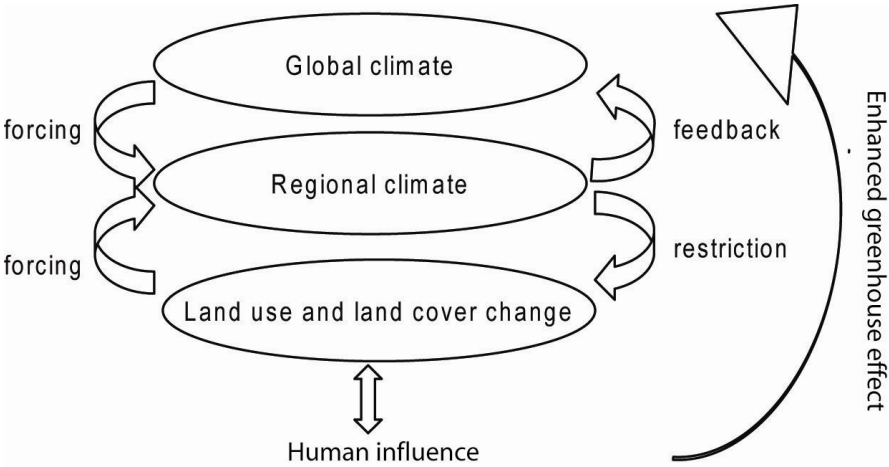
High albedo: more solar radiation is reflected back to atmosphere



Albedo measurements in Burkina Faso within a year. Agriculture (20-25%), Natural vegetation (savannah) (16%) degraded savannah (19%), (Eva et al., 2006).

Land cover changes

- Land cover, its changes and scenarios are important factors in climate change studies
- With climate change, land cover change affects also ecosystem services, food security and livelihoods
- The best area-efficient method for studying land cover and albedo changes is remote sensing

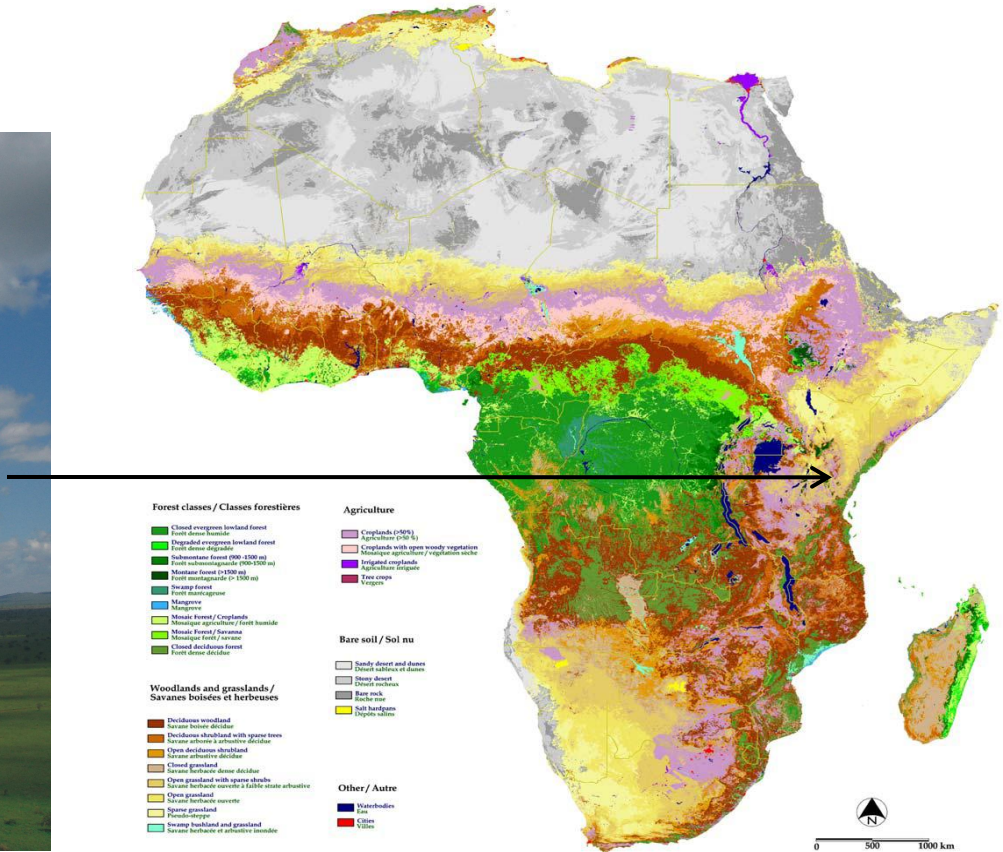


Dakacha woodlandand cleared for pine apple in Kenya, 2009

Contents

- Regional land cover changes: airborne remote sensing and satellite remote sensing in the Taita Hills, Kenya
- Continental land cover changes: satellite remote sensing of land cover in sub-Saharan Africa

The Taita Hills in Kenya, 2004

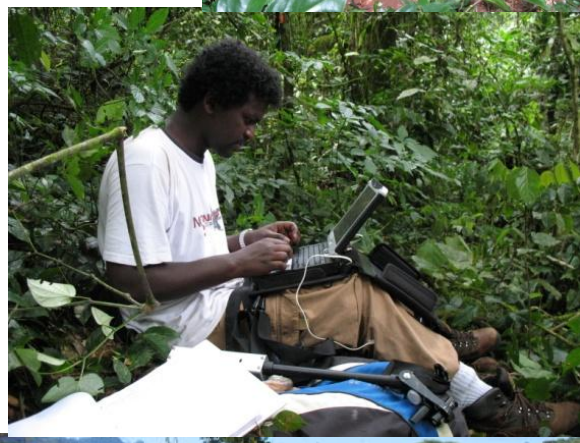


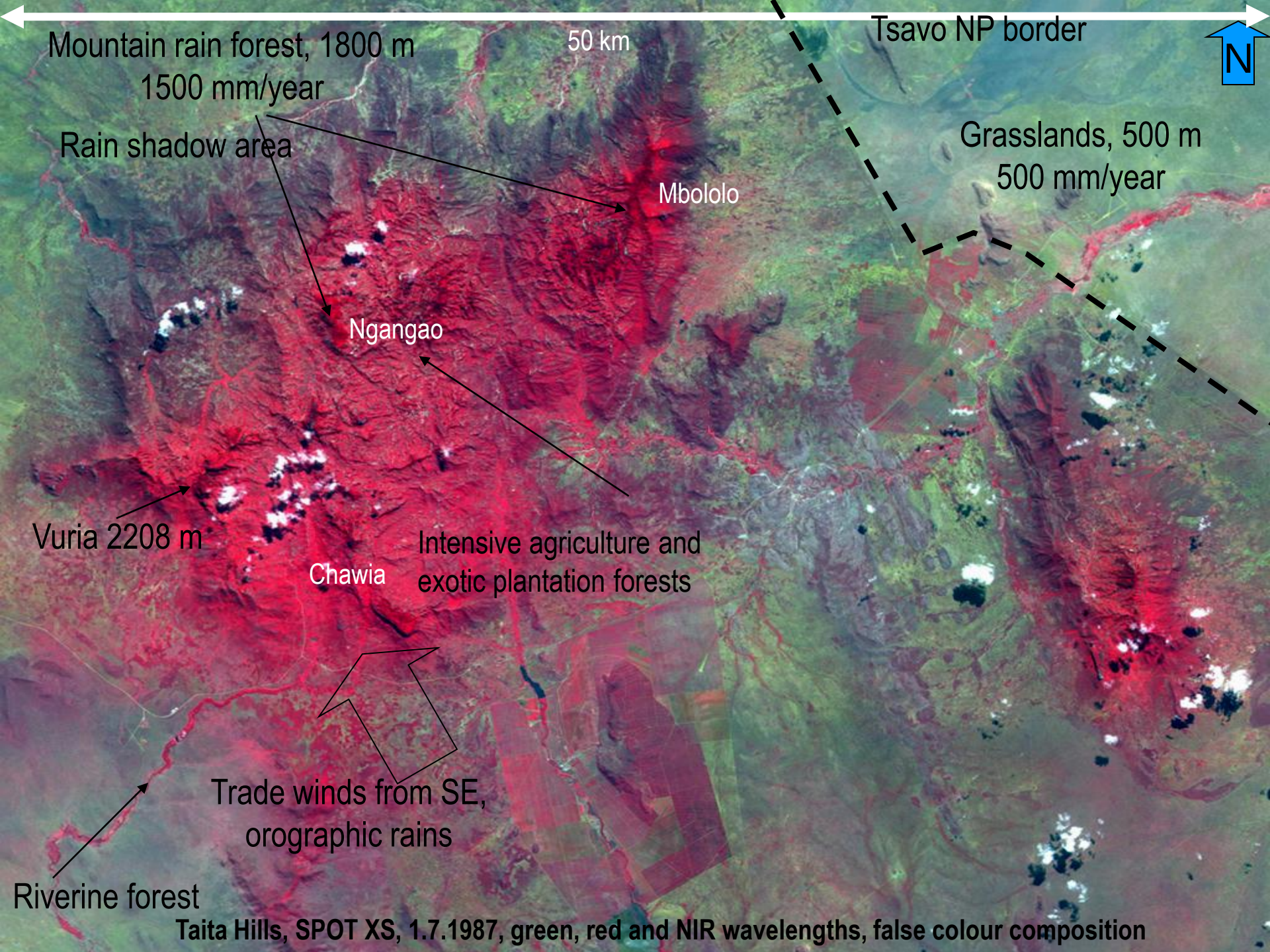
University of Helsinki in Taita Hills

- Research expedition in 1989 funded by Ministry for Foreign Affairs of Finland
  - Land use change studies
  - 6 MSc theses
- TAITA - Developing land use change detection methods using remote sensing
  - 2003-2005, Academy of Finland
  - Taita Hills Environmental Monitoring System
  - 7 MSc theses and 1 PhD thesis
  - Mika Siljander, Nina Himberg, Barnaby Clark, Eduardo Maeda, Alemu Gonsamo, Johanna Hohenthal

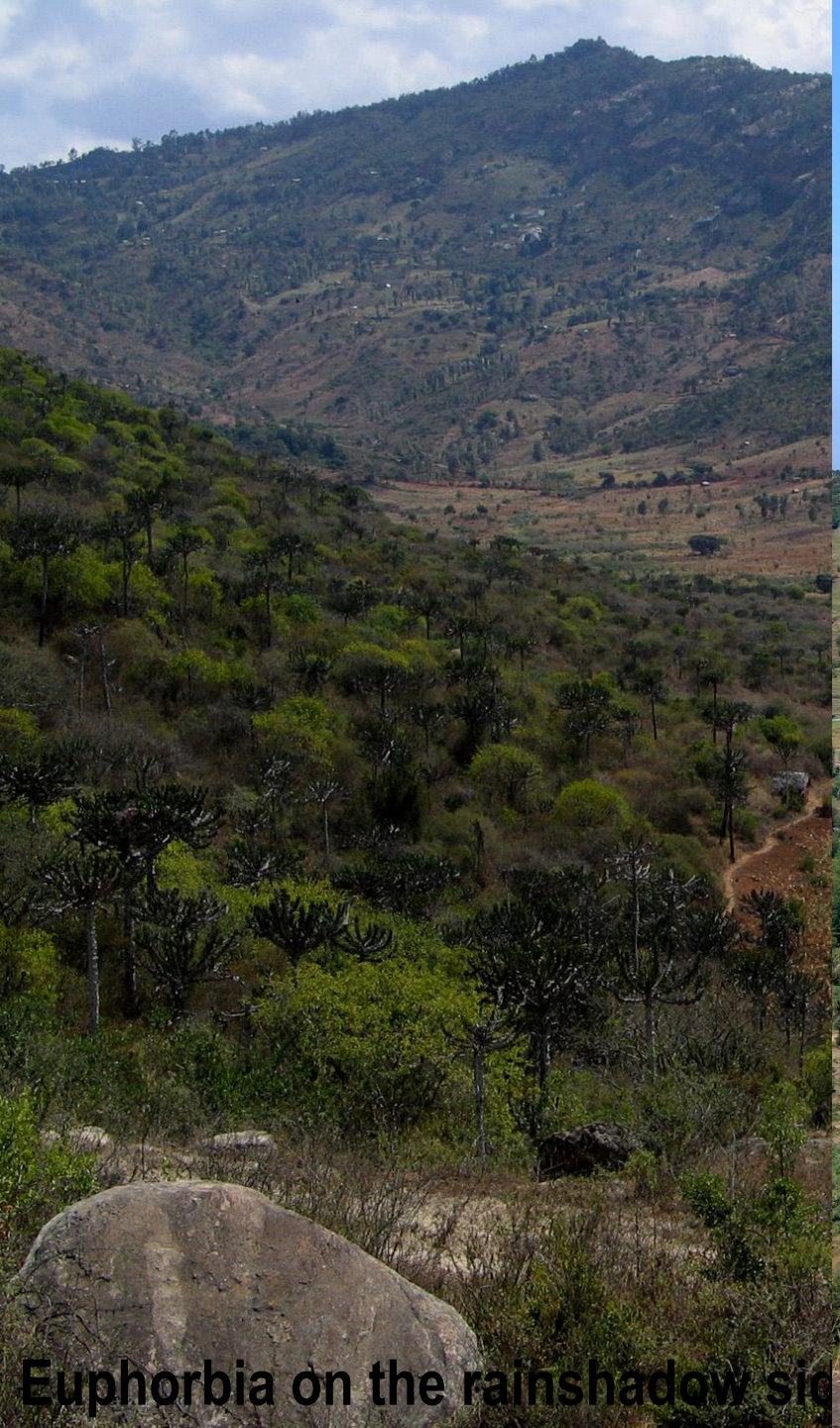
University of Helsinki in Taita Hills

- TAITATOO - Applications for developed land cover change data
  - 2006-2009, Academy of Finland
  - Ecological modelling
  - Landscape conservation through forest corridors
  - Soil erosion modelling
  - Participatory GIS as part of qualitative research methods
  - Community based natural resource management
  - 4 MSc theses and 5 PhD theses in 2009-2010





Taita Hills, SPOT XS, 1.7.1987, green, red and NIR wavelengths, false colour composition



Euphorbia on the rainshadow sid

Croplands in the middle of the hills

Land cover changes

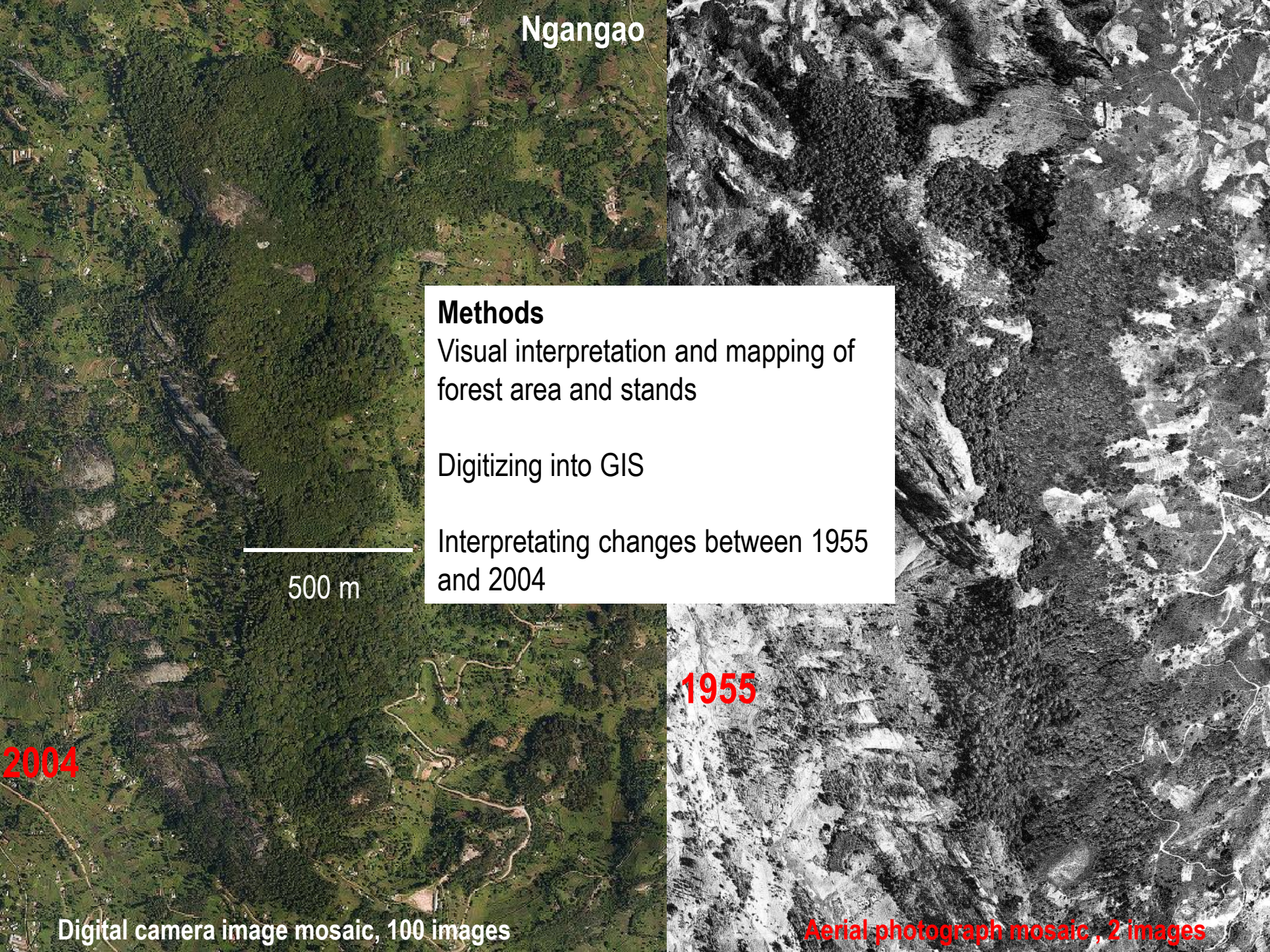
Remote sensing of native forests with remote sensing data
1955 - 2004

EnsoMOSAIC imaging system of the University of Helsinki

Data

- Digital camera mosaics, 2004
  - Nikon D1X and EnsoMOSAIC
  - Computer, GPS, navigation and imaging system, control unit
  - True colour data
  - Images with XYZ-coordinates, time and flying direction
  - Seamless orthorectified image mosaics
  - Geometric accuracy 1-2 m
- Black & white aerial photography, 1955
  - Georeferenced to mosaics

Digital camera image, Sagala, Kenya: houses, road, shamba, forest, ground resolution 0.35 cm



Methods

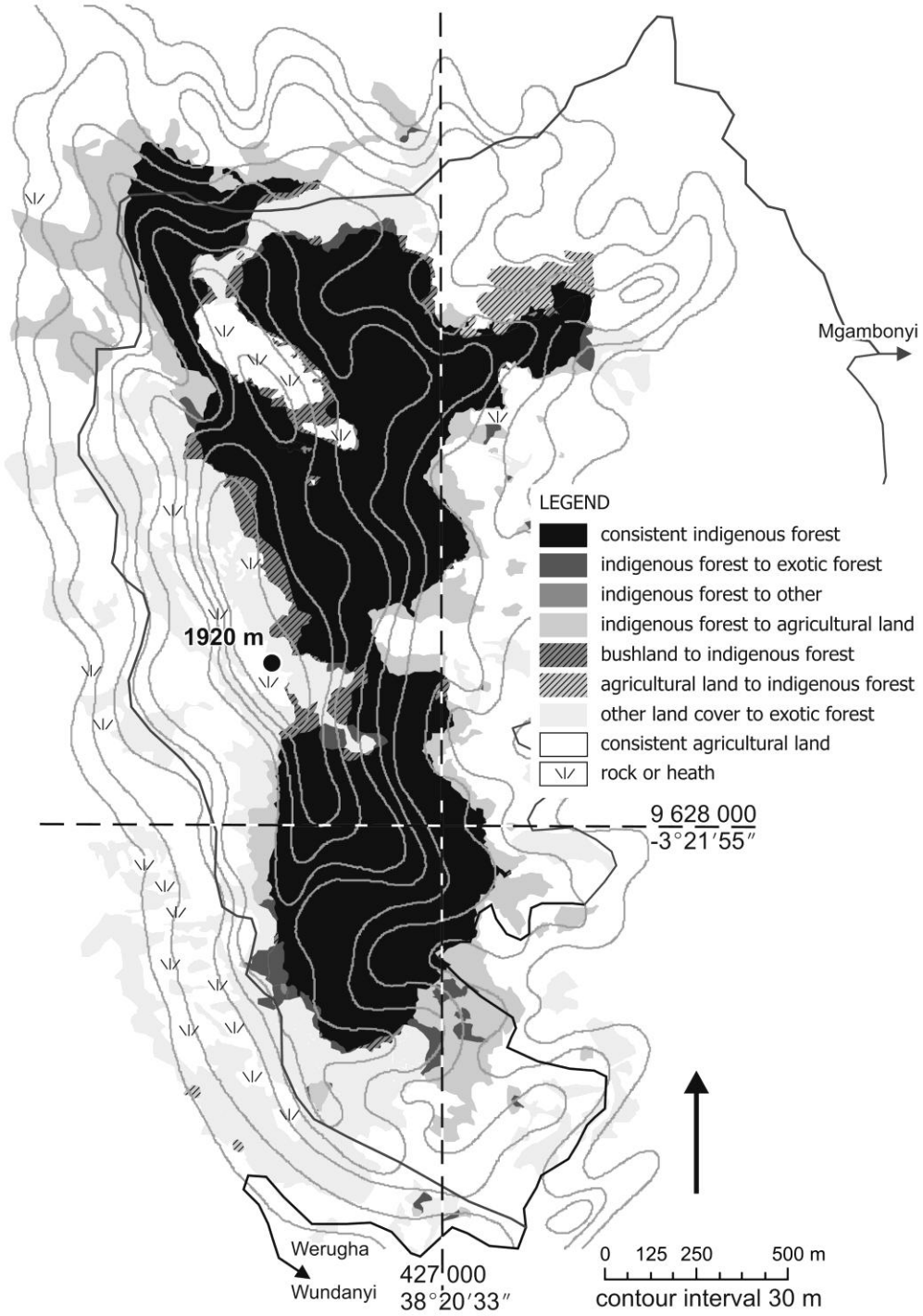
Visual interpretation and mapping of forest area and stands

Digitizing into GIS

Interpretating changes between 1955 and 2004

Forest cover changes 1955-2004
Ngangao, Taita Hills, Kenya

	1955	2004
Native forest	150 ha	120 ha
Exotic forest	-	70 ha
Rock	10 ha	2 ha



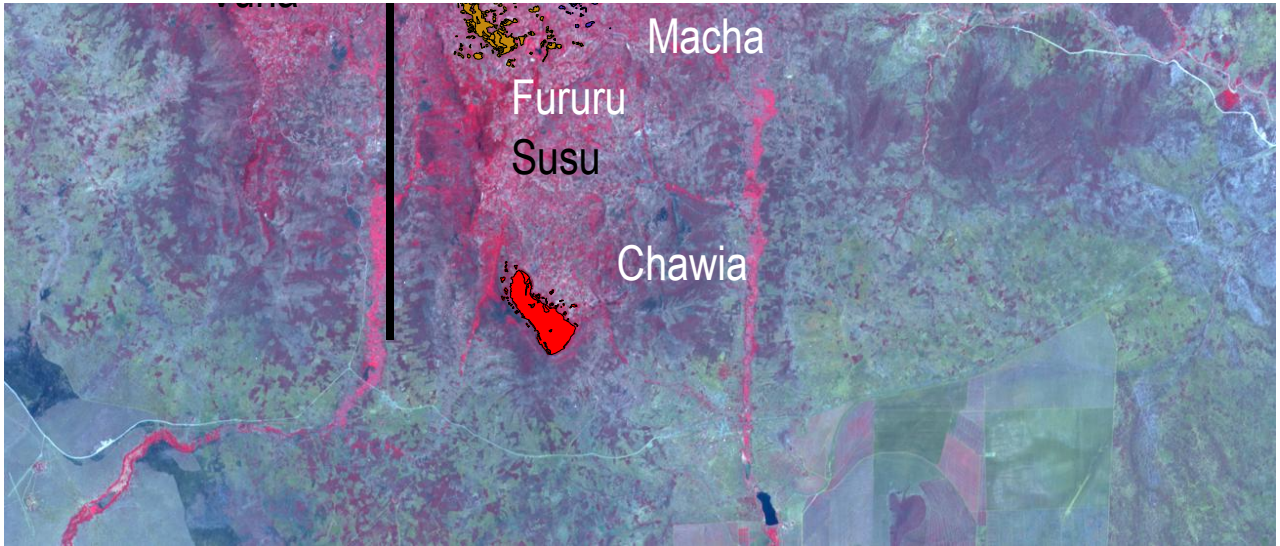
Results from 6 forest fragments 1955 - 2004

Indigenous forest area decreased by 50%

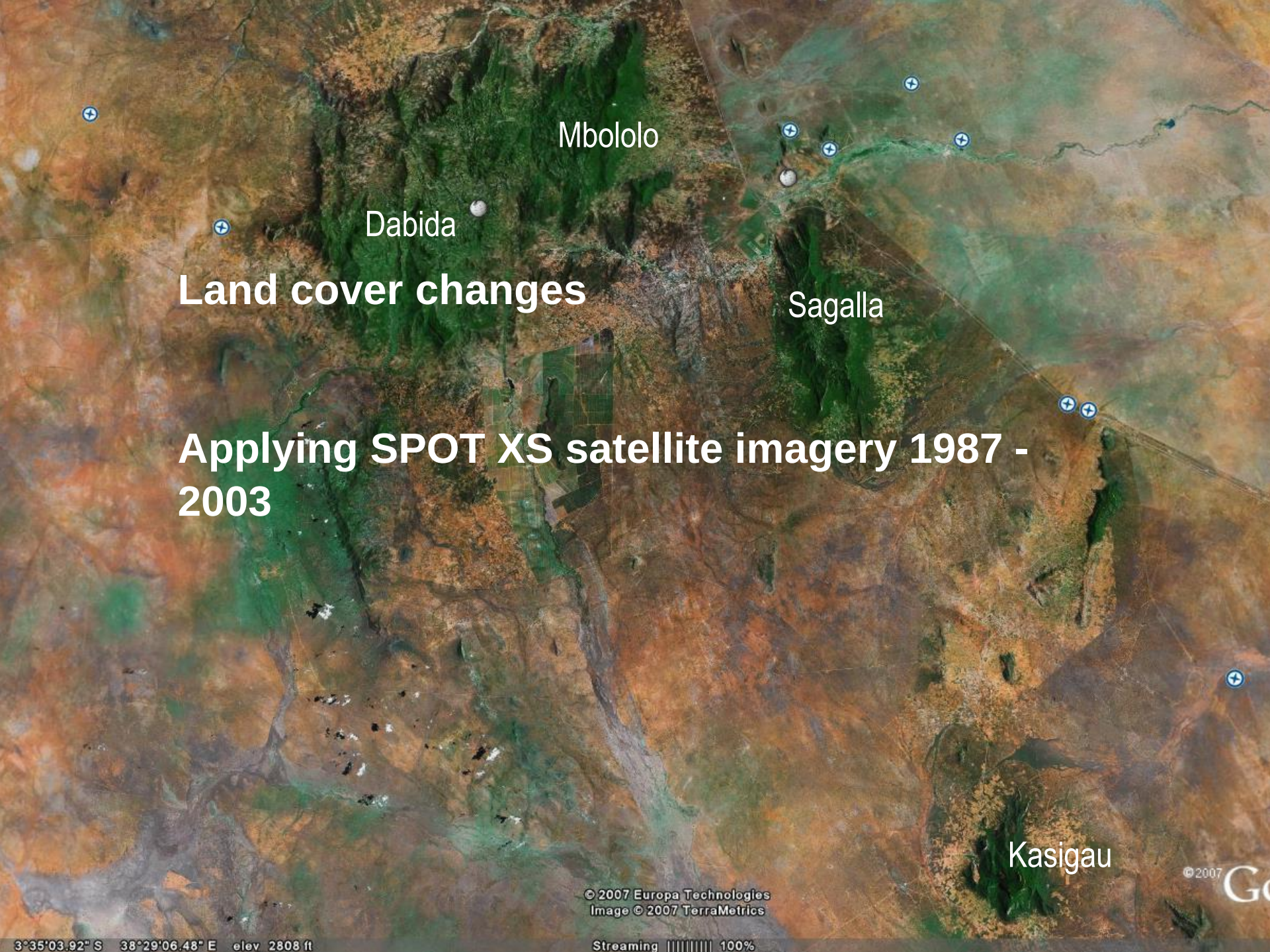
Total forest area remained the same (indigenous forests + plantation forests)

Indigenous forests were cleared for agriculture

Exotic plantations were established mostly on barren areas, but also within the forests during 1960s and 1980s



Pellikka, P. et al., 2009. Airborne remote sensing of spatiotemporal change (1955-2004) in indigenous and exotic forest cover in the Taita Hills, Kenya. 2009. *International Journal of Applied Earth Observation and Geoinformation.*


Mbololo
Dabida
Land cover changes
Sagalla
Applying SPOT XS satellite imagery 1987 - 2003
Kasigau
© 2007 Europa Technologies
Image © 2007 TerraMetrics
3°35'03.92" S 38°29'06.48" E elev 2808 ft
Streaming 100%

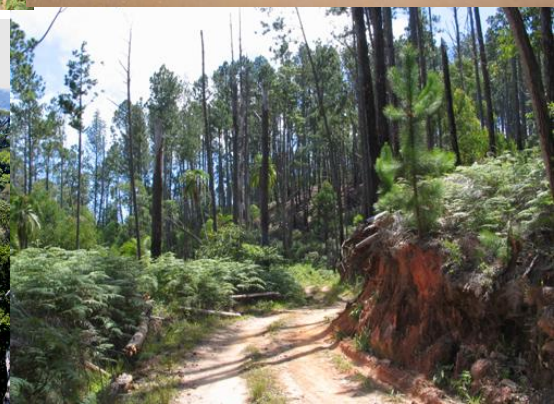
Mapping land cover

- Taita Hills and surrounding plains
- SPOT data 1987, 1992, 2003, 20m spatial resolution
- Land Cover Classification System adopted from FAO
- Croplands, bushlands, thickets, open woodland, plantation forests, closed canopy rain forests, grasslands, barren land, built-up area, rocks, water and burned areas









Taita Hills, Kenya

SPOT Satellite Image 1987

This SPOT satellite image was captured on 1st July 1987

This is a "false colour" image, healthy vegetation shows red.

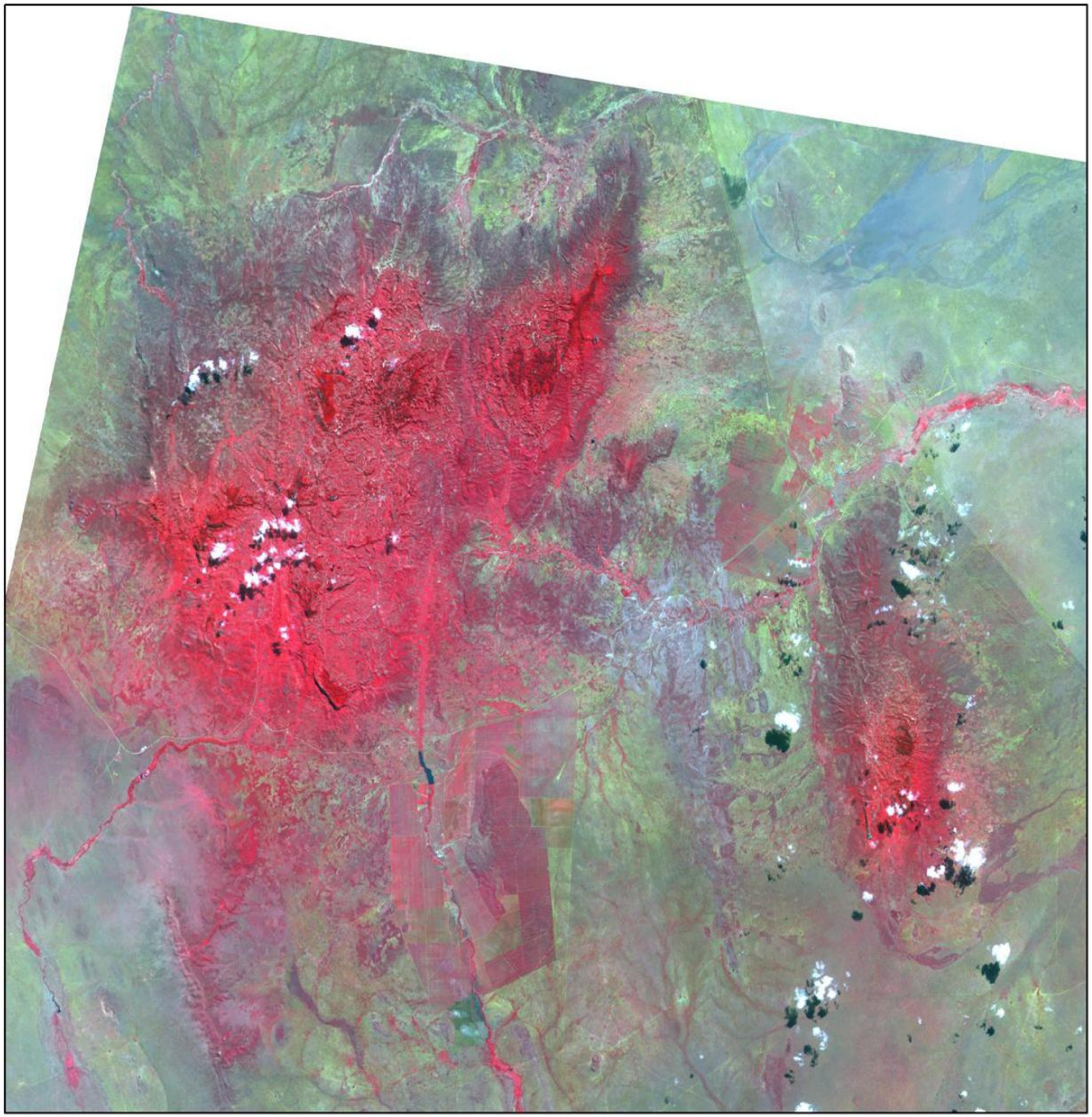
There are three spectral bands:

Green
Red
Near-infrared

This image has been orthorectified and corrected for atmospheric and topographic effects

The orbital position is
Path: 143 Row: 357

Image taken after rainy season



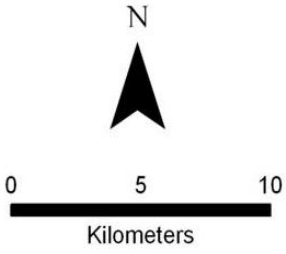


Image processing: Barnaby Clark

Taita Hills, Kenya

SPOT Satellite Image 2003

This SPOT satellite image was captured on 15th October 2003

This is a "false colour" image, healthy vegetation shows red.

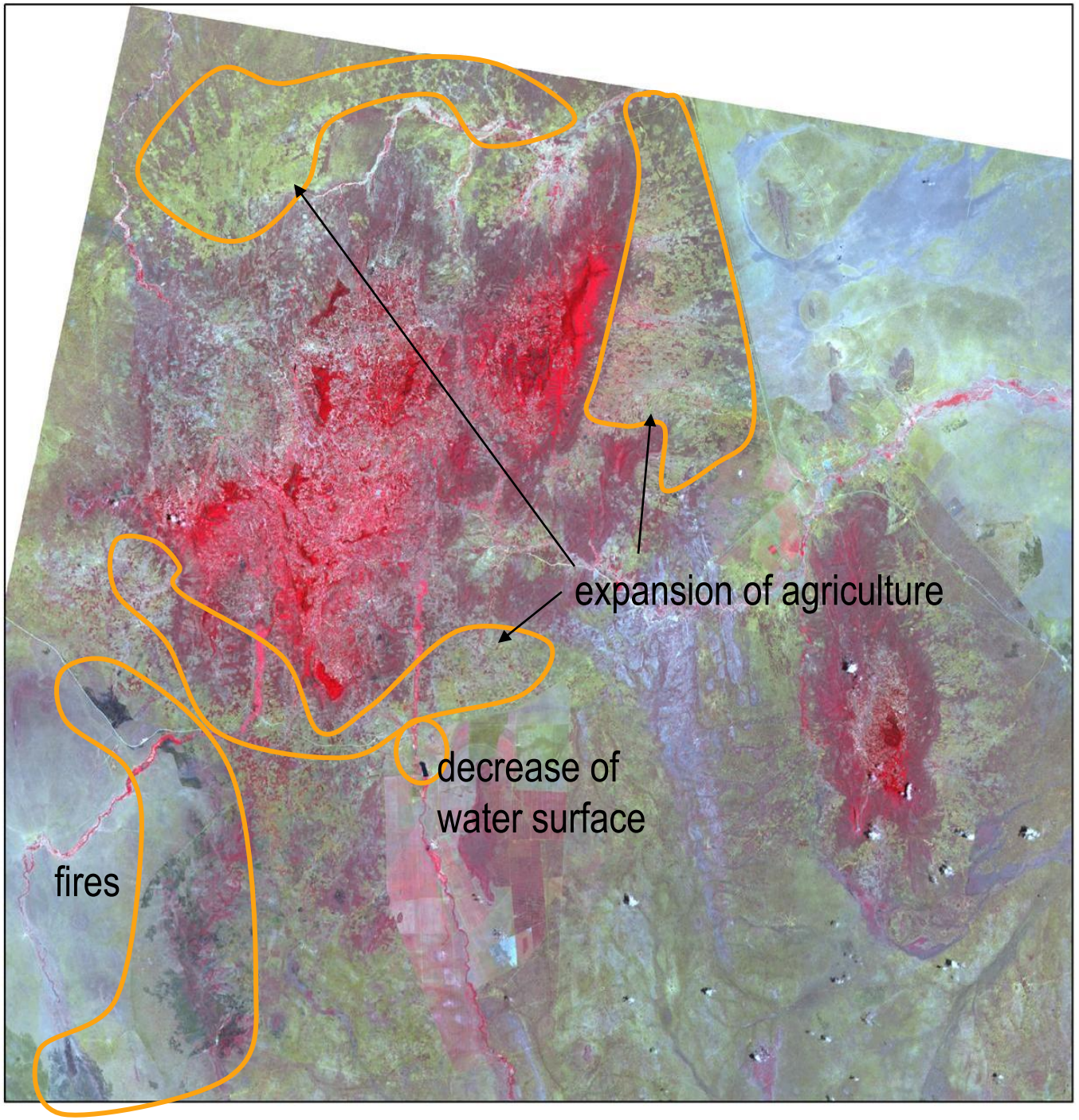
There are three spectral bands:

Green
Red
Near-infrared

This image has been orthorectified and corrected for atmospheric and topographic effects

The orbital position is
Path: 143 Row: 357

Image taken after the dry season



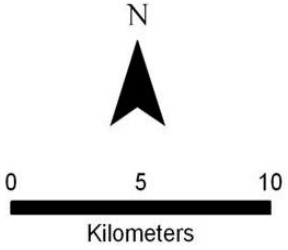


Image processing: Barnaby Clark

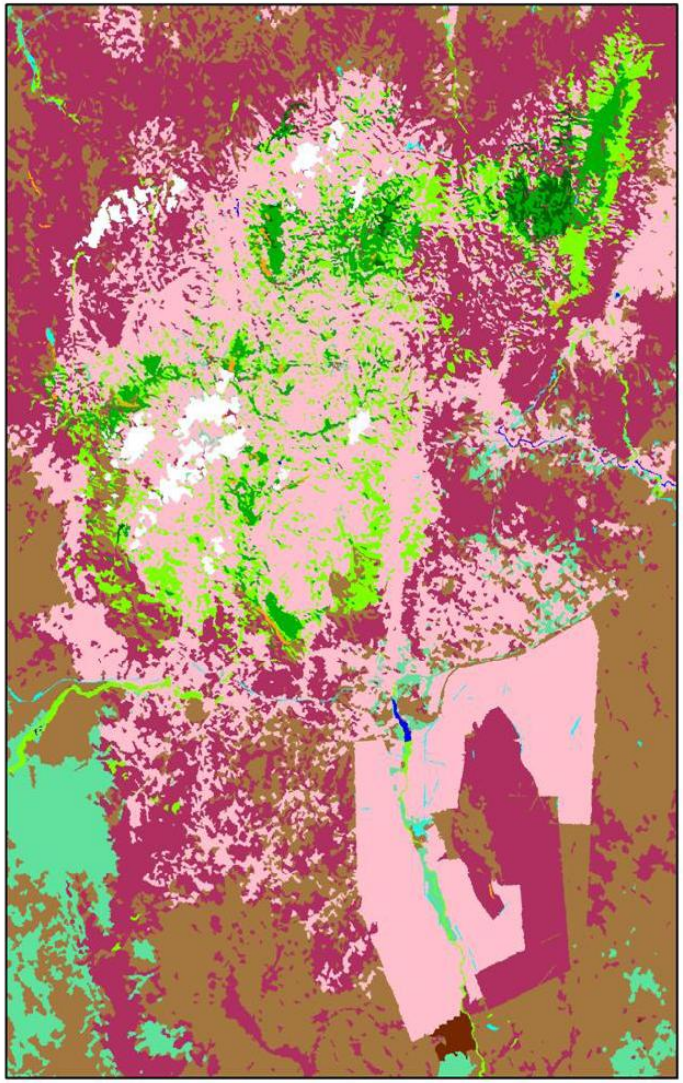
Land Cover in the Taita Hills, Kenya

SPOT, 1.7.1987 and 15.10.2003

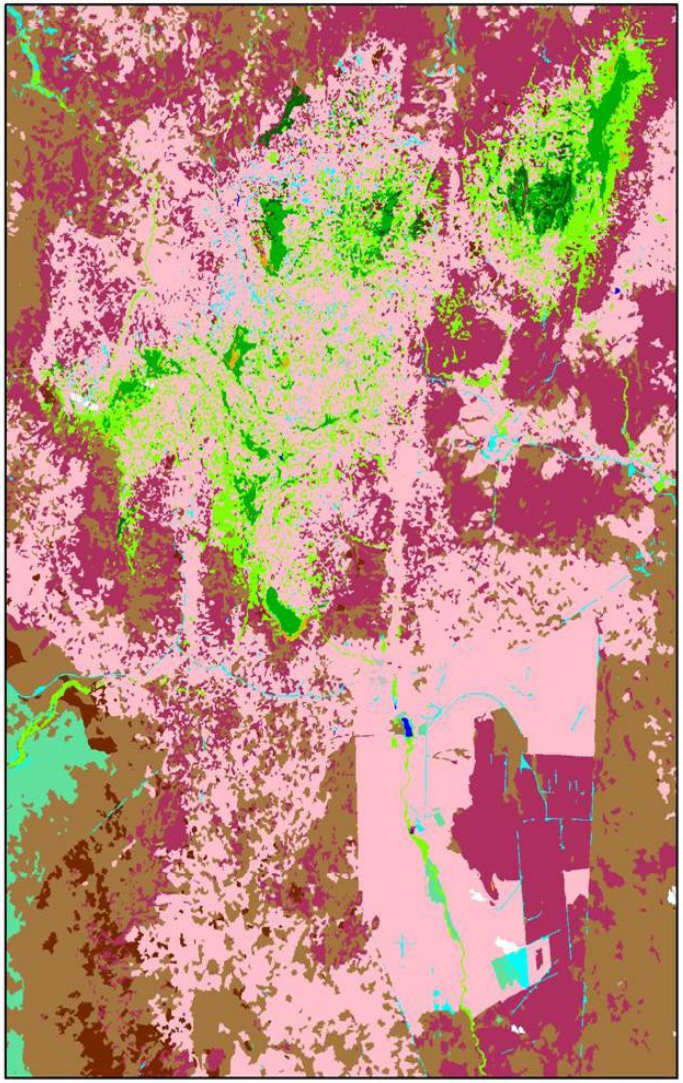
Object oriented classification

Accuracy 89%

Land Cover in 1987

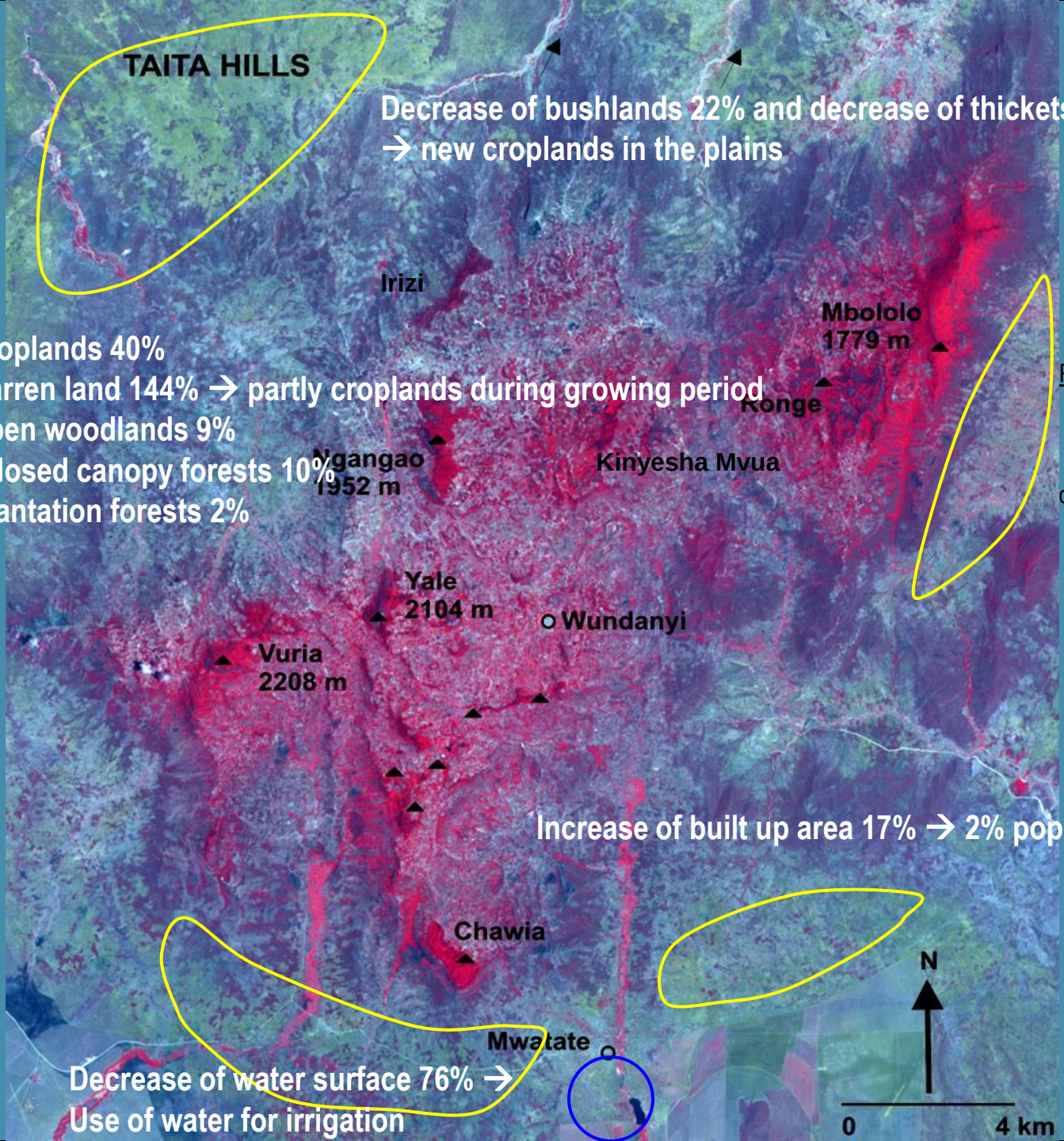


Land Cover in 2003



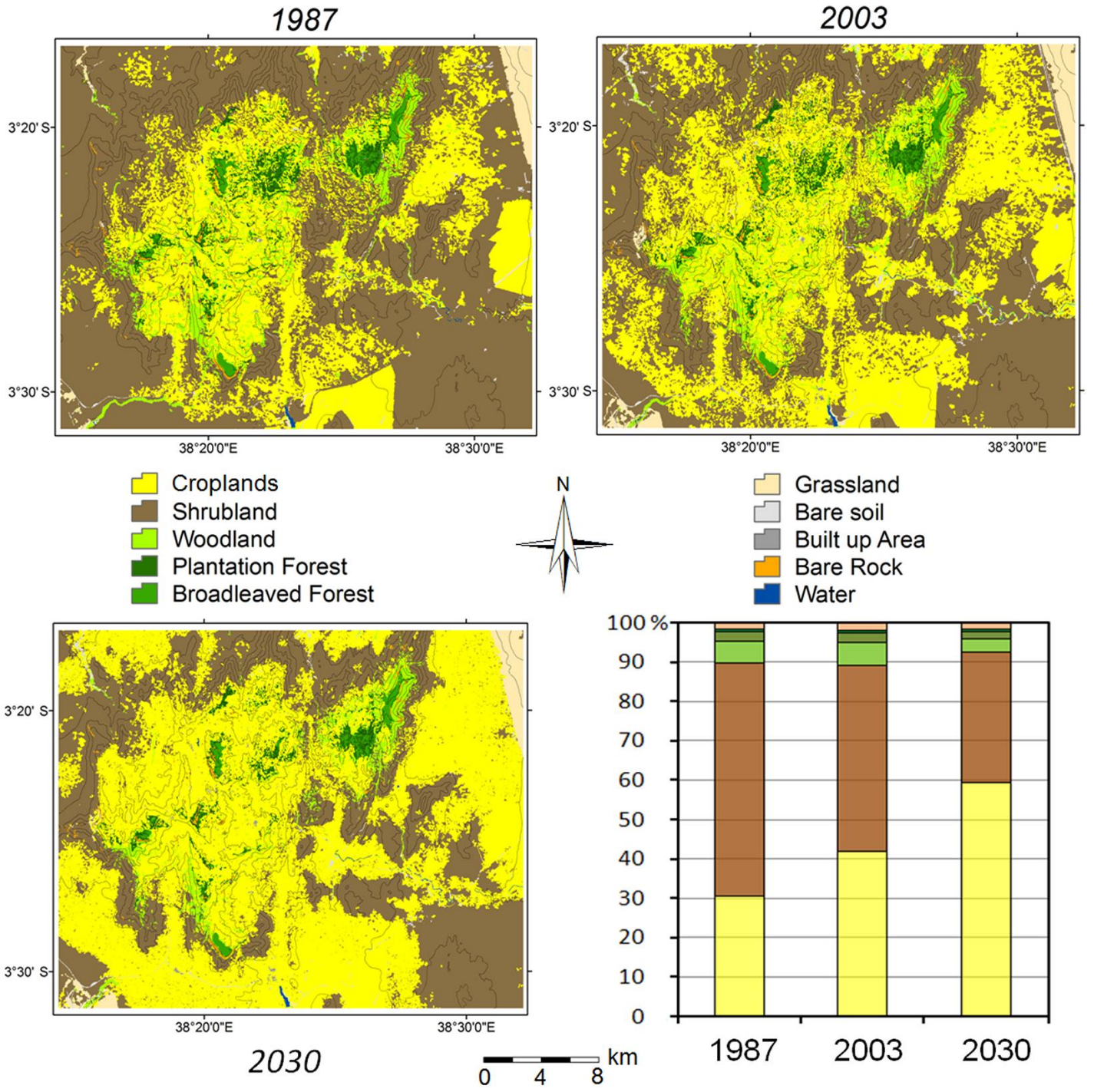
Clark & Pellikka, 2009

Loss of woodland and thickets



Clark, B.J.F. & P.K.E. Pellikka, 2009. Landscape analysis using multiscale segmentation and object orientated classification. In: Röder, A. (ed.) *Recent Advances in Remote Sensing and Geoinformation Processing for Land Degradation Assessment*. Taylor & Francis.

SPOT, 15.10.2003



Land use scenario
For Taita Hills for 2030 simulated from past changes

Maeda et al. Modelling agricultural expansion in Kenya's eastern arc mountains biodiversity hotspot. *Agricultural Systems*, submitted.

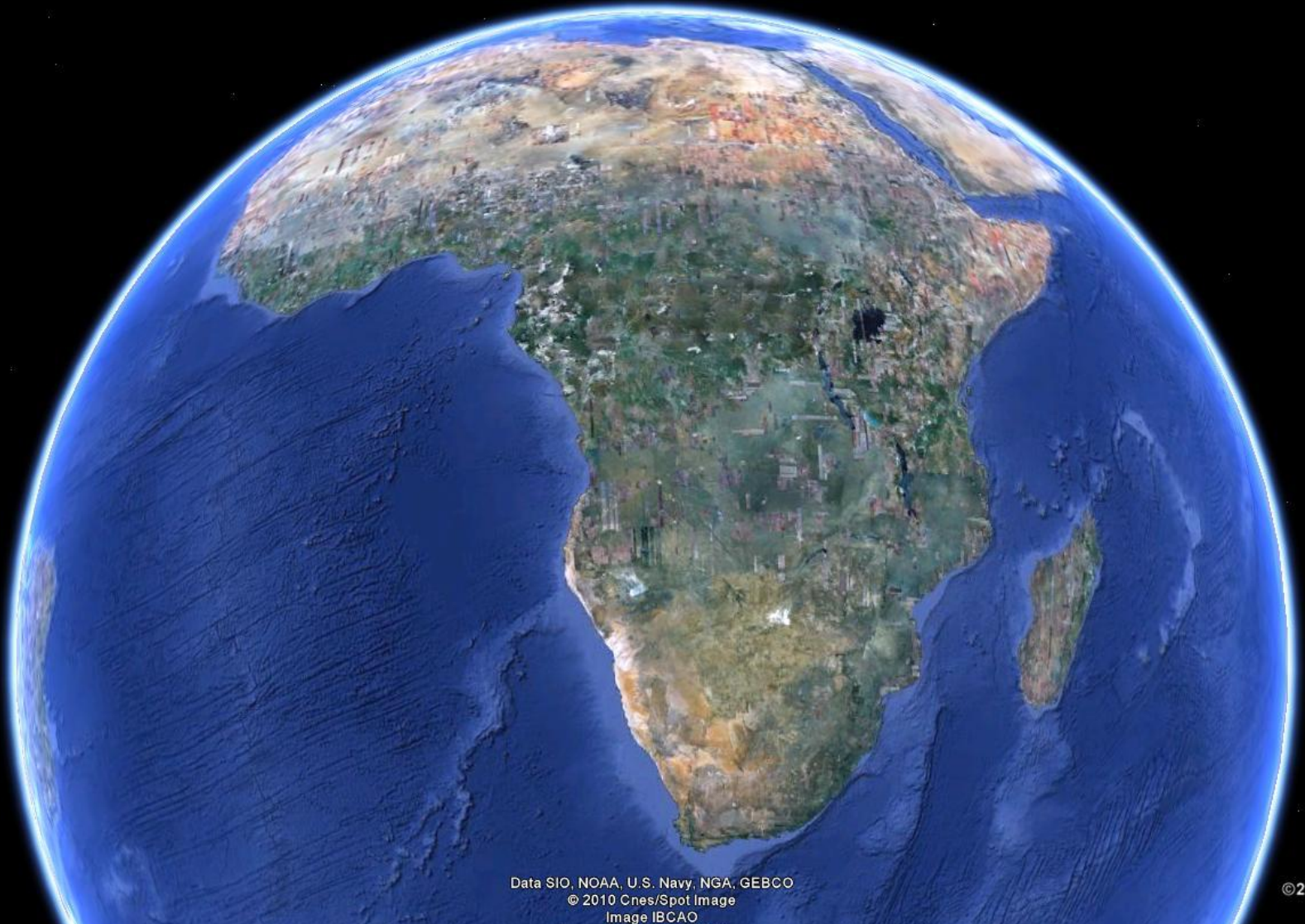
Consequences

- Decrease of potentially usable land for agriculture and grazing
- Land use conflicts
- Endangered ecosystem services
  - Climate regulation
    - Decreased formation of clouds without multi-layered indigenous forest
    - Decreased moisture capture by forests due to decreased volume
  - Fresh water resources
  - Soil formation and nutrients
  - Habitats for pollinators
  - Ecotourism

Indigenous forest

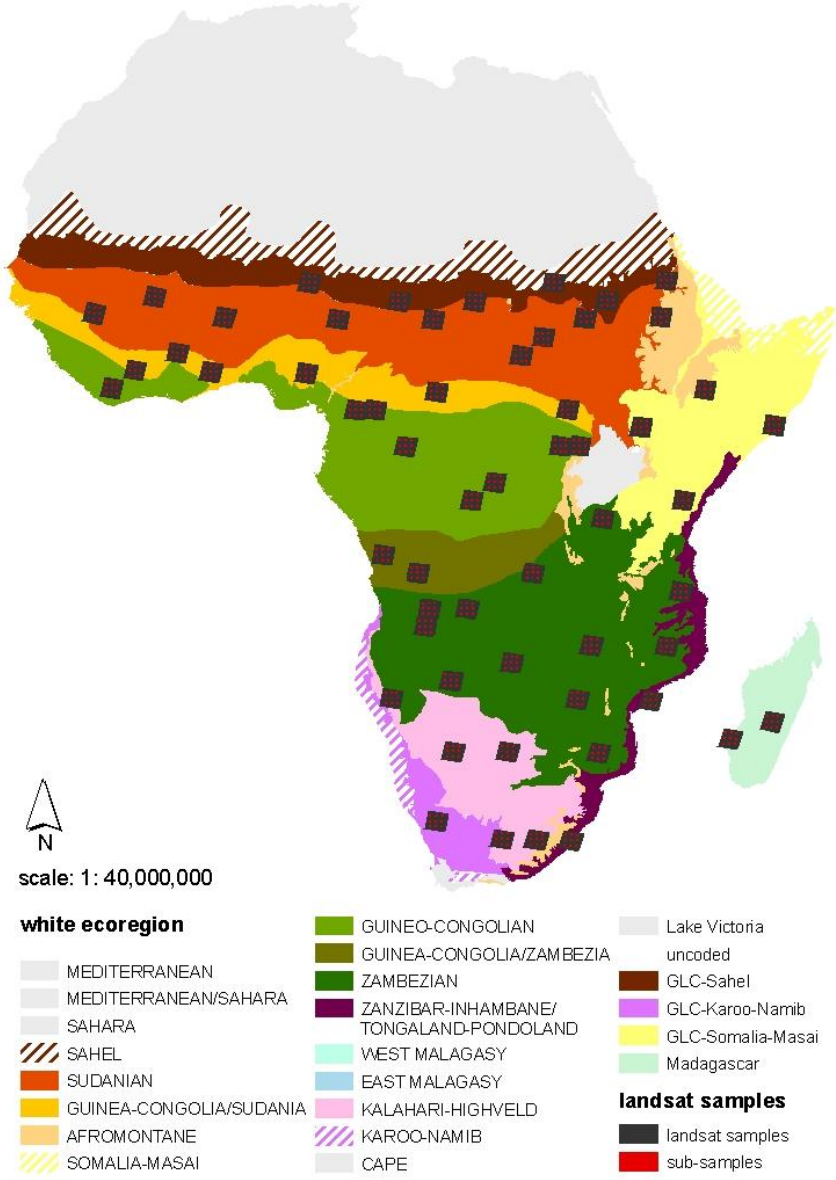
Cypress plantation

Continental land cover changes in sub-Saharan Africa

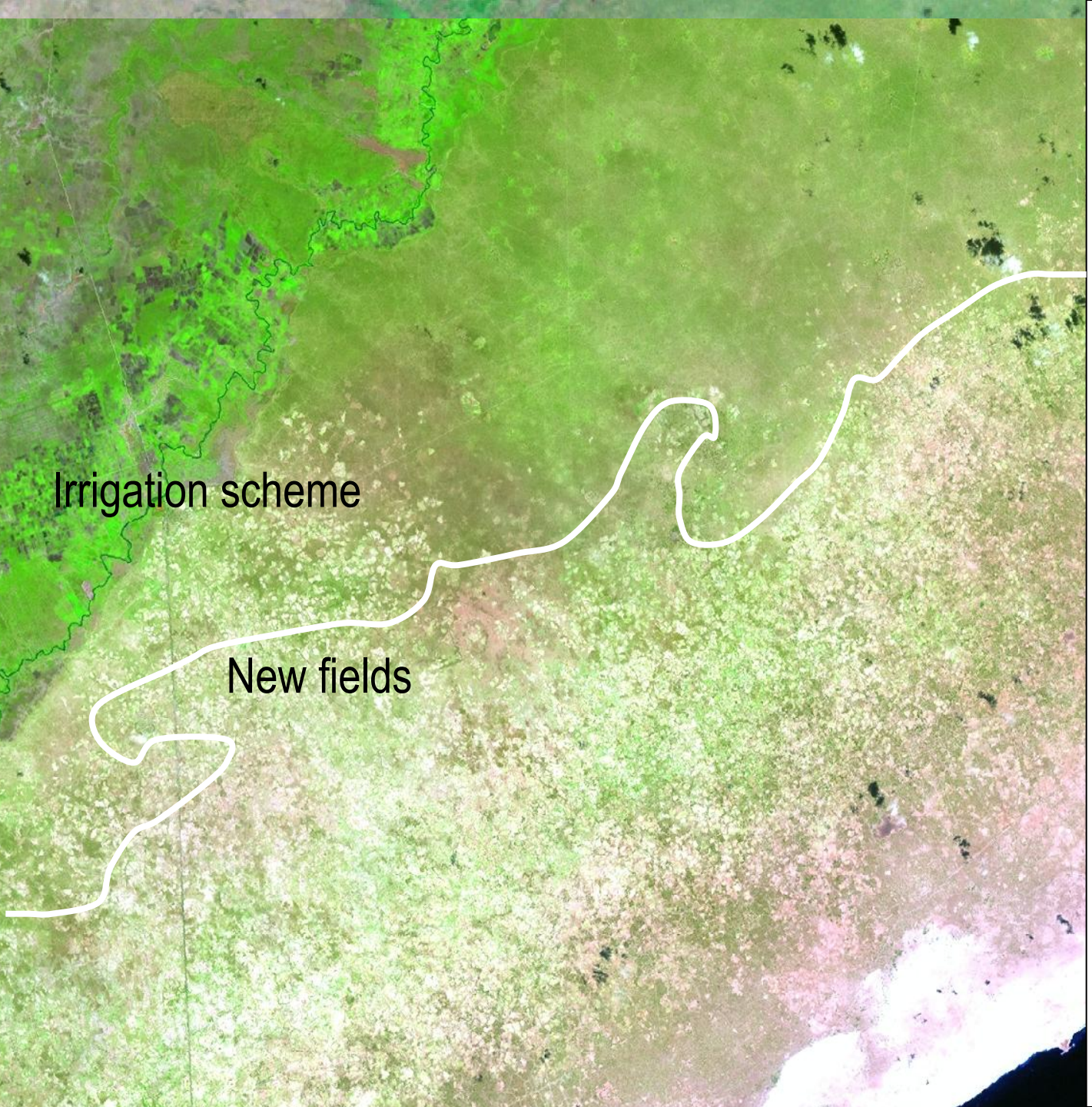


Africa

- Land cover change study between 1975 and 2000 by Joint Research Centre of EC
- 57 areas in various ecoregions
- Landsat satellite imagery
- Agriculture, forest, non-forest vegetation, barren land



Brink, A.B., Eva, H.D., 2008. Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. Applied Geography.

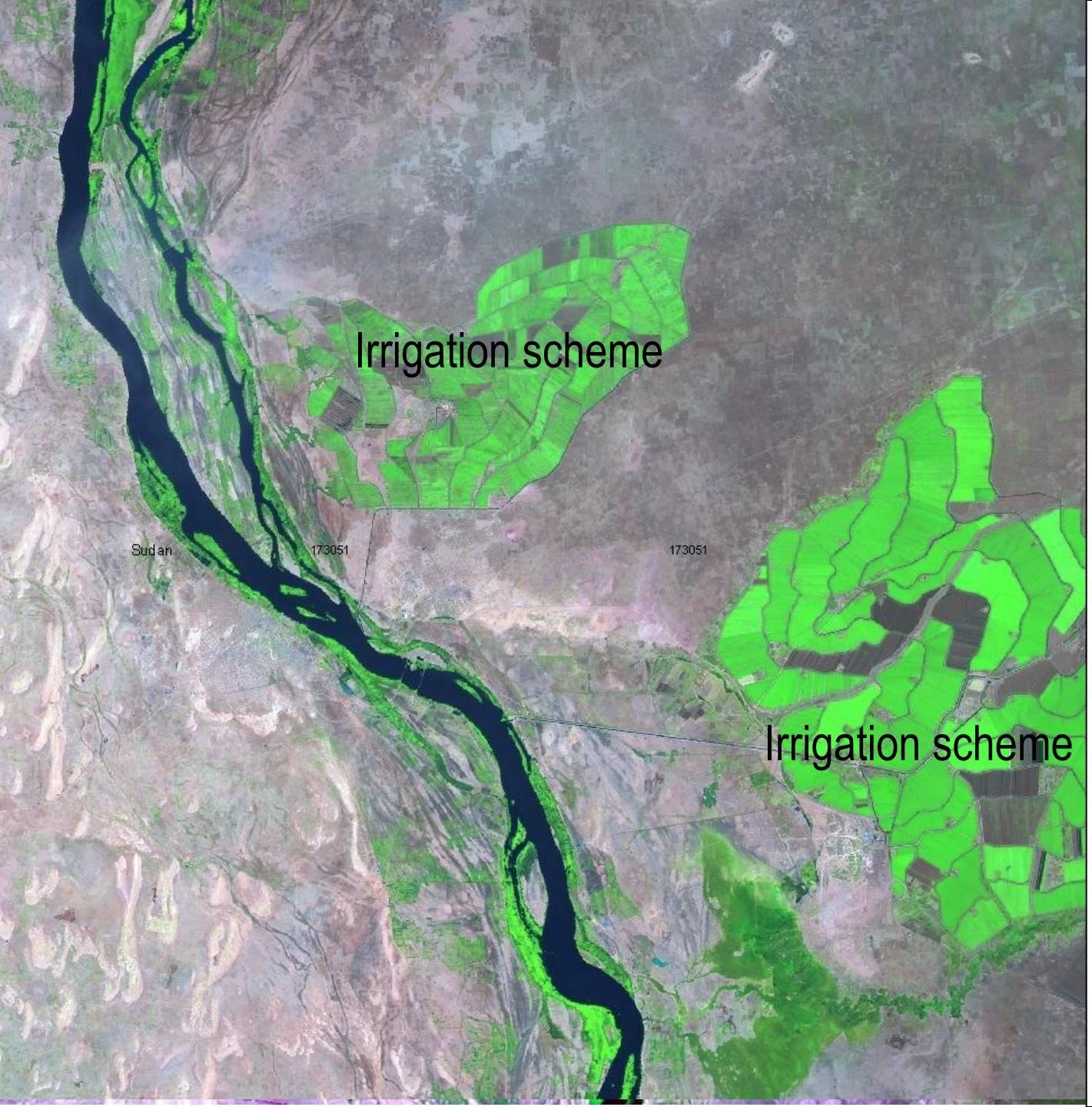


Increase and intensification of agriculture in Somalia

(Brink & Eva, 2008)

1973 - 2000

New fields and an irrigation area



New irrigation schemes in the Sudan

(Brink & Eva, 2008)

1972 - 2000

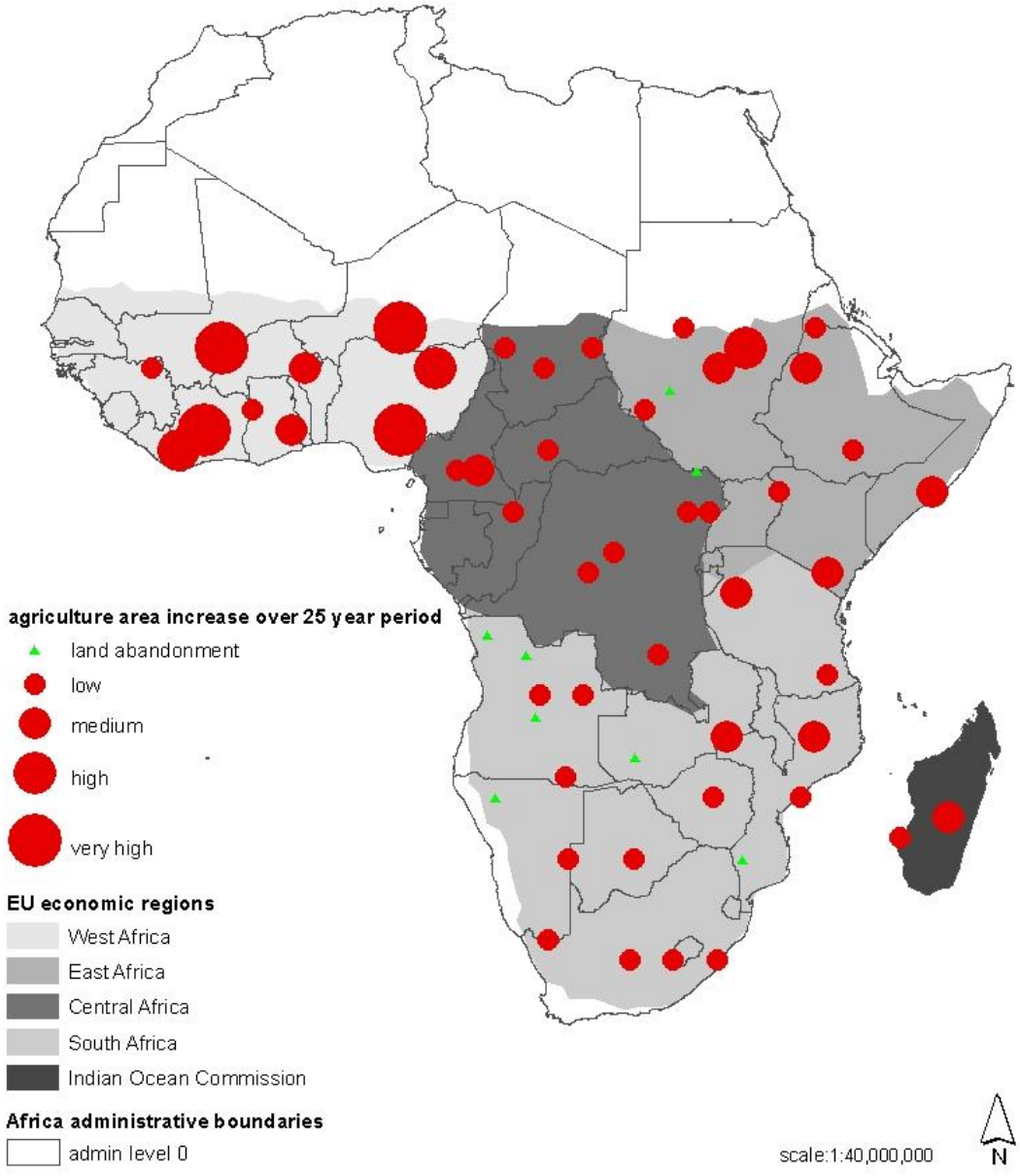
Yearly changes (%) in the ecoregions

(Eva et al., 2006)

Ecoregion	Agriculture	Forest	Non-forest vegetation	Barren
AFROMONTANE (Ethiopia, Kenya)	1.3	**-3.8**	-0.4	1.1
GUINEA-CONGOLIA/SUDANIA	**2.6**	-1.7	0.0	-1.4
GUINEA-CONGOLIA/ZAMBEZIA	-1.7	-0.9	0.4	0.0
GUINEO-CONGOLIAN	**2.3**	-0.2	-1.2	**6.8**
KALAHARI-HIGHVELD	0.4	0.0	0.0	0.7
KAROO-NAMIB (Namibian coast)	**4.2**	0.0	-0.1	0.2
MADAGASCAR	**2.8**	-1.7	-0.4	-0.5
SAHEL	**2.3**	**-3.2**	**-0.7**	-0.7
SOMALIA-MASAI (Horn of Africa)	**3.4**	-2.2	-0.3	0.6
SUDANIAN	**1.6**	-2.2	-0.3	**4.1**
ZAMBEZIAN	1.3	-1.3	0.0	0.3
ZANZIBAR-TONGO-COAST	0.7	-0.6	-0.3	0.0
Mean	**2.3**	-0.7	-0.2	0.6

Increase of agriculture

- Strongest in Madagascar, Sahel zone and West Africa
- Madagascar 50%
- West Africa 45%
- East Africa, 36%
- Central Africa 25%
- South Africa 24%



Results and consequences

- Population has doubled in 25 years (1975-2000)
- Agricultural land has increased by 55% and food production by 50%
- Agricultural land is decreased per capita from 1.1 ha to 0.9 ha
- The land resource has been decreased
- Firewood resource has been reduced
- Less land for pastoralists and grazing and conflicts between farmers and pastoralists
- Marginal lands are cleared for agriculture triggering soil erosion

Results and concequences

- Taita Hills has lost 20% of the forests in 16 years
- Africa has lost 16% of its forests and 5% of open woodlands and grasslands in 25 years (annually 50 000 km^2)
- In Taita Hills, agricultural land has increased relatively more than population
- In Africa in general, population growth exceeds agricultural production
- Marginal lands are cleared for agriculture triggering soil erosion

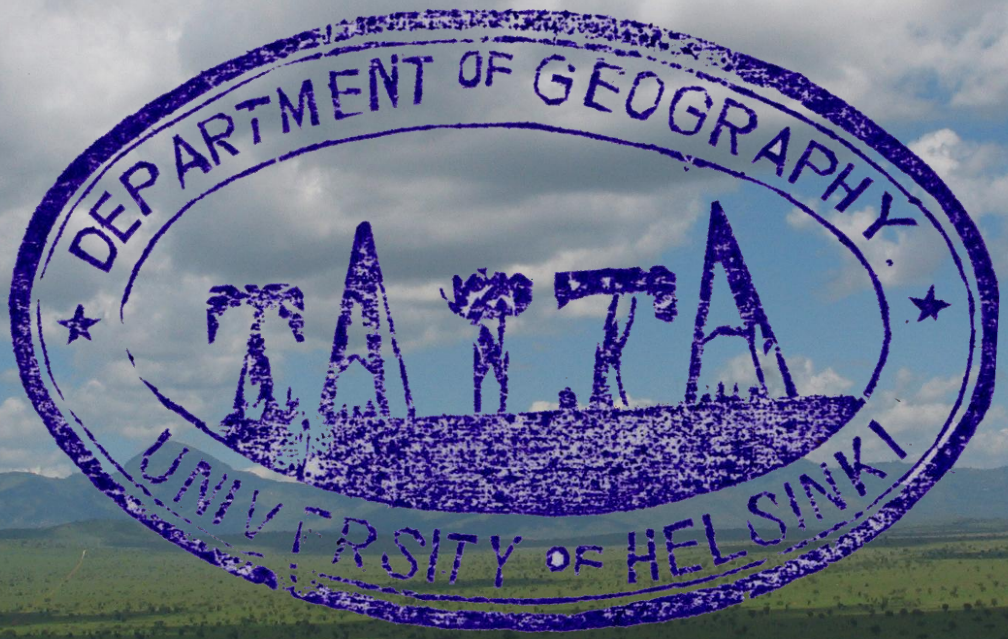
Further activities of University of Helsinki

- Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa – Increasing Knowledge, Building Capacity and Developing Adaptation Strategies
  - A regional development project under preparation with Ministry for Foreign Affairs of Finland
  - University of Helsinki focuses on land cover studies and modelling
- TERRA research station of the University of Helsinki in the Taita Hills, Kenya
  - A base camp for research activities in Kenya
  - Research and development projects, student excursions, school trips
  - http://www.helsinki.fi/geo/research/researchstations.html
  - http://www.helsinki.fi/science/taita/

Thanks for:

Academy of Finland and University of Helsinki for funding

Andreas Brink (JRC) and the TAITA team at the University of Helsinki for collaboration



More information:

http://www.helsinki.fi/science/taita

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