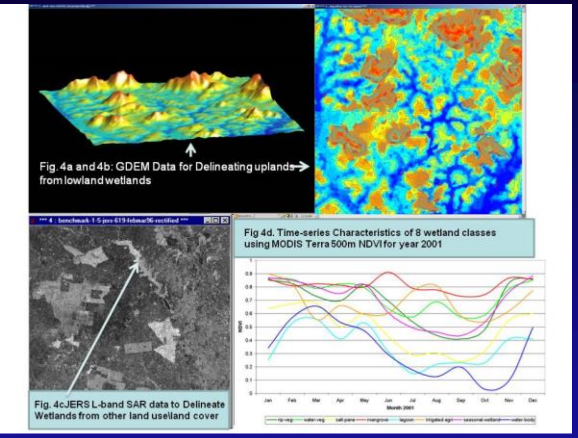
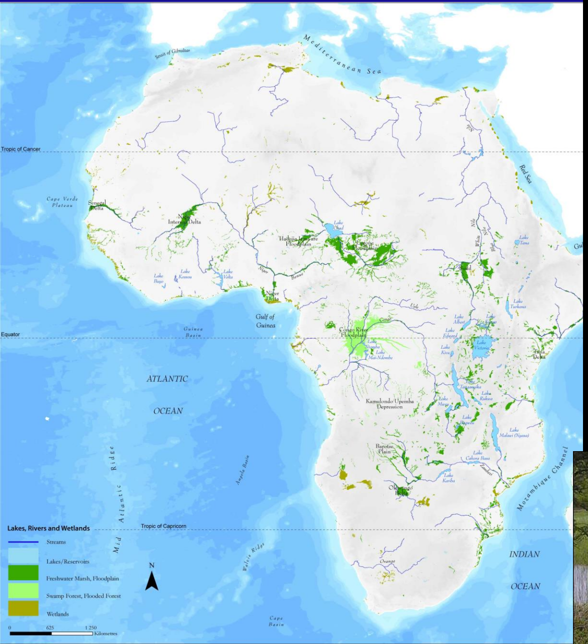
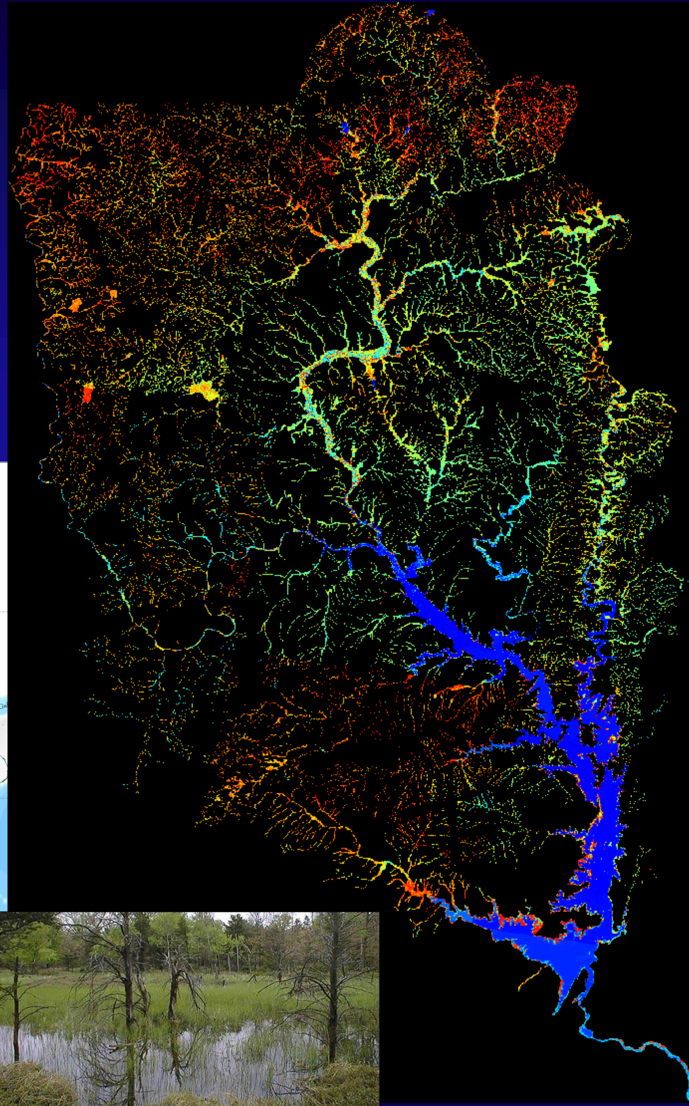
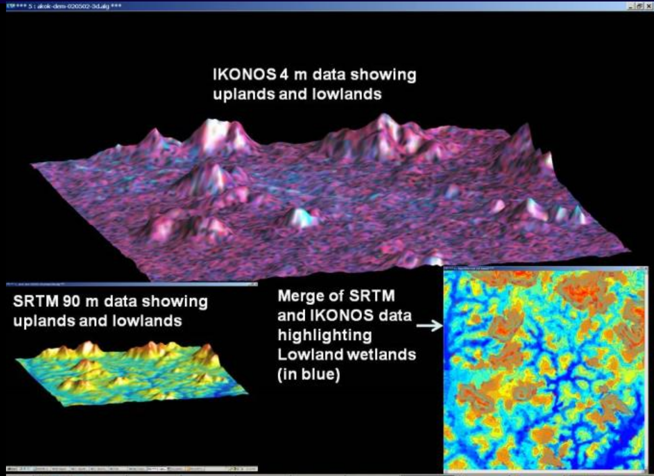
# Remote Sensing of Inland Valley Wetlands of Africa

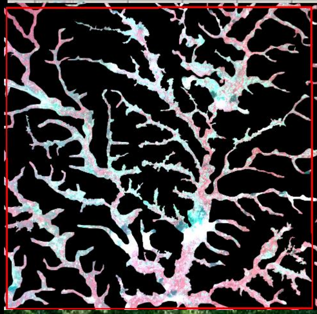
## their Pivotal Role in Africa's Green and Blue Revolution







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NASA LCLUC Meeting, Rockville, Maryland, USA. April 2-4, 2013

# Overview of Today’s Lecture

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# Remote Sensing of Inland Valley Wetlands of Africa
## Overview of Today's Presentation

1. Africa's wetlands;
2. What are Inland Valley (IV) Wetlands?;
3. Importance of IV wetlands for Africa's Green and Blue Revolution;
4. Need for utilization of wetlands for Africa's green and blue revolution;
5. Remote sensing of inland valley wetlands;
6. Methods of Delineation, Mapping, Characterization using remote sensing
7. Results;
8. Conclusions;
9. References.

# Africa’s Wetlands

## (not accounting inland valley wetlands)

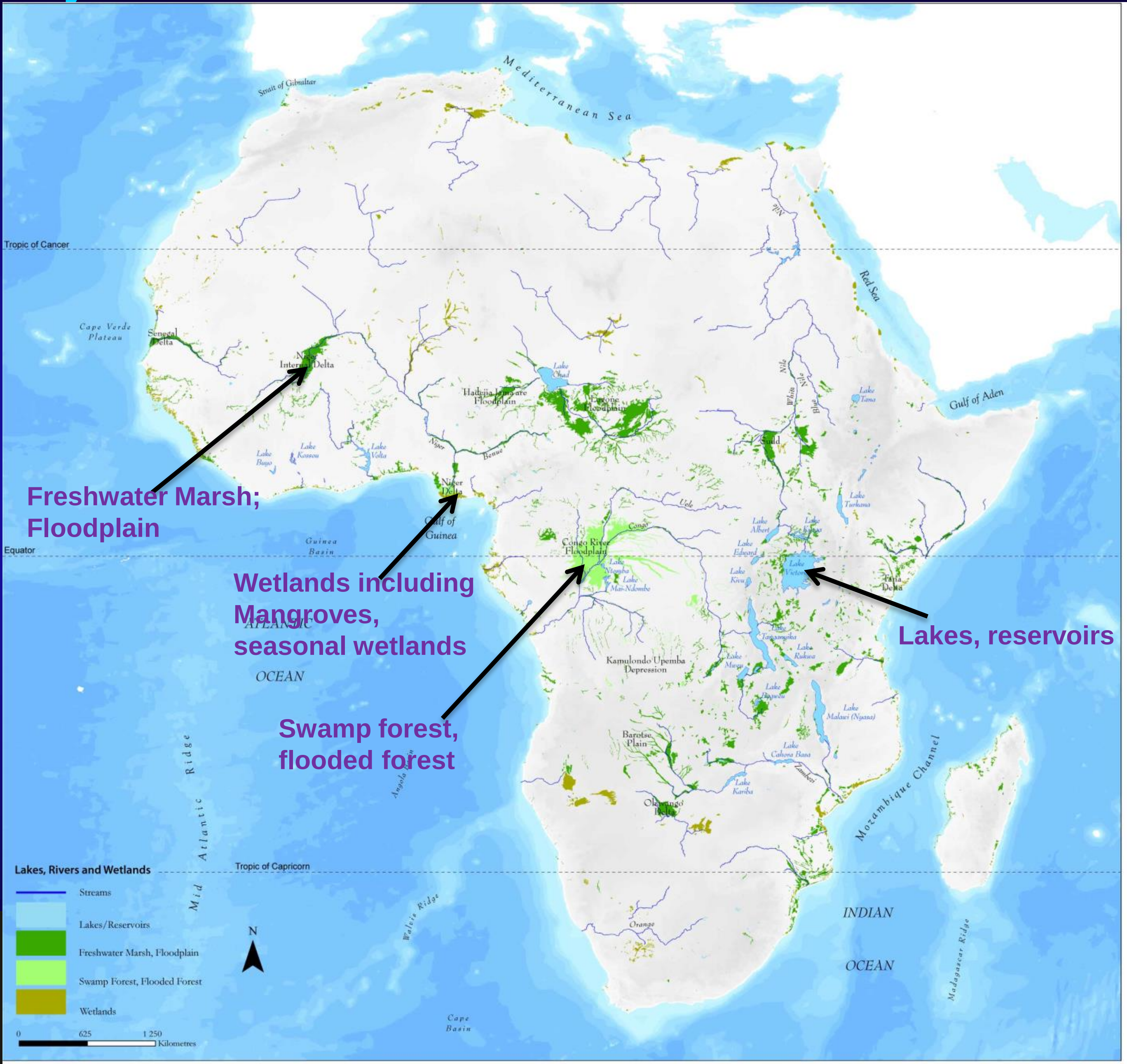
# Wetlands of Africa

# Major Conventional Wetlands

**Africa has 131 million hectares of Conventional Wetlands or 4.34% of total land area (3022,000,000 hectares)**

**However, this does not account for inland valley wetlands, which is roughly 15% of land area**

**Source: 1. United Nations; 2. "A directory of African wetlands by R.H. Hughes et al. 1992; 3. Tom Kabii, Ramsar Bureau, Switzerland**

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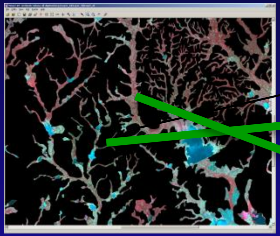
# Definition of Wetlands

## Needed for Accurate Mapping using Remote Sensing

**Hydrological**

- Flood plains? (higher order streams)
- valleys? (lower order streams)




**Topographic**

- Lowlands?


**Water/moisture levels**

- Water bodies?
- Moist lands?
- Deltas or Alluvial plains?
- Estuaries?

Definition of wetlands (one view): "land units or ecosystems with water and moisture to sustain life"


**Man-made wetlands**

- Irrigated areas?



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# Definition of Wetlands

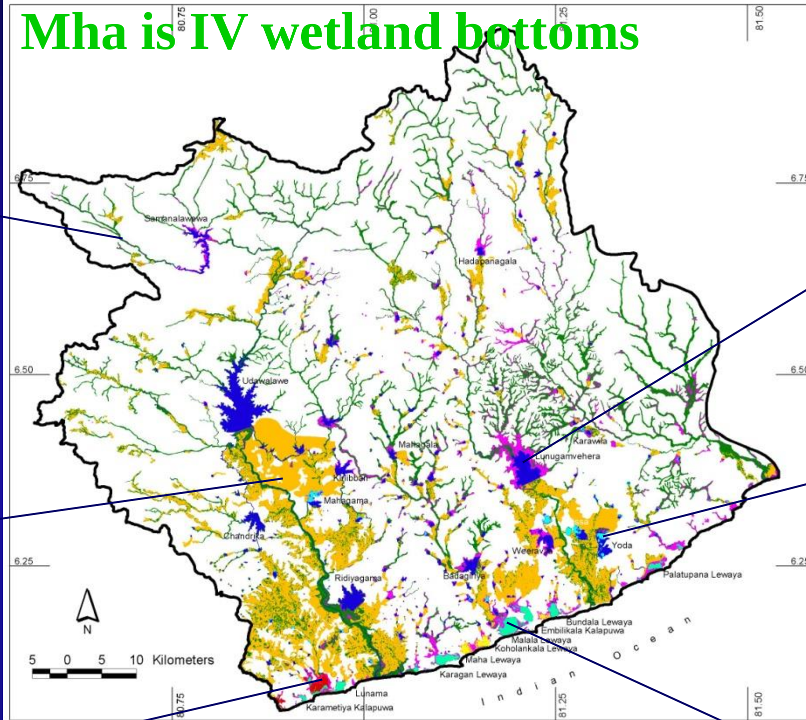
## Needed for Accurate Mapping using Remote Sensing

Riparian vegetation

Irrigated rice field

Mangrove

**1. IV wetland area: 24 % of 0.61 Mha is IV wetland bottoms**




Basin boundary

| Wetland types | Average NDVI (Dimensionless) | Area (Hectre) | Percentage |
|---|---|---|---|
| Irrigated agriculture | 0.094 | 60406.28 | 41.45 |
| Lagoon | -0.350 | 2140.93 | 1.47 |
| Mangrove | 0.203 | 624.15 | 0.43 |
| Natural vegetation (riparian/homestead) | 0.249 | 53041.87 | 36.40 |
| Permanent marshes/waterbody with vegetation | 0.250 | 1079.26 | 0.74 |
| Salt pane | -0.413 | 494.64 | 0.34 |
| Seasonal wetlands | -0.007 | 15077.39 | 10.35 |
| Waterbody (fresh) | -0.270 | 12866.37 | 8.83 |

**2. IV wetland cultivation: 41.5 % of the valley bottoms were cultivated**

Water body (fresh)

Water body covered by aquatic plants

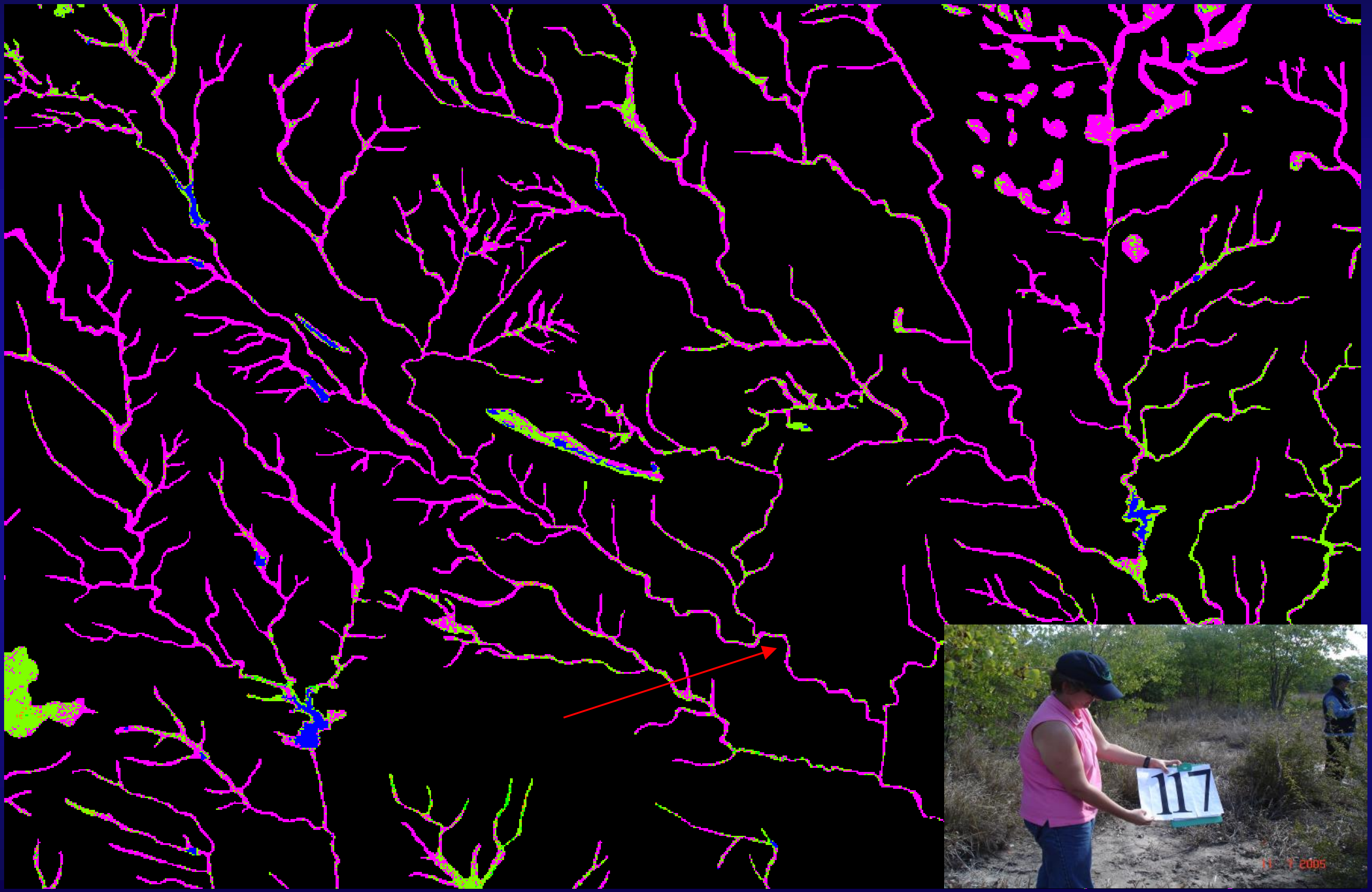
Lagoon

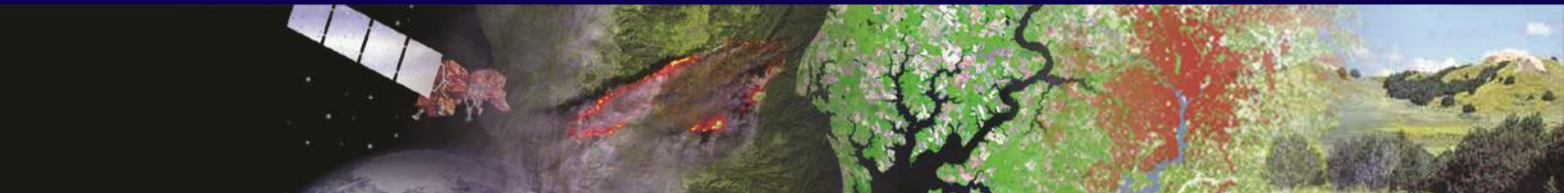
# What are
# Inland Valley Wetlands

# Inland Valley Characterization using Remote Sensing

## Inland Valley Wetlands Occur overwhelmingly along lower order Streams

**Definition: Inland valley wetlands occur overwhelmingly along the lower order streams (typically, 1-4th order)**



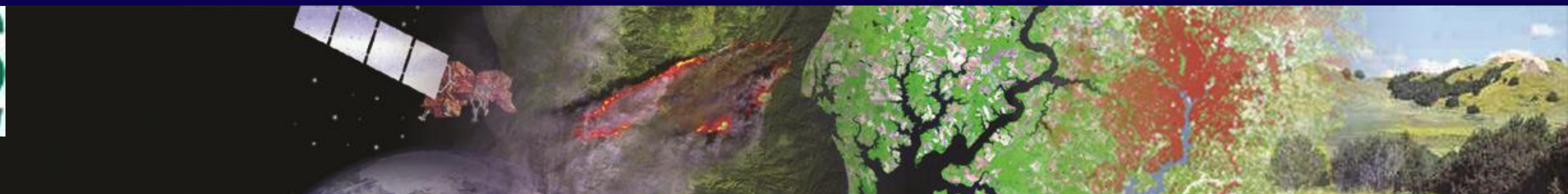



# Inland Valley Characterization using Remote Sensing

## Definition for Mapping: Inland Valley Wetlands

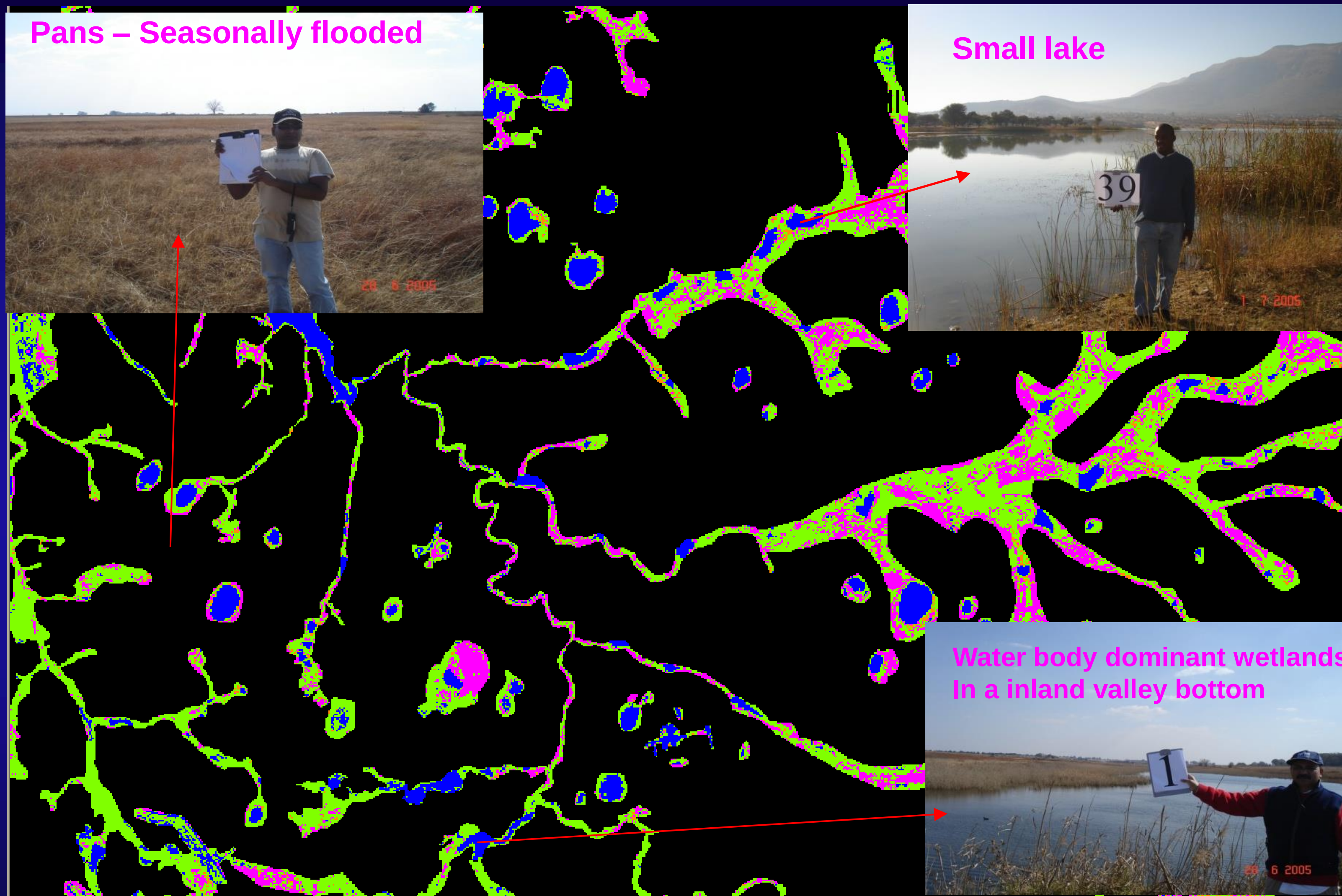

Topographic maps: only lines or linear features (stream bed)
SRTM derived drainage: only lines or linear features (stream bed)

……………………..only RS can provide valley bottom width (wetland area). This facilitates wetland: (a) area calculations, (b) land use pattern study, and (c) characterization.



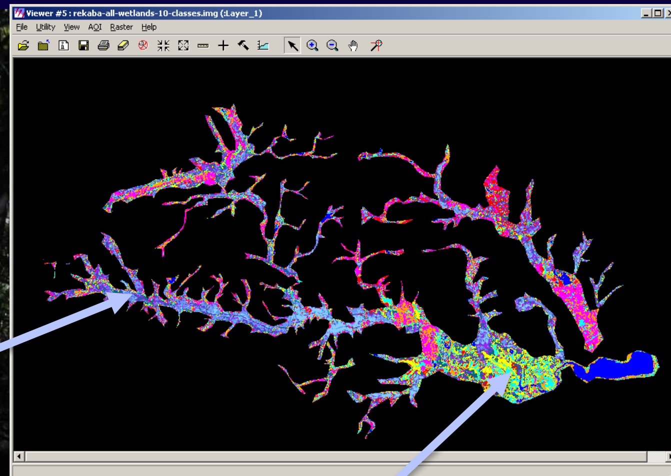
# Inland Valley Characterization using Remote Sensing

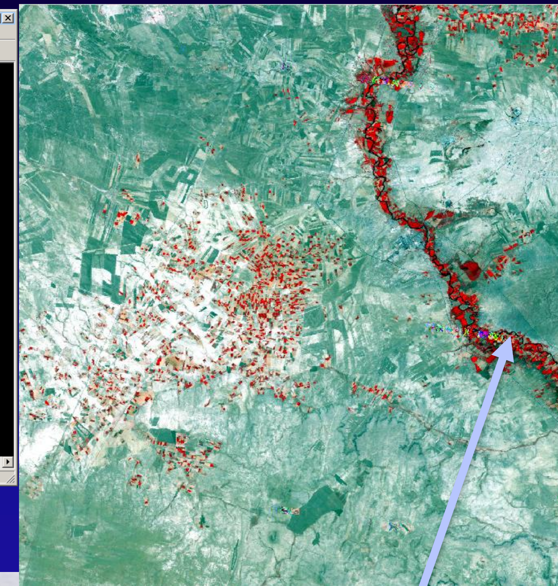
## Inland Valley Wetlands Occur overwhelmingly along lower order Streams



# Inland Valley Characterization using Remote Sensing

## Inland Valley Wetlands Occur overwhelmingly along lower order Streams



Lower order swamps: inland valleys

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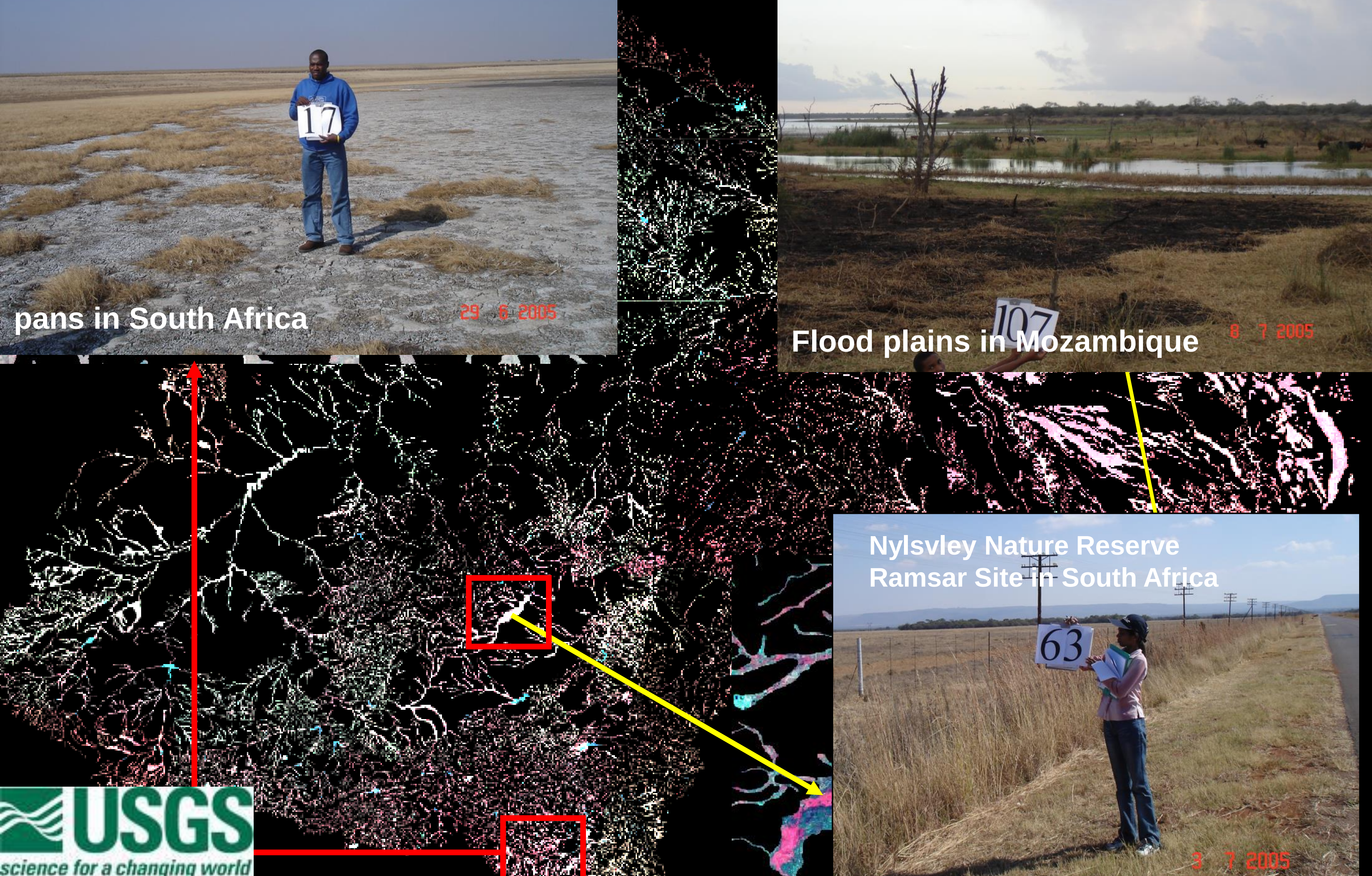
# Inland Valley Characterization using Remote Sensing

## Inland Valley Wetlands Occur overwhelmingly along lower order Streams

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# Importance of
# Inland Valley Wetlands
# for Africa's Green and Blue Revolution

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## Inland Valley Potential for Green and Blue Revolution in Africa
## Conditions that are Ideal for exploiting Inland Valleys for Agriculture

1. **Agroecosystems**
   **A. inland valleys are heavily exploited for agriculture in Asia inland valleys are;**
   **B. overwhelmingly unexploited for agriculture in Africa;**

2. **Advantage over uplands**

   **relative to uplands, inland valleys have: (a) fertile soils, (b) significantly higher moisture availability all through the season, provide much higher productivity, and have potential for greater water productivity.**

3. **Main season farming (e.g., wetland crops like rice)**
   **During main crop growing season, often, wetland crops like rice can be grown in lowlands but NOT in uplands**

4. **Dry season farming (e.g., only areas to grow crops)**
   **During dry season lowlands are likely to be only areas with enough moisture to grow any crops**

5. **Flora and fauna**
   **Unique relative to uplands (e.g., raphia palm in lowlands of Africa, unique animal and avian species)**

………..point 1 to 4 are conditions primed for a green revolution in Africa.

# Inland Valley Potential for Green and Blue Revolution in Africa

## Causes of Under-utilization of IV Wetlands in Africa

**IV wetlands in WCA are highly under-utilized mainly as a result of:**

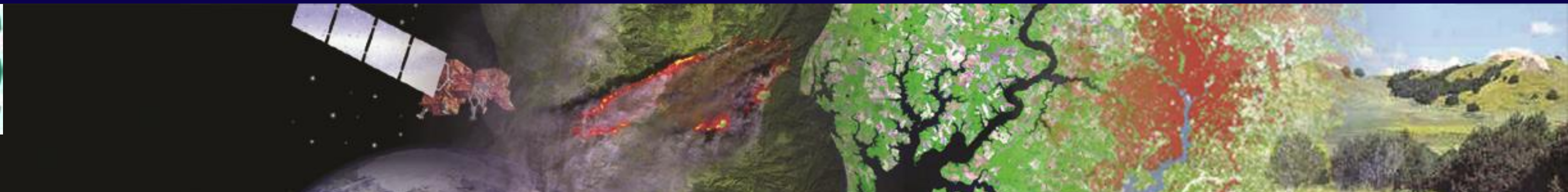
**(a) water borne diseases such as *Malaria, Bilharzias, Trypanosomiasis* (sleeping sickness), *Onchocerciasis* (river blindness), and *Dracontiasis* (guinea worm), and**

**(b) difficulty in accessing them from roads-settlements-markets (WARDA, 2003, Lafferty, 2009).**

**But these difficulties can be overcome with modern health care (Hetzel et al., 2007) and infrastructure (Woodhouse, 2009).**

**Note: Currently, ~90 percent of WCA's current agriculture is concentrated in uplands, which have very poor soils and scarce water resources. In spite of such huge advantages over uplands,**





# Development versus Preservation

Balancing the need to develop more land for agriculture are the ecological concerns about the environmental impacts of wetland development (and the catchments that surround them) and the profound social and economic repercussions for people dependent on their natural resources and ecosystem functions. IV wetlands play an important role in bio-geochemical cycling, flood control, and recharging of aquifers. They are considered to be one of the richest and most productive biomes, serving as cradles of biological diversity that support unique flora and fauna (RAMSAR, 2004). They serve as potential sites for breeding waterfowl and significant carbon sinks in soils and plants (Mitsch and Gosselink, 2007, Hansen et al., 2002).

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# Need for Utilizing
# Africa's Wetlands
# for Africa's Food Security

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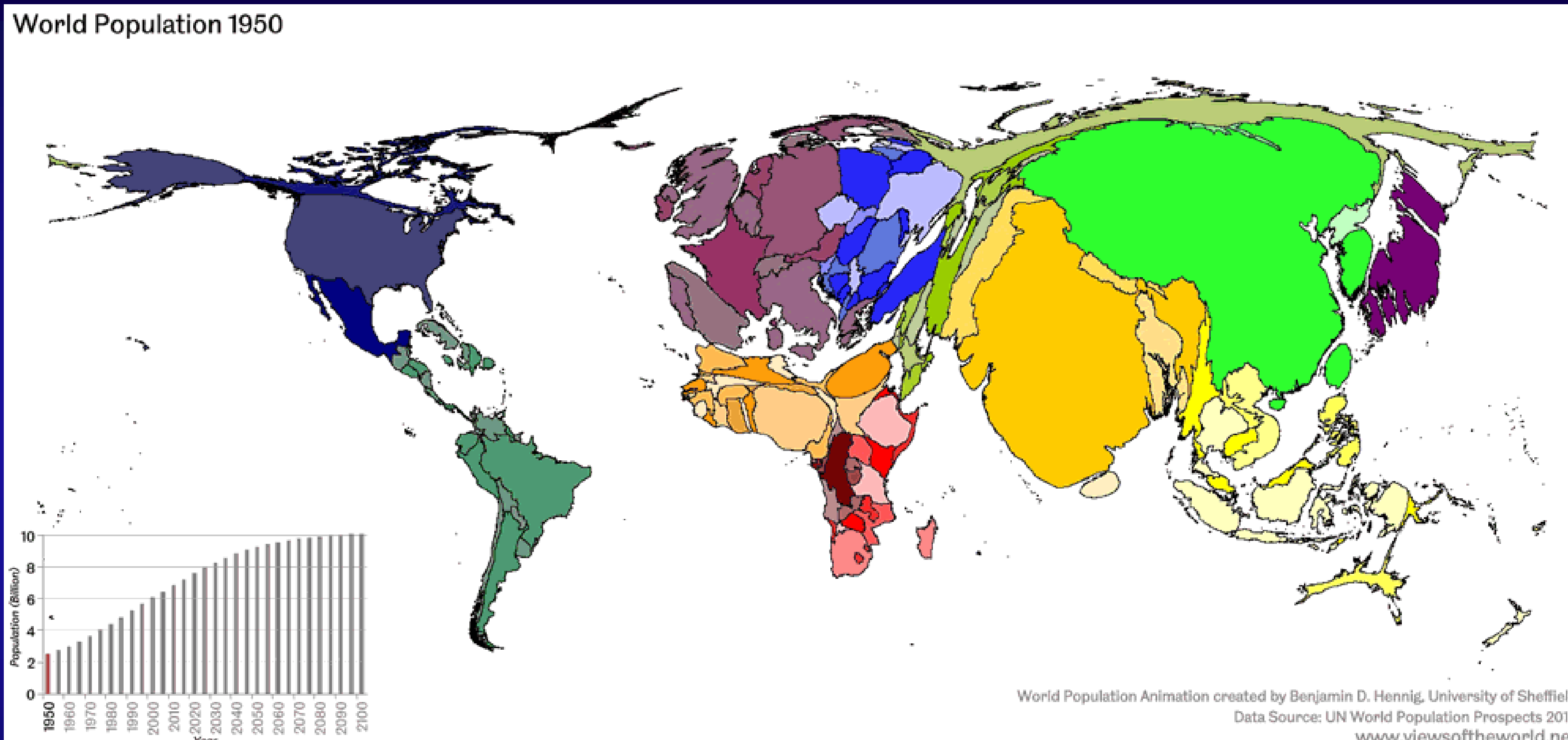
# Need for Utilization of Inland Valley Wetlands for Africa’s Food security

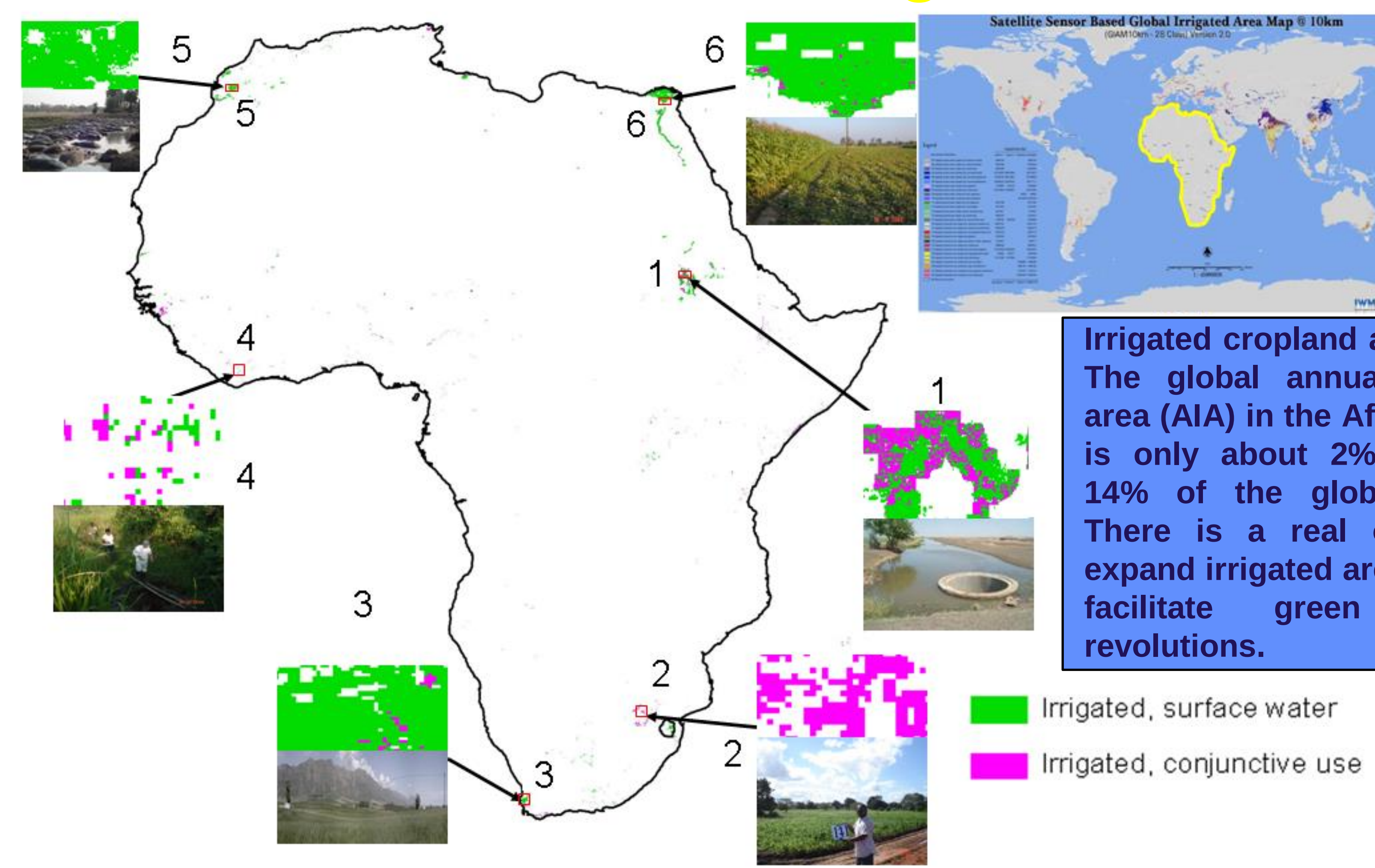
# Population Growth




**Africa’s population will double over next 50 years and triple over next 100 years…. from current ~1 billion to ~3 billion**

# Need for Utilization of Inland Valley Wetlands for Africa's Food security

## Lack of Irrigation




**Irrigated cropland areas of Africa. The global annualized irrigated area (AIA) in the African continent is only about 2% compared to 14% of the global population. There is a real opportunity to expand irrigated areas in Africa to facilitate green and blue revolutions.**

**Thenkabail et al., 2009**

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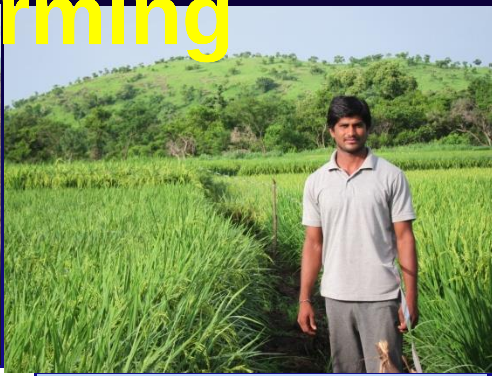
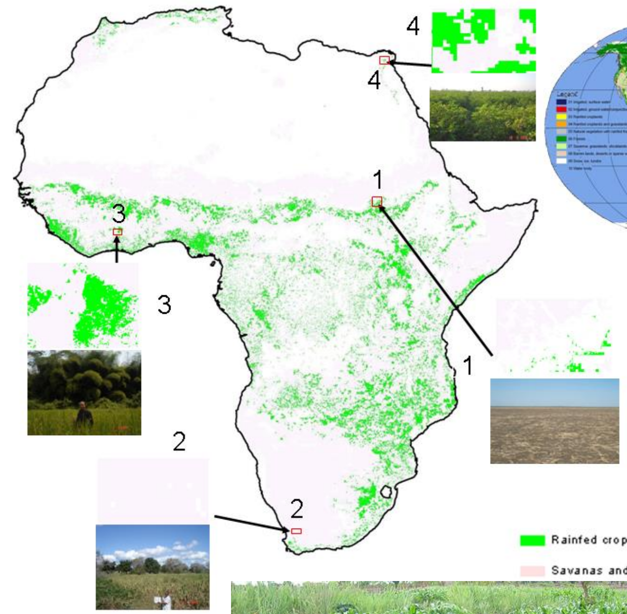
# Need for Utilization of Inland Valley Wetlands for Africa's Food security

# Small Holder Subsistence Farming


Other Countries are Looking for Land in Africa to produce food for their Countries….virtual water use will increase in coming years



So, will Africa play a big role in addressing World Food Security?




Bill Gates In Nigeria (Photo credit: Bill and Melinda Gates Foundation)

Studying grain, Karsana, Nigeria

But, will that result in marginalizing the the subsistence farmer?

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# Remote Sensing

## Characterization, Monitoring, and Mapping of Inland Valley Wetlands of Africa

## Methods

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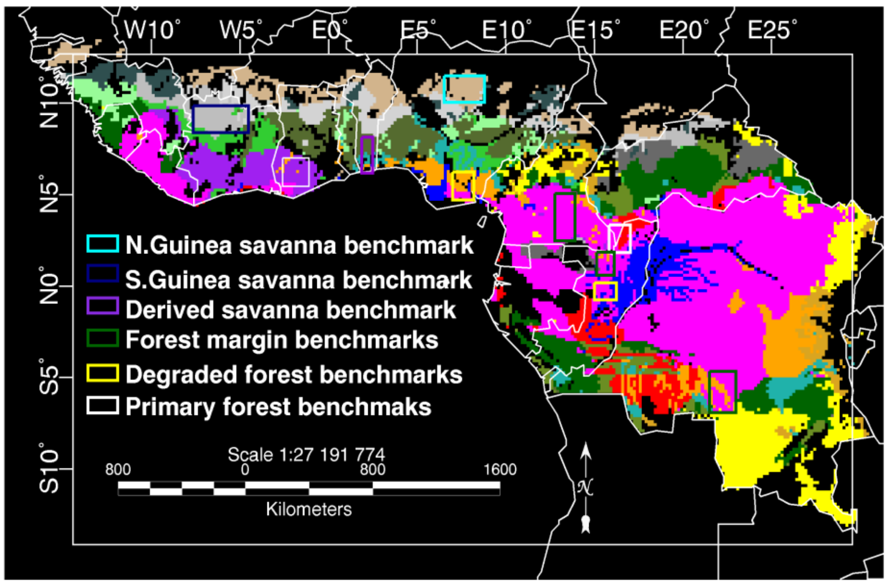
# Inland Valley Wetland Characterization, Monitoring, and Mapping
## In Different Agroecosystems of Africa

**The wetlands of Africa are increasingly considered "hotspots" for agricultural development and for expediting Africa's Green and Blue Revolution. Currently, these IV wetlands are un-utilized or highly under-utilized in WCA (Figure) in spite of their rich soils and abundant water availability as a result of:**

**(a) limited road access to these wetlands, and**

**(b) prevailing diseases such as *Malaria, Trypanosomiasis* (sleeping sickness) and *Onchocerciasis* (river blindness).**

**However, the utilization of IV wetlands for agriculture is becoming unavoidable in WCA countries due to increasing pressure for food from a ballooning human population and difficulty finding arable land with access to water resources.**




# Agroecological and Soil Zones (AESZ) in Humid-forests and savannas of West and Central Africa

- Derived savanna:Acrisols (11.7 Mha)
- Derived savanna:Lithosols (10.8 Mha)
- Humid forest:Ferralsols (150.1 Mha)
- Humid forest:Nitosols (27.2 Mha)
- Humid forest:Gleysols (19.2 Mha)
- Humid forest:Arenosols (18.9 Mha)
- Humid forest:Acrisols (18.0 Mha)
- Mid-alt. savanna:Ferralsols (45.4 Mha)
- Mid-alt. savanna:Nitosols (12.3 Mha)
- N.Guinea savanna:Luvisols (25.2Mha)
- S.Guinea savanna:Luvisols (18.4 Mha)
- S.Guinea savanna:Acrisols (12.4 Mha)
- S.Guinea savanna:Ferralsols (11.9 Mha)
- S.Guinea savanna:Lithosols (10.7 Mha)
- Derived savanna:Ferralsols (47.2 Mha)
- Derived savanna:Luvisols (24.9 Mha)
- Derived savanna:Nitosols (14.2 Mha)
- Derived savanna:Arenosols (14.0 Mha)

**Classification Key**

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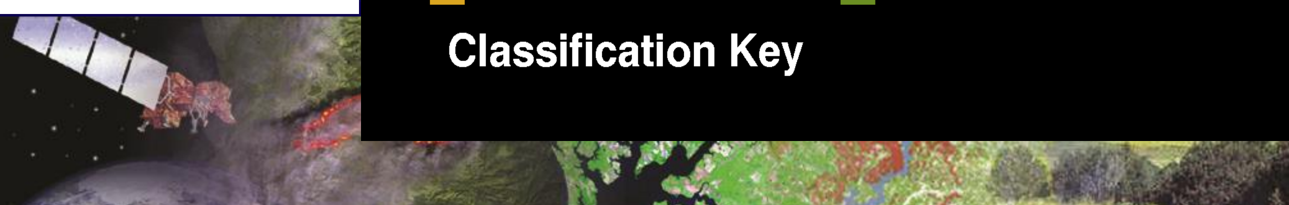

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# Image enhancement, Display, digitize

**The semi-automated methods (Figure 4) involved:**

1. **Image enhancements**

   **enhancement of images through ratios;**

2. **Image display**

   **display of enhanced images in red, green, blue (RGB) false color composites (FCCs) at the highest possible "zoom in view";**

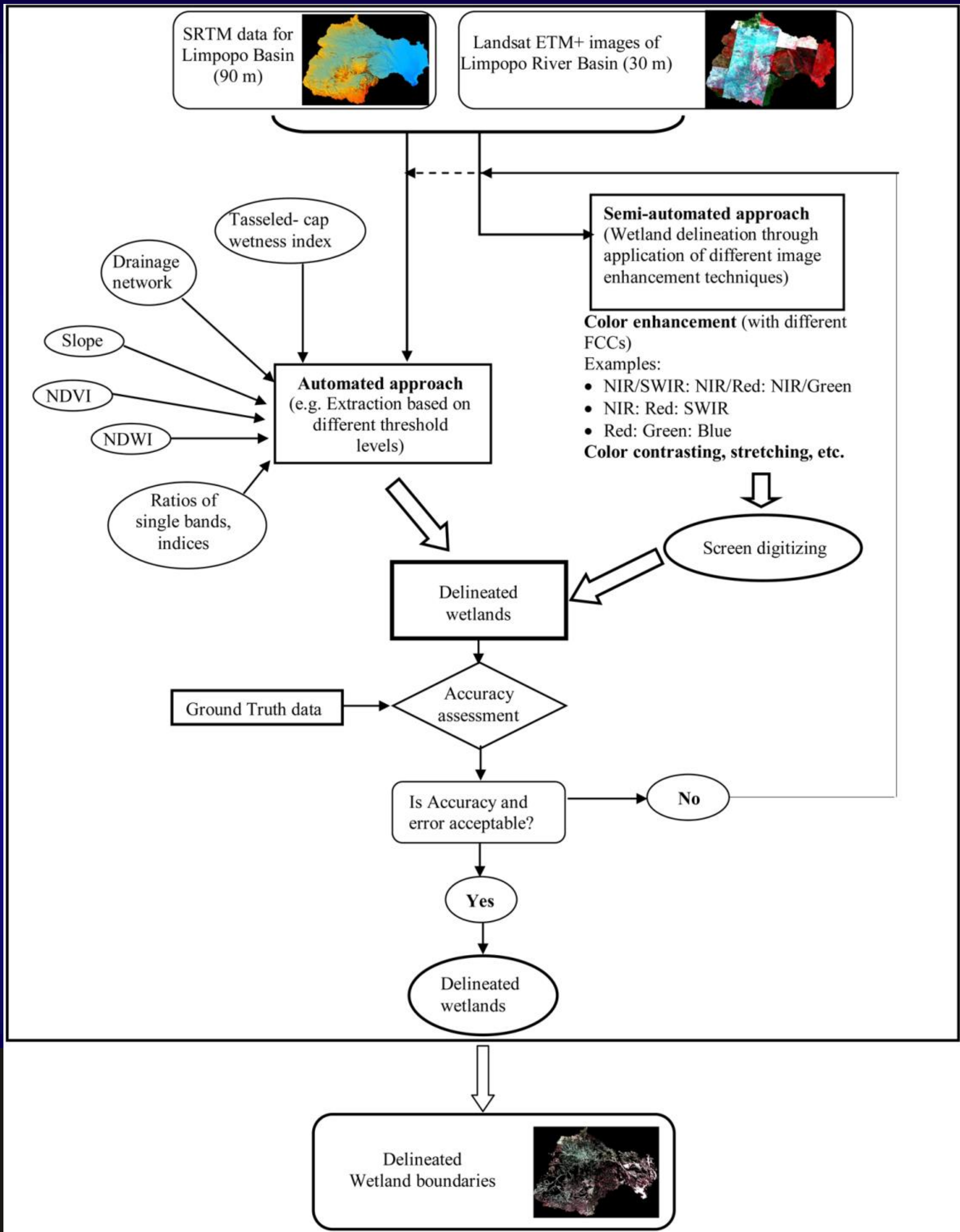
3. **Digitizing**

   **digitize directly of the screen the enhanced images that are zoomed in and displayed.**

Based on the above 3 steps the wetlands are delineated.

# Delineating inland valley Wetlands through Semi-Automated Methods

# Methods Flow-Chart




**Four peer-review publications on methods**

1. Thenkabail P.S., Nolte, C., and Lyon, J.G. 2000. Remote sensing and GIS modeling for selection of benchmark research area in the inland valley agroecosystems of West and Central Africa. Photogrammetric Engineering and Remote Sensing, Africa Applications Special Issue, 66(6):755-768.

2. Thenkabail S. Prasad, and Nolte, C. 2000. Regional characterisation of inland valley agroecosystems in West and central Africa using high-resolution remotely sensed data. (Book Chapter # 8 Pp. 77-99). in the book entitled: "GIS applications for water resources and watershed management" by John G. Lyon, Pp. 266. Taylor and Francis, London and New York.

3. Kulawardhana, R. W., Thenkabail, P. S., Vithanage, J., Biradar, C., Islam, Md. A., Gunasinghe, S., Alankara, R. 2007. Evaluation of the Wetland Mapping Methods using Landsat ETM+ and SRTM Data. Journal of Spatial Hydrology (JoSH) (accepted, in press).

4. Islam, Md. A., Thenkabail, P. S., Kulawardana, R. W., Alankara, R., Gunasinghe, S., Edussriya, C., and Gunawardana, A., 2007. Semi-automated Methods for mapping wetlands using Landsat ETM+ and SRTM data. International Journal of Remote Sensing. (accepted, in press)

http://wetlands.iwmi.org/
http://www.iwmidsp.org

# 1. Image Enhancement

## Two band vegetation indices (TBVIs)

$$TBVI_{ij} = \frac{(R_j - R_i)}{(R_j + R_i)}$$

where: i, j = 1, N, (with N = number of bands = 7 for Landsat ETM+ multispectral); R = reflectance of bands. A total of 49 TBVIs were computed for Landsat band matrix of λ1 (7 bands) by λ2 (7 bands). The indices above the diagonal are transpose of the indices below the diagonal. Hence, after reducing for this redundancy, only 21 unique indices will be left. Each TBVI were subjected to variable thresholds to get the best separability for wetlands.

# Delineating Wetlands through Semi-Automated Methods

## 1. Image enhancement: Vegetation Indices (some examples)

| Index or parameter | Definition | Range<br>-1.0 to 1.0 dimensionless or 0 to 100 % | Threshold values that best delineated wetlands |
|---|---|---|---|
| a. Slope derived from SRTM DEM | This is the percentage slope derived using spatial analyst tools available in Arc GIS | 0 to 100 | <1 % |
| b. Normalized Difference Vegetation Index (NDVI)<br>(Rouse et al., 1974) | $NDVI = \frac{\rho_4 - \rho_3}{\rho_4 + \rho_3}$<br>where, $\rho_3$ and $\rho_4$ are the reflectance values derived from the bands 3 (Red) and 4 (NIR) of Landsat ETM+ data respectively. | -1.0 to +1.0 | -0.25 to 0.10 |
| c. Tasseled-cap Wetness Index (TWI)<br>(Crist and Cicone, 1984) | TWI = ([B1] * 0.1509 + [B2] * 0.1973 + [B3] * 0.3279 + [B4] * 0.3406 + [B5] * -0.7112 + [B7] * -0.4572)<br>Where, B1 to B7 are the DN values of the respective bands of Landsat ETM+ data. This index represents the overall degree of wetness over the area as reflected by the image data. | 0 to 100 | 0 to 30 |
| d. Normalized Difference Water Index (NDWI)<br>(McFeeters, 1996) | $NDWI = \frac{\rho_2 - \rho_4}{\rho_2 + \rho_4}$<br>where, $\rho_2$ and $\rho_5$ are the reflectance values derived from the bands 2 (Green) and 4 (NIR) of Landsat ETM+ data respectively. | -1.0 to+ 1.0 | -0.15 to 0 |
| e. Mid Infrared Ratio (MIR)<br>(Coppin and Bauer, 1994) | $MIR = \frac{Band\,4}{Band\,5}$<br>where, Band 4 and 5 are NIR and Mid Infra-red bands of Landsat ETM + data respectively. | 0 to 4 | >0.25 |
| f. Ratio Vegetation Index (RVI)<br>(Tucker, 1979) | $RVI = \frac{Band\,4}{Band\,3}$<br>where, Band 4 and 3 are NIR and Red bands of Landsat ETM + data respectively | 0 to 6 | <0.6 |
| g. Green Ratio (GR) (Lo, 1986) | $GR = \frac{Band\,4}{Band\,2}$<br>where, Band 4 and 2 are NIR and Green bands of Landsat ETM + data respectively. | 0 to 4 | 0.5 to 0.8 |
| h. Ratio of indices (this study) | RoI = B4/B7 * B4/B3 * B4/B2 | 0 - 240 | 12.5 - 20 |
| i. Reflectance of SWIR 1 band (this study) | This is the percentage reflectance of Band 5<br>where, Band 5 is the Shortwave Infra-red band 1 of Landsat ETM + data. | 0 to 47 | <1 |

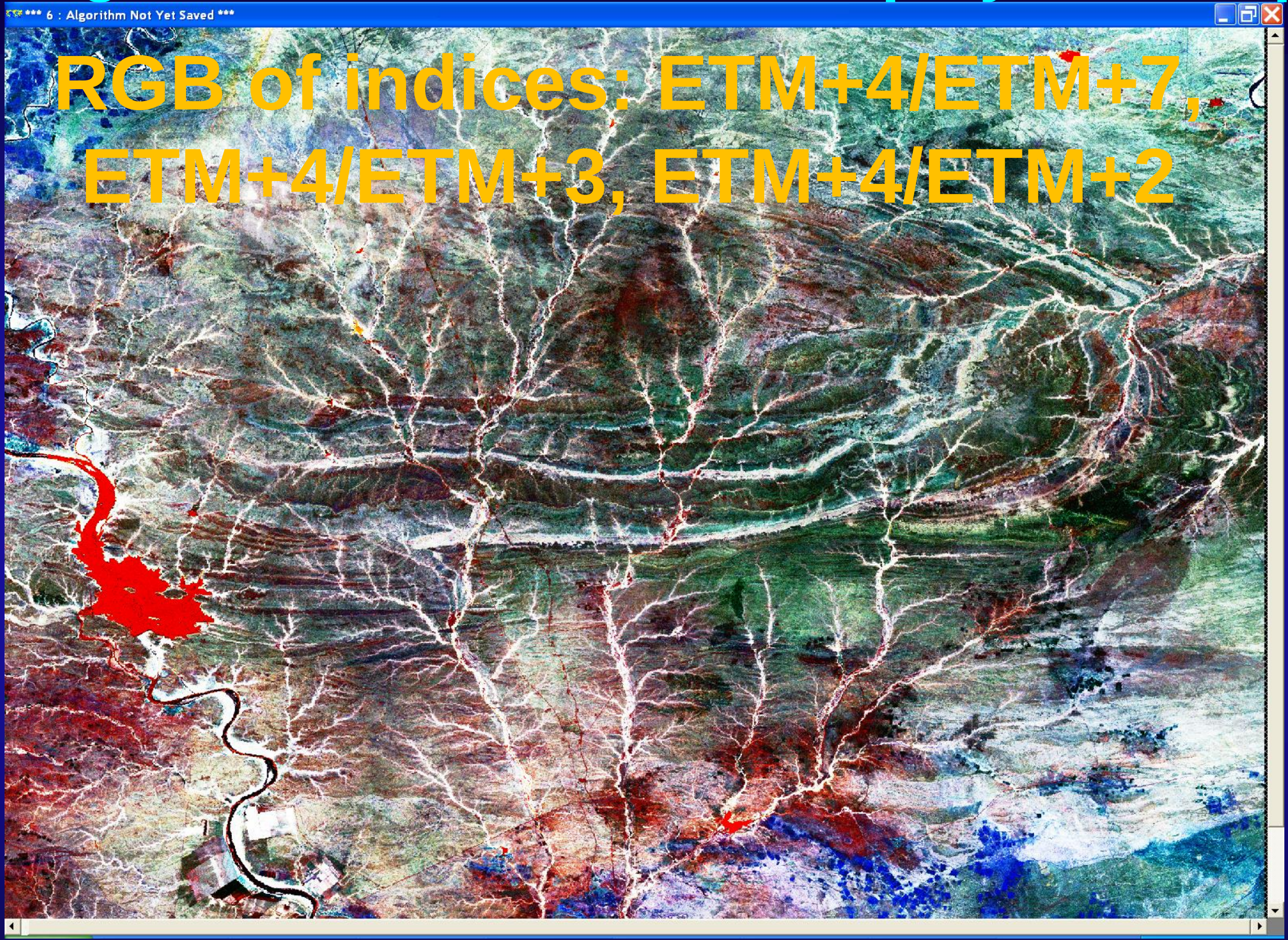
# 2. Image display

**Following display combinations were found powerful in delineating wetlands from other land units**

- FCC RGB: ETM+4/ETM+7, ETM+4/ETM+3, ETM+4/ETM+2
- FCC RGB: ETM+4, ETM+3, ETM+2
- FCC RGB: ETM+3, ETM+2, ETM+1

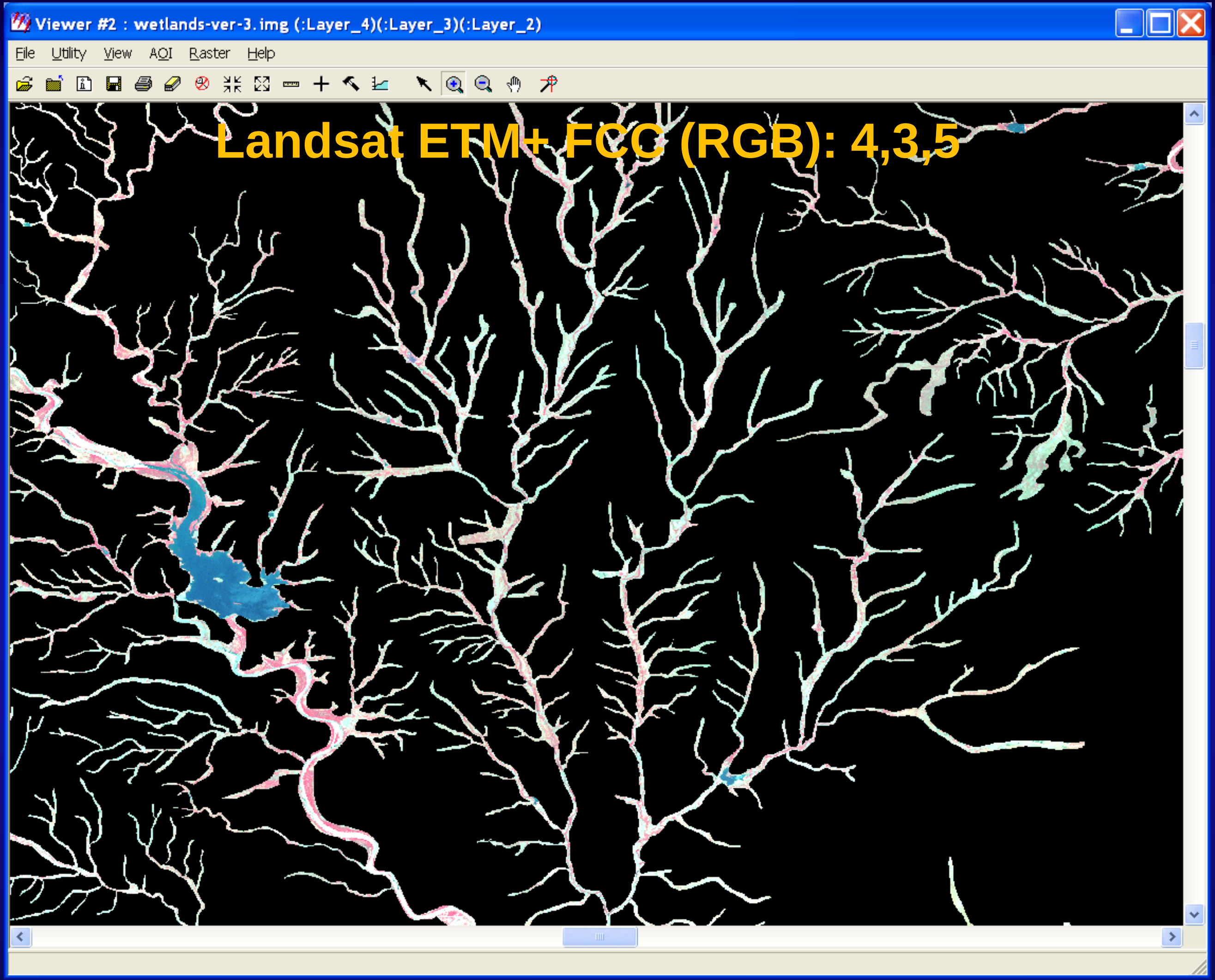
## Delineating Wetlands through semi-Automated Methods

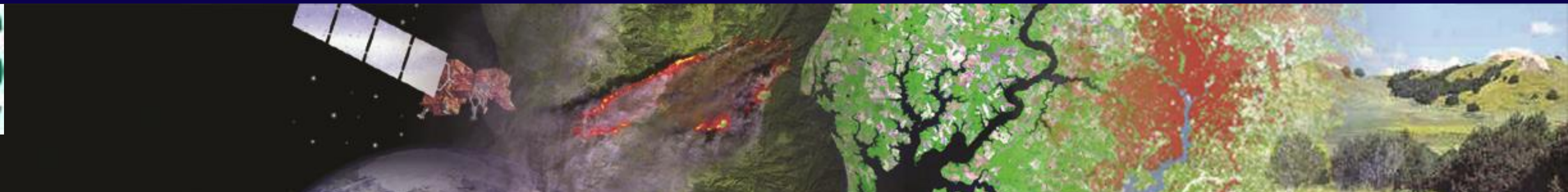
# Image enhancement and Display Techniques



# Delineating Wetlands through semi-Automated Methods

## Delineated wetland areas

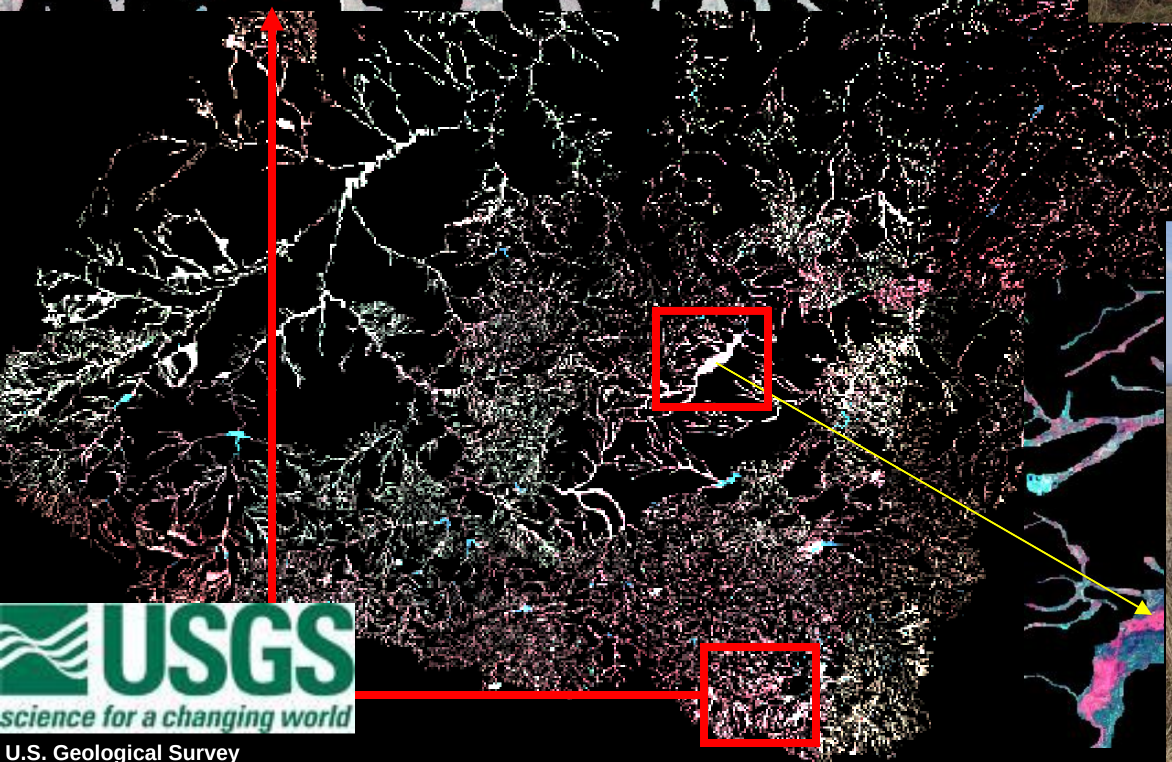


# Delineating Wetlands through semi-Automated Methods

# Delineated Wetlands of the Limpopo River Basin



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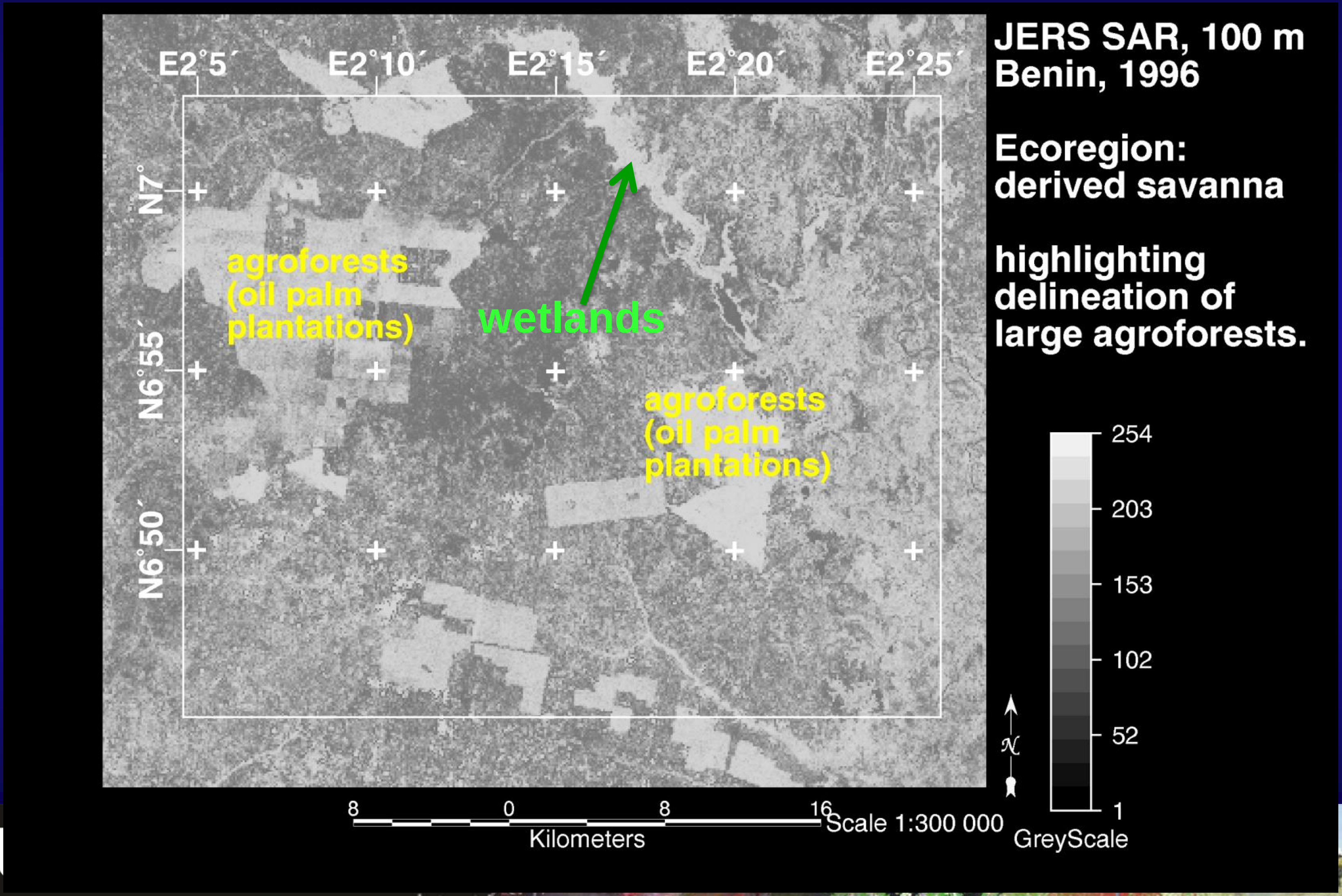
Kulawandana et al., 2007

Delineating Wetlands through JERS SAR Data

# Delineated Wetlands in West Africa

## JERS SAR Data; SAR Backscatter



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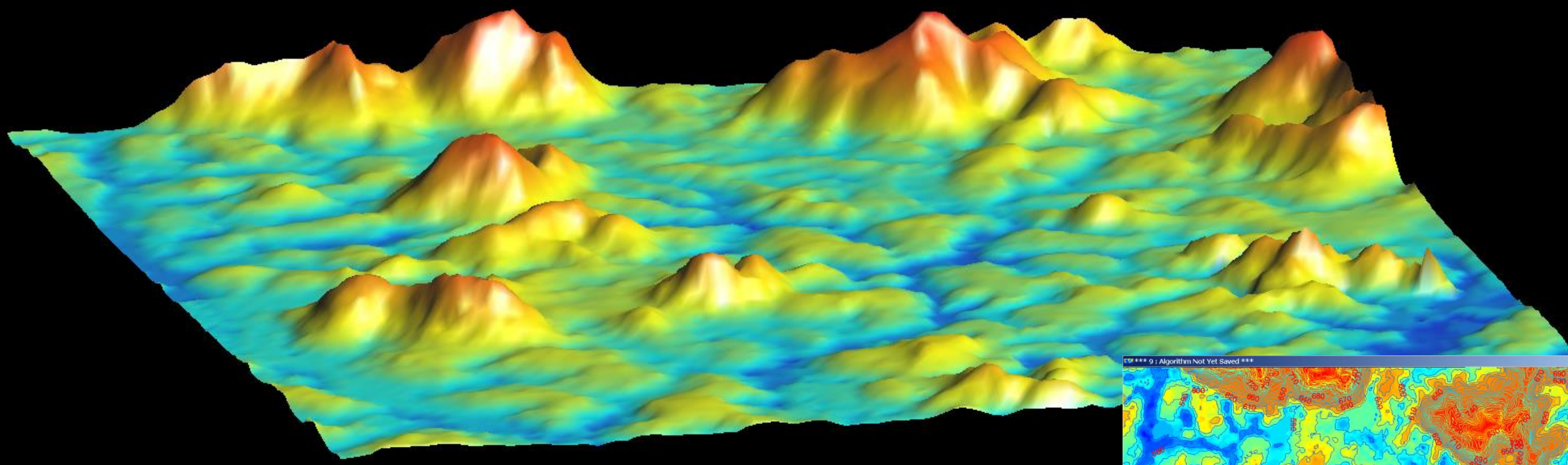
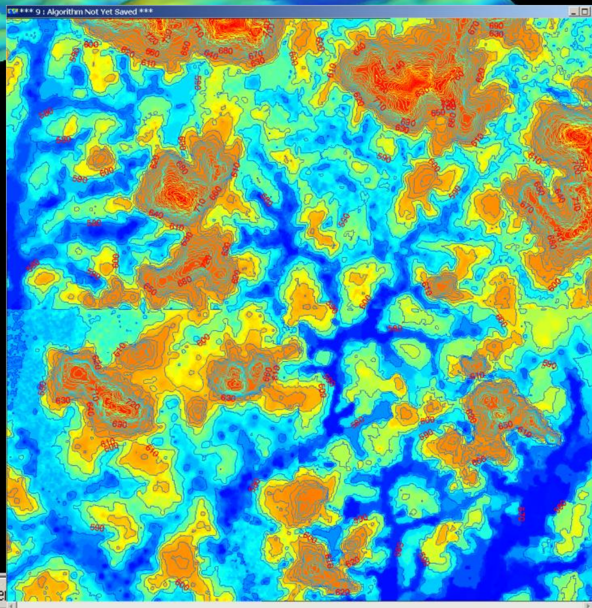
# Delineating Wetlands through Multiple Datasets

# Delineated Wetlands in West Africa

## IKONOS 4 m Stereo Data





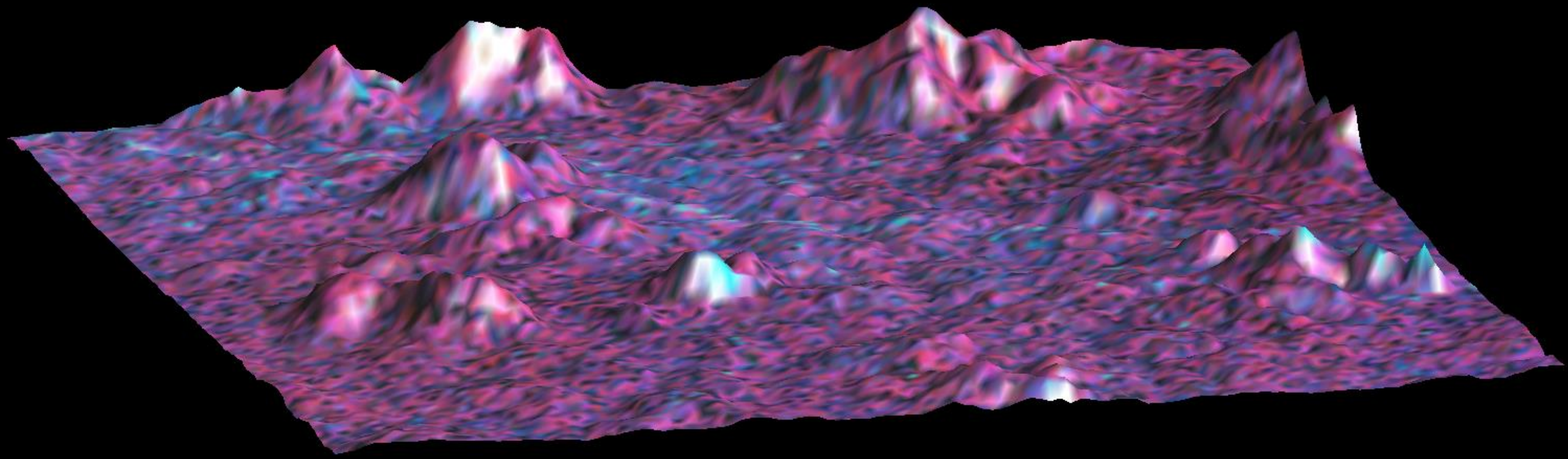
Start | README Us... | ER Mapper | 1 : Algorith... | 2 : akok-hy... | Tools | Map Compo... | *** 5 : ako... | Documer

*** 5 : akok-dem-020502-3d.alg ***

# Delineating Wetlands through multiple Datasets

# Delineated Wetlands in West Africa

## IKONOS 4 m FCC draped on 4 m Stereo Data



Start | README Users... | ER Mapper | 1 : Algorithm ... | 2 : akok-hyper... | Tools | Map Compositi... | *** 5 : akok... | Document1 - ... | Microsoft Pow... | 12:08 PM

## Delineating Wetlands through Multi-sensor Data

# Wetlands in Congo Rainforests

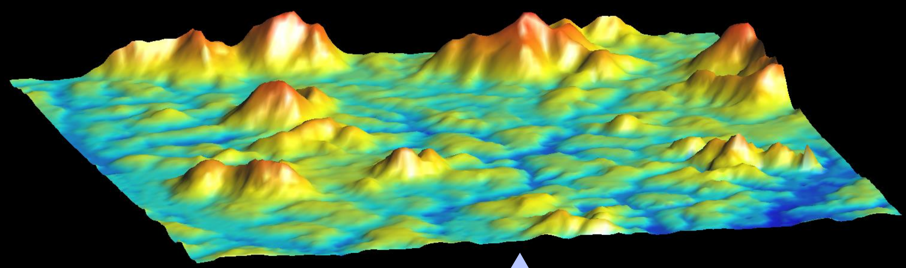
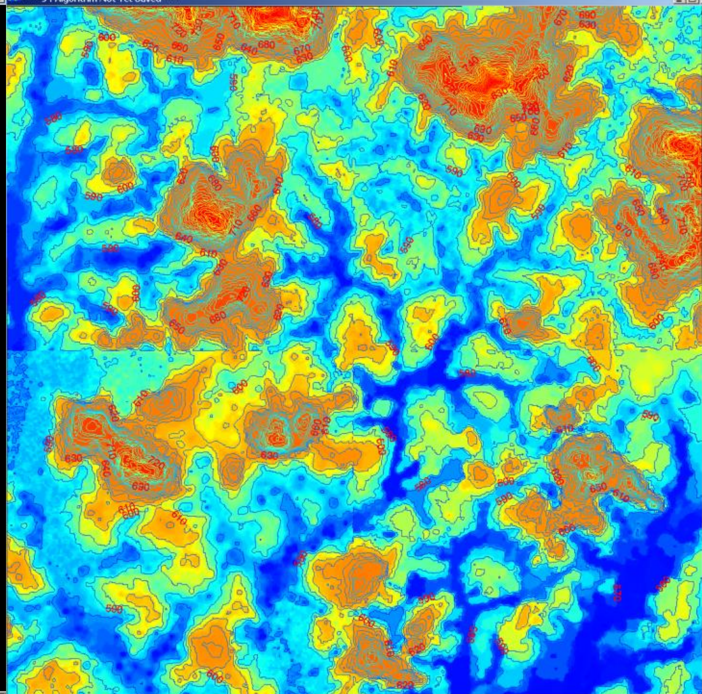


Fig. 4a and 4b: GDEM Data for Delineating uplands from lowland wetlands



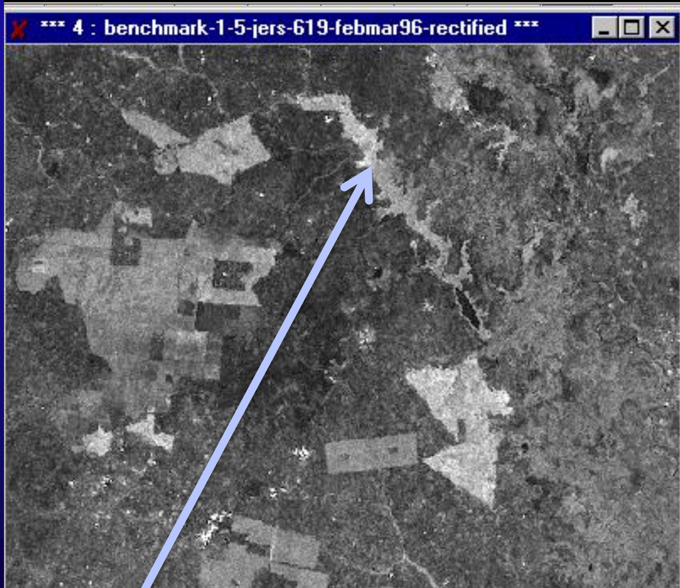
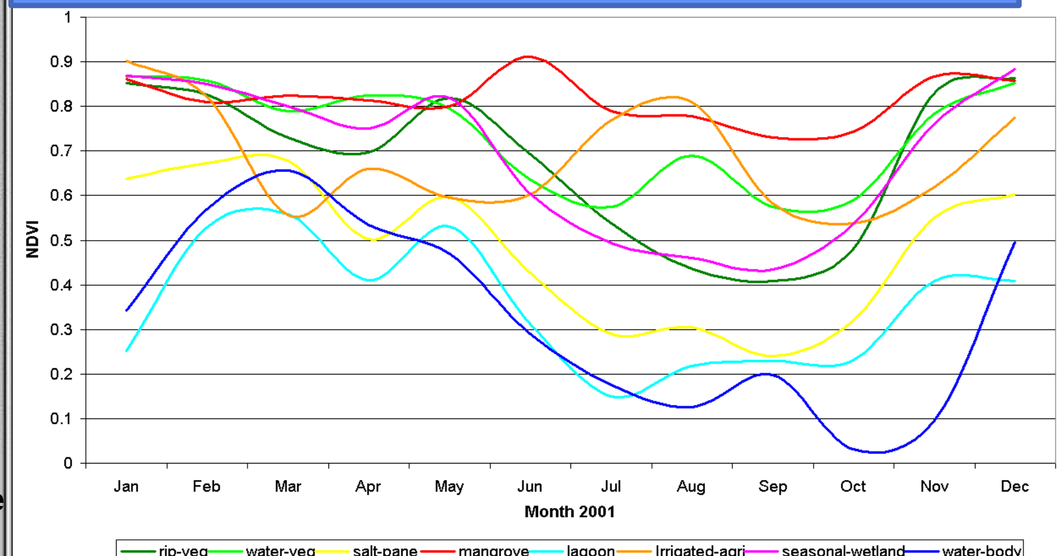



**Fig. 4c: JERS L-band SAR data to Delineate Wetlands from other land use\land cover**

**Fig 4d. Time-series Characteristics of 8 wetland classes using MODIS Terra 500m NDVI for year 2001**



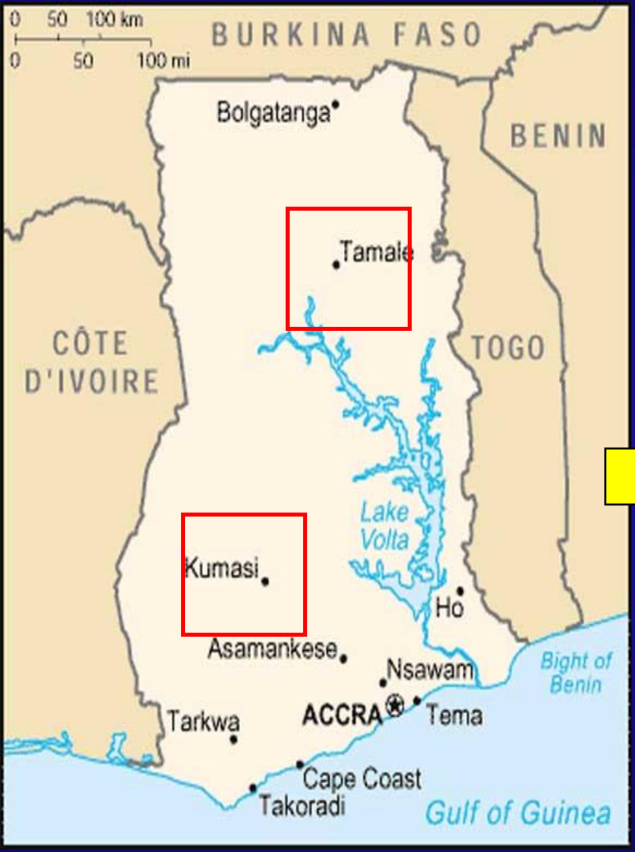
# Remote Sensing

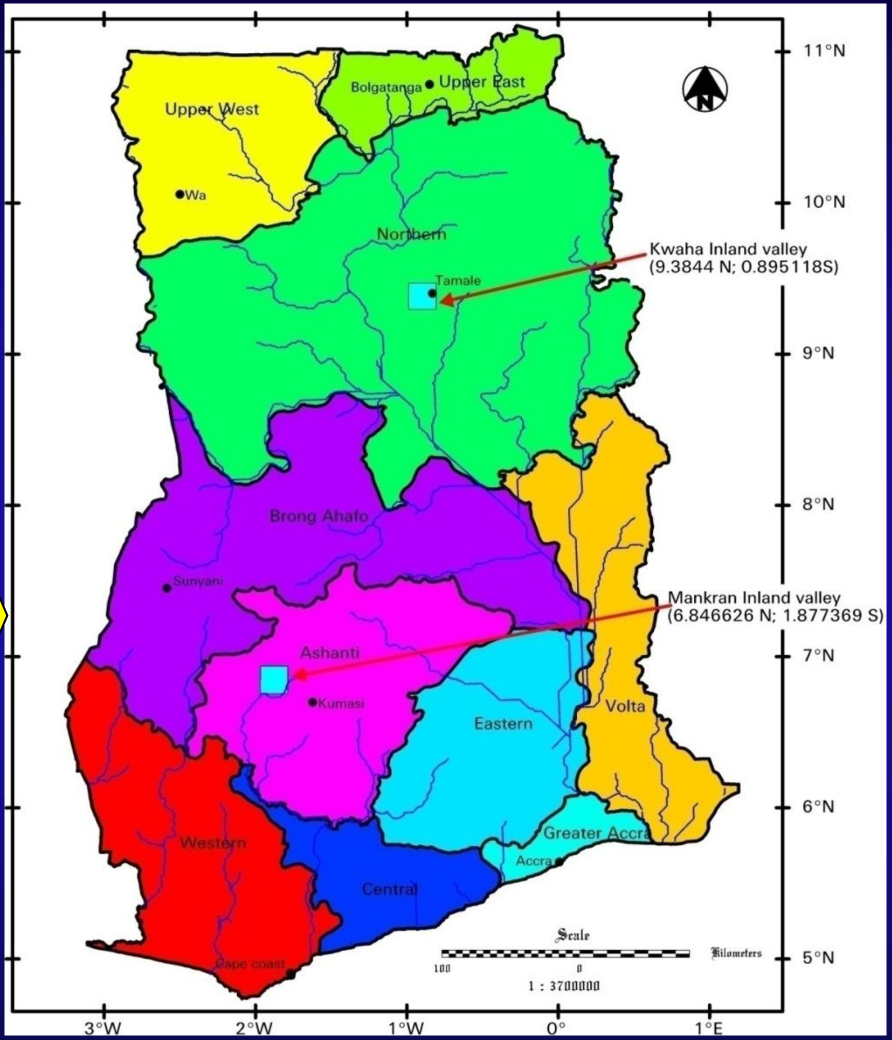
## Characterization, Monitoring, and Mapping of Inland Valley Wetlands of Africa

## RESULTS

# Inland Valleys of West and Central Africa using Remote Sensing

## Inland Valley wetlands of Ghana: Location of the study areas



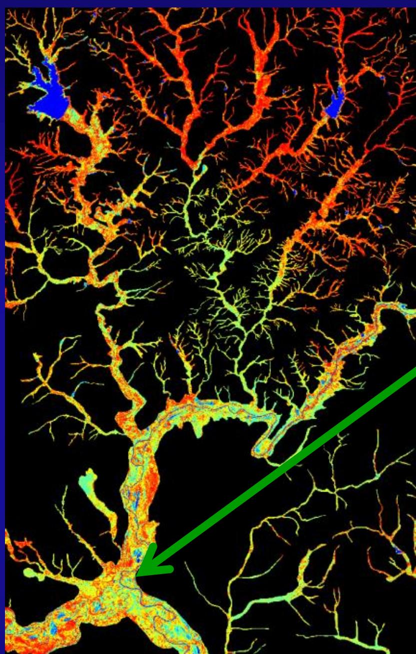

Reference Map from Fujii

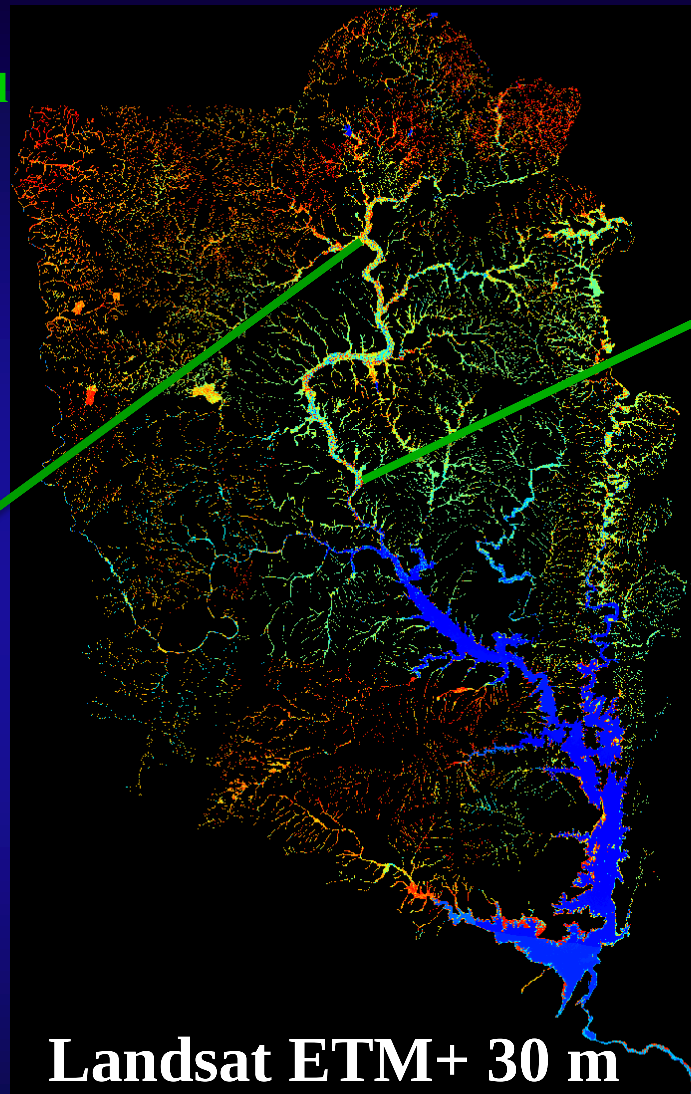
U.S. Geological Survey
U.S. Department of Interior

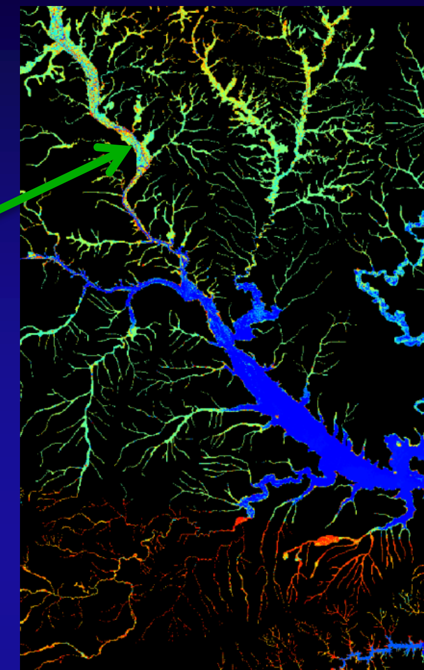
# Inland Valley Wetlands of Ghana using Landsat ETM+ 30m Data

## IV Area and % area cultivated

1. **IV wetland area: 11.4 % (2,714,946 hectares) of the total geographic area of Ghana which is 23,853,300 hectares.**





2. **IV wetland cultivation: < 5% (130,000 ha) of IV wetlands are currently cultivated.**

**Color key**

**Colors indicate characteristically similar inland valley wetlands in biophysical terms.**

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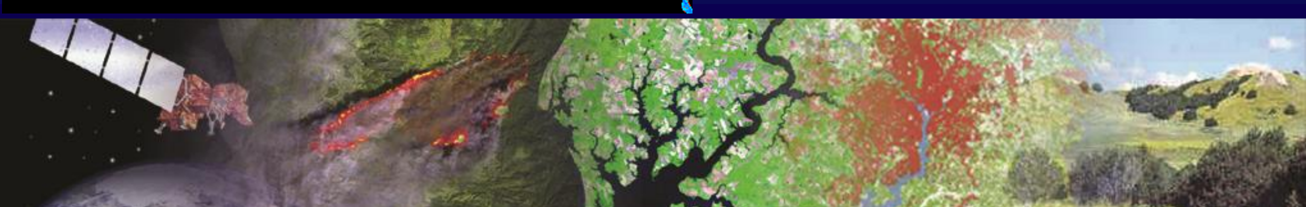
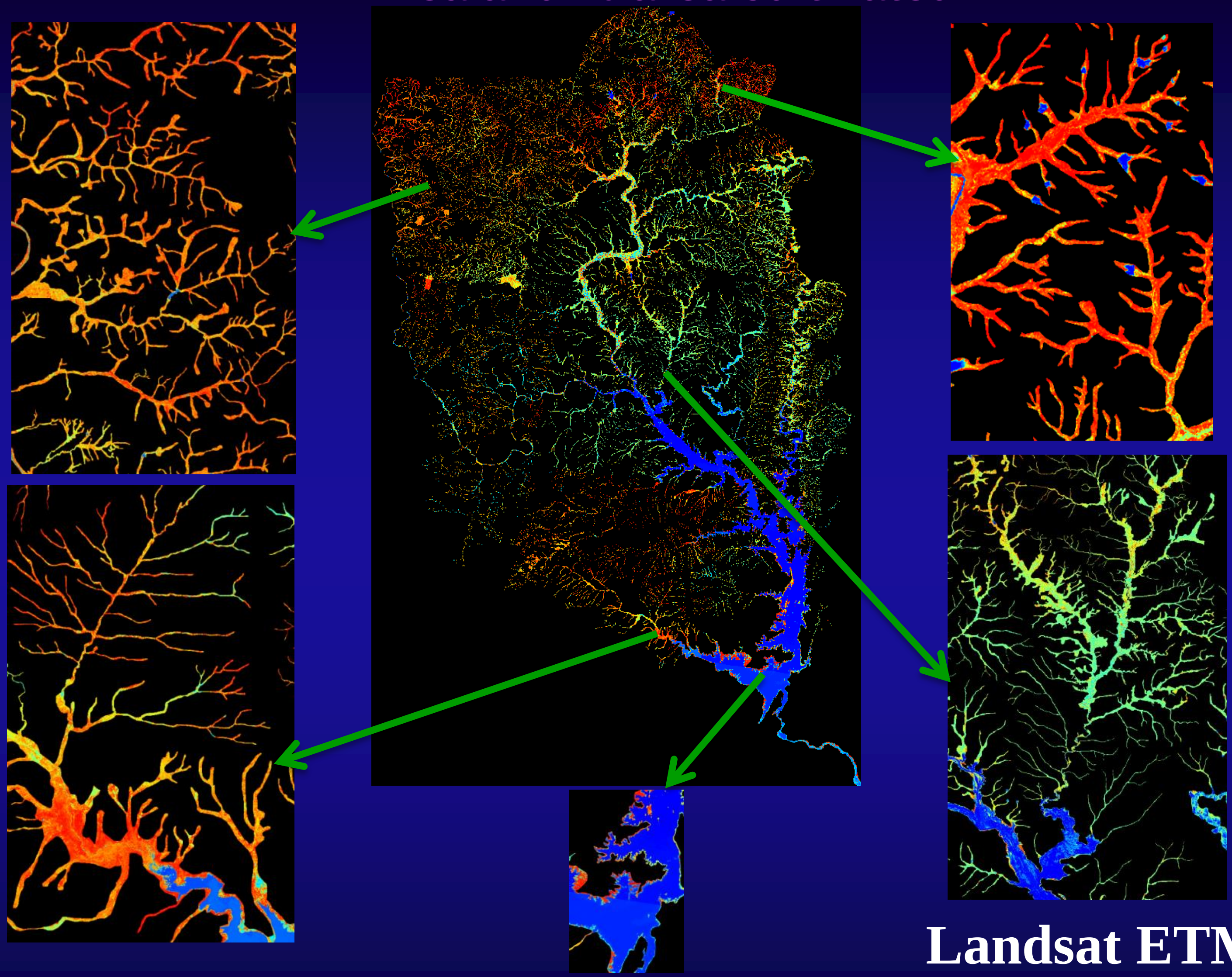


# Inland Valley Wetlands of Ghana using Landsat ETM+ 30m Data

## IV Area and % area cultivated



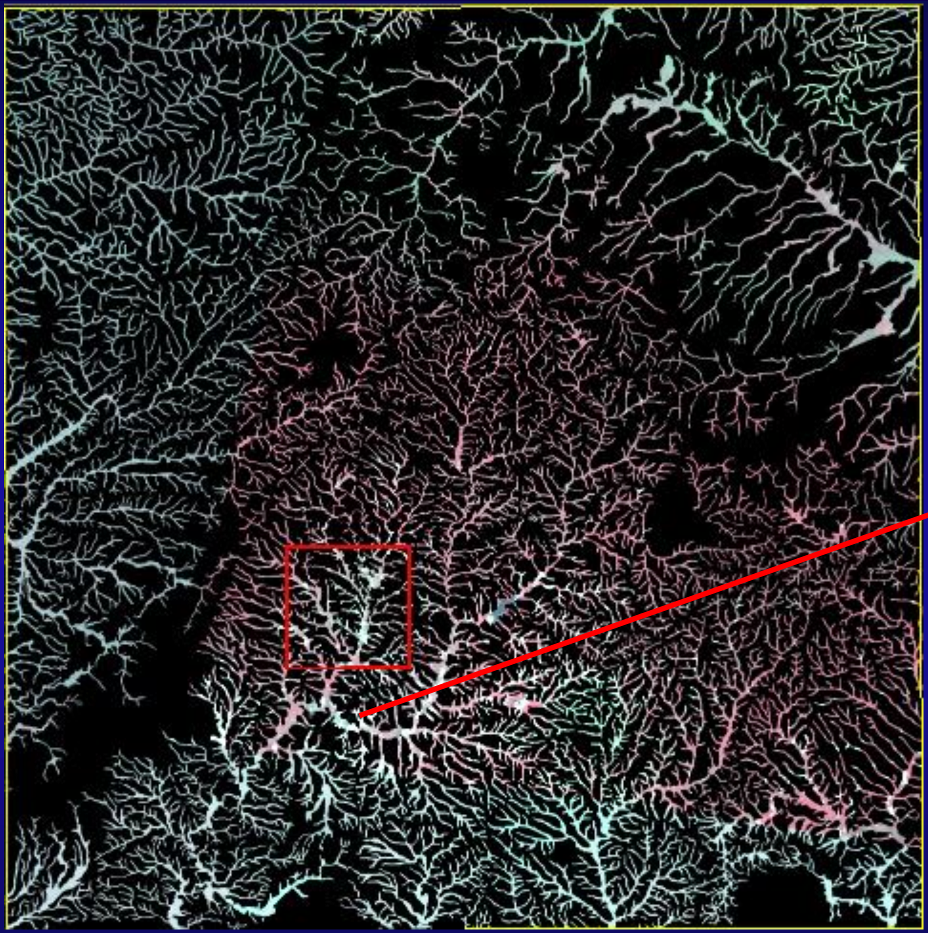
**Landsat ETM+ 30 m**

# Inland Valleys of West and Central Africa using Remote Sensing

## Inland Valleys of Mankran, Kumasi, Ghana: IV Area and % area cultivated

**Landsat ETM+ 30 m**

**Semi-detailed Study area: 12,100 Km2**



Landsat ETM+ Data displayed as FCC of bands 432

Image acquisition dates:

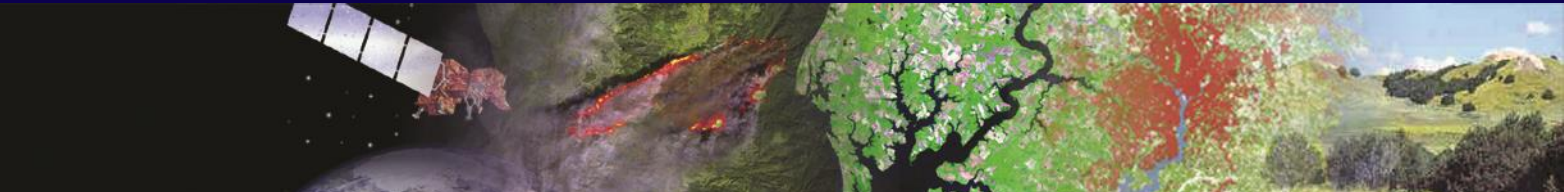
1986-Jan-11, 2002-March-20

Detailed study area: 15km by 15 km

**Total land area of study site**
**12100 km$^2$**

**Total land area of IVs**
**2475 km$^2$**

**% area of IVs: 20.5 %**



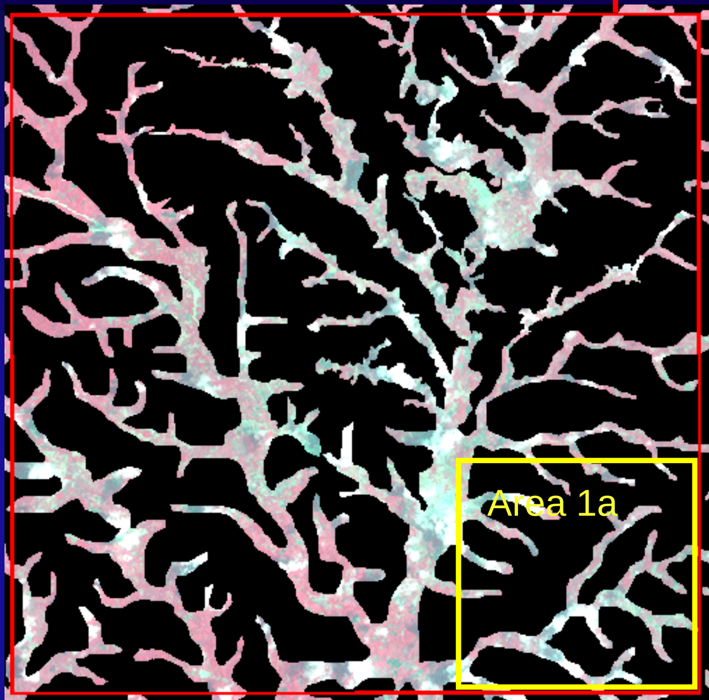
U.S. Geological Survey
U.S. Department of Interior

## Inland Valleys of West and Central Africa using Remote Sensing

## Inland Valleys of Mankran, Kumasi, Ghana: IV Area and % area cultivated

# Landsat ETM+ 30 m

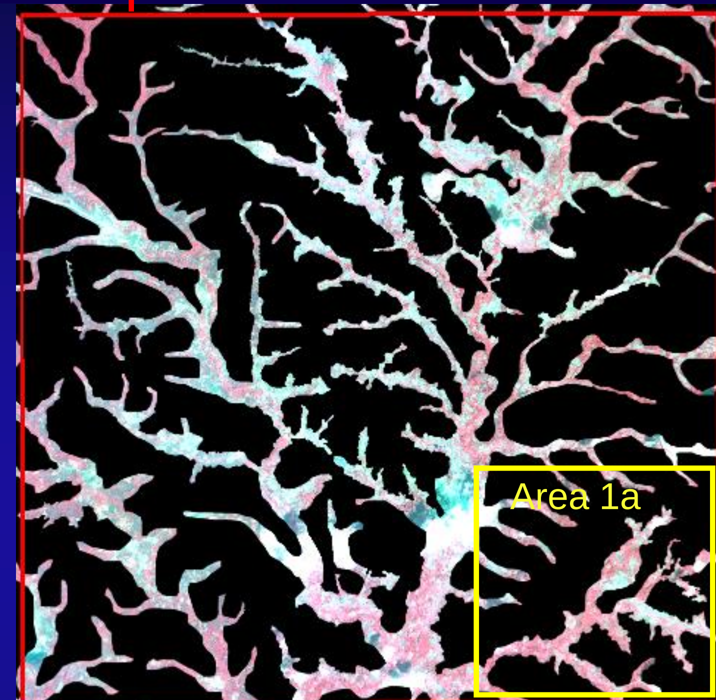
Detailed study area ($225 km^2$)




Landsat ETM+ data displayed as FCC of bands 432
Image acquisition date: 2002-March-20

**These are all 1 to 4th order streams**

# IKONOS 4 m

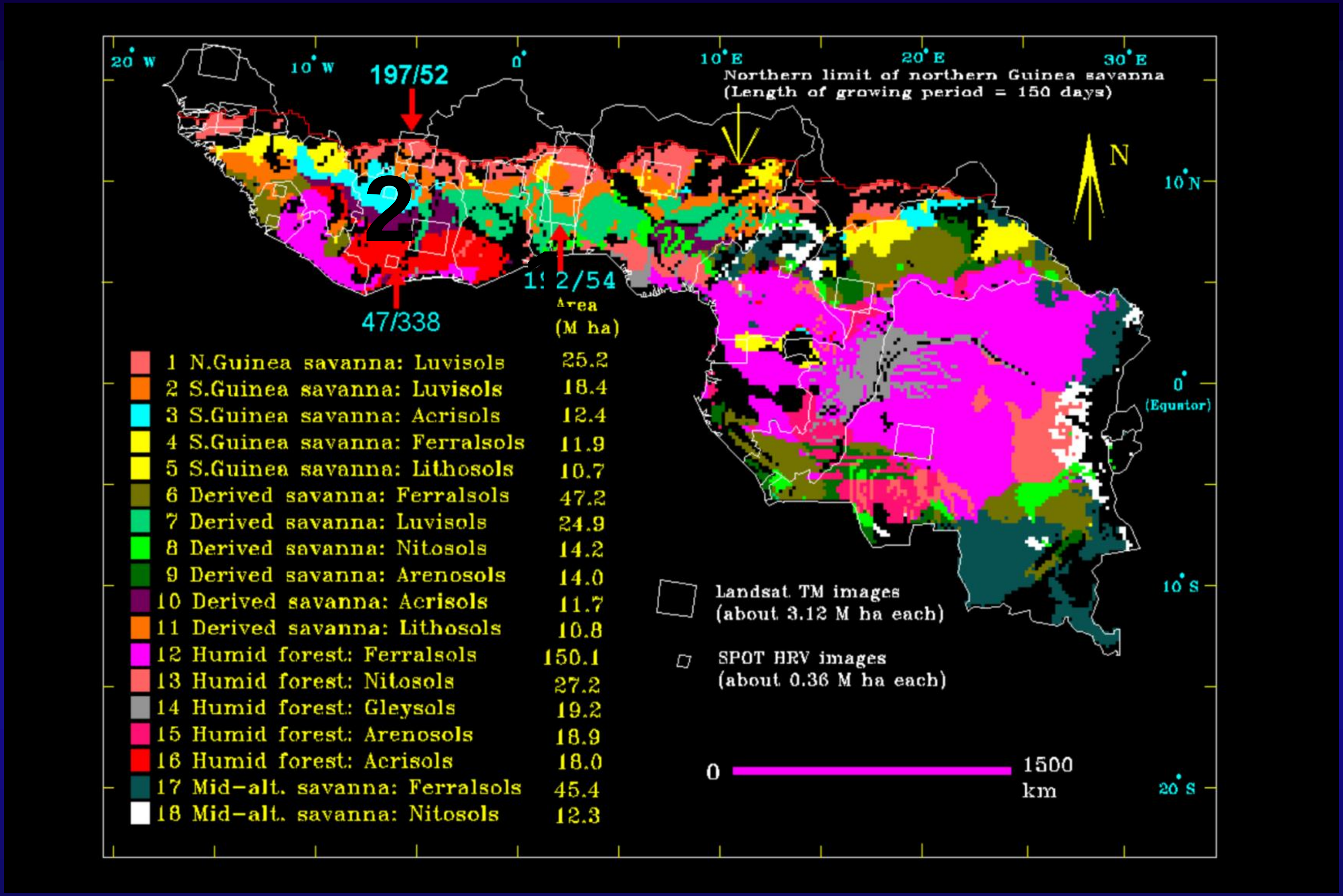



IKONOS Data - Displayed as FCC of bands 432
Image acquisition dates: 2000-02-13, 2003-01-16

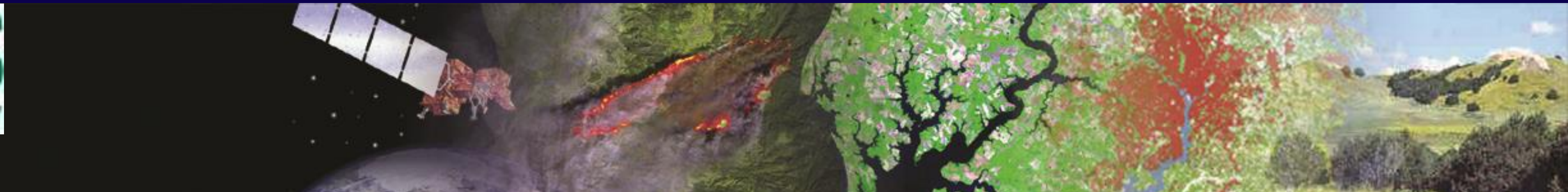
| | Derived from Landsat data | Derived from IKONOS data |
|---|---|---|
| Total area of IVs ($km^2$) | 63 | 64.9 |
| % area of IVs | 27.72% | 28.50% |

# Inland Valleys of West and Central Africa using Remote Sensing

## Agroecological and Soil Zones (AESZ) of West and Central Africa




**AESZ > 10 Mha are reported here…..1,2,and 3 illustrated in following slides**

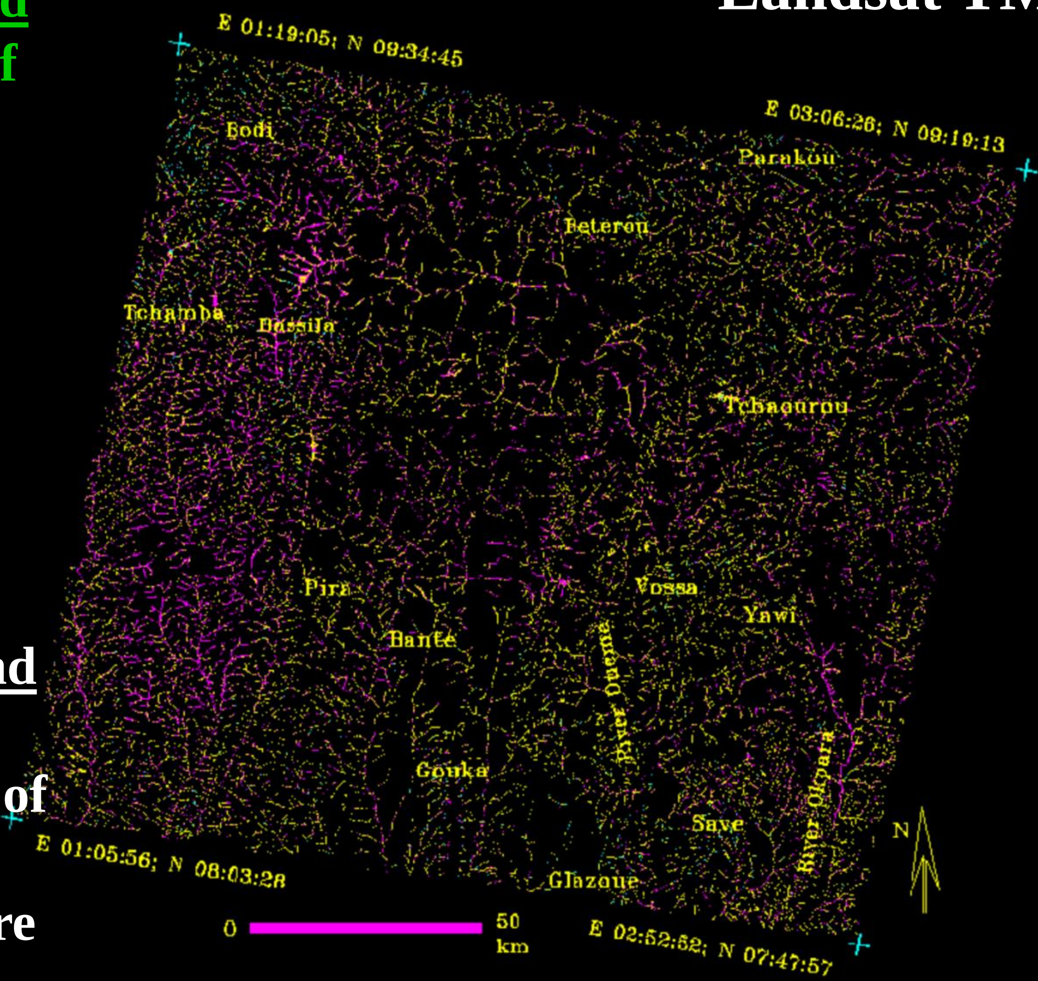


**Inland Valleys of West and Central Africa using Landsat TM 30m Data**

**Inland Valleys of Republic of Benin: IV Area and % area cultivated**

**1. IV wetland area: 9 % of 3.12 Mha is IV wetland bottoms**

# Landsat TM+ 30 m




**2. IV wetland cultivation: Only 7.9 % of the valley bottoms were cultivated**

**Color key**

**Cyan = significant farmlands**

**Yellow = scattered farmlands**

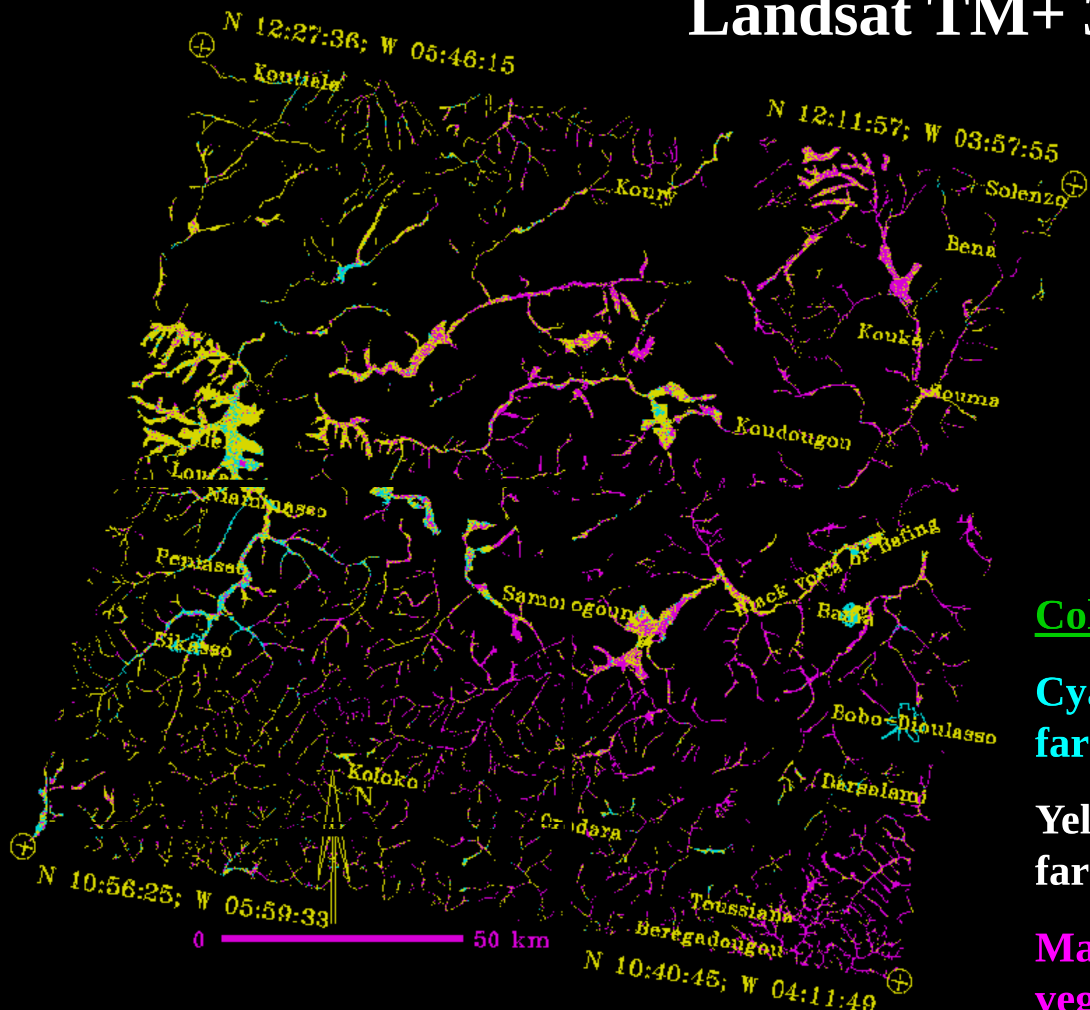
**Magenta = natural vegetation**

## Inland Valleys of West and Central Africa using Landsat TM Data

## Inland Valleys of Burkina Faso and Mali: IV Area and % area cultivated

**Landsat TM+ 30 m**

**1. IV wetland area: 8.6 % of 3.12 Mha is IV wetland bottoms**




**Color key**

**Cyan = significant farmlands**

**Yellow = scattered farmlands**

**Magenta = natural vegetation**

**2. IV wetland cultivation: Only 18.4 % of the valley bottoms were cultivated**

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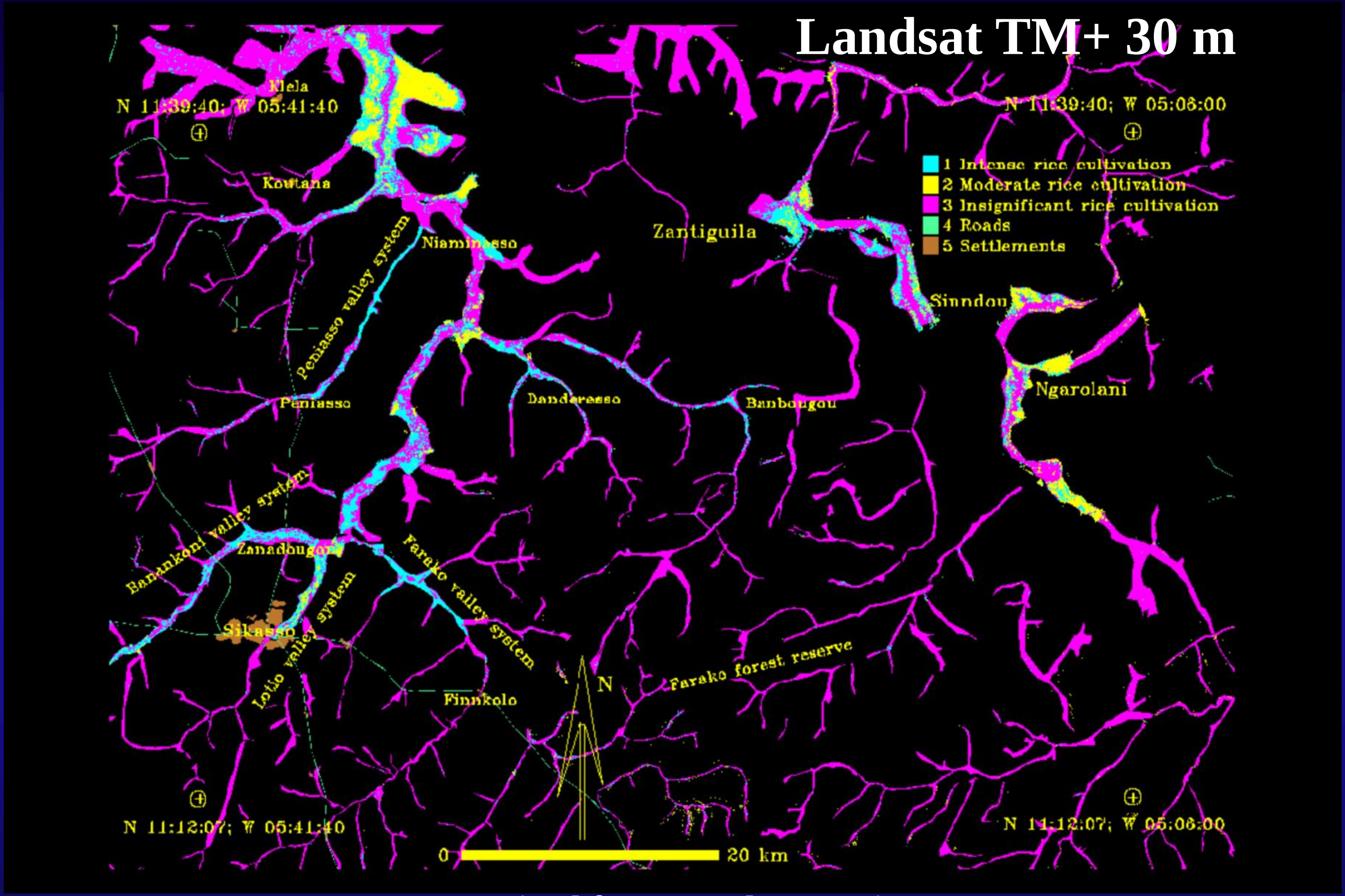
Inland Valleys of West and Central Africa using Remote Sensing

Inland Valleys of Sikasso, Mali: Rice cultivation (class 1 and 2)



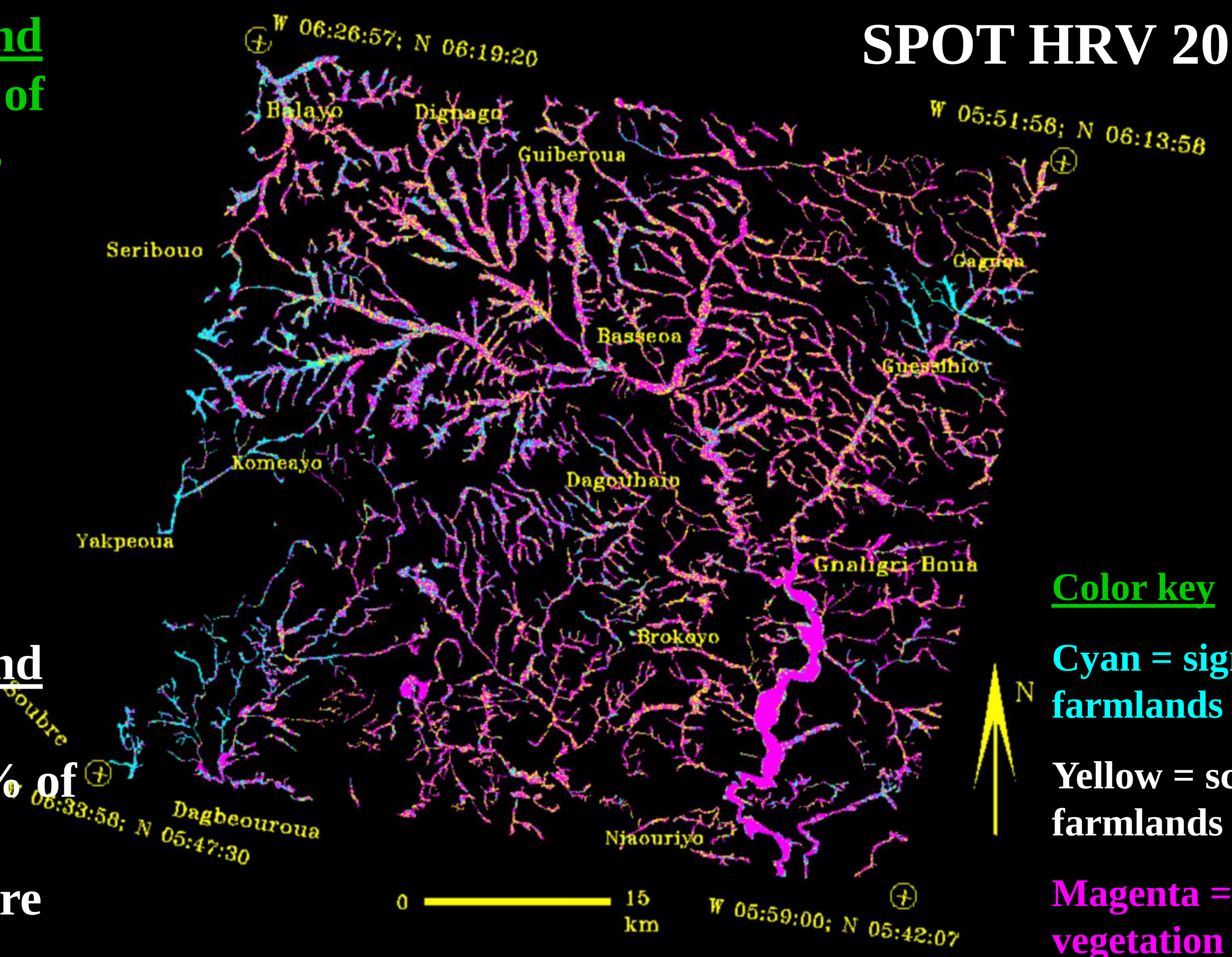

Derived from Landsat TM image

## Inland Valleys of West and Central Africa using Remote Sensing
### Cote d'Voire: IV Area and % area cultivated

1. **IV wetland area: 18 % of 0.39 Mha is IV wetland bottoms**

2. **IV wetland cultivation: Only 20.6 % of the valley bottoms were cultivated**

**SPOT HRV 20 m**

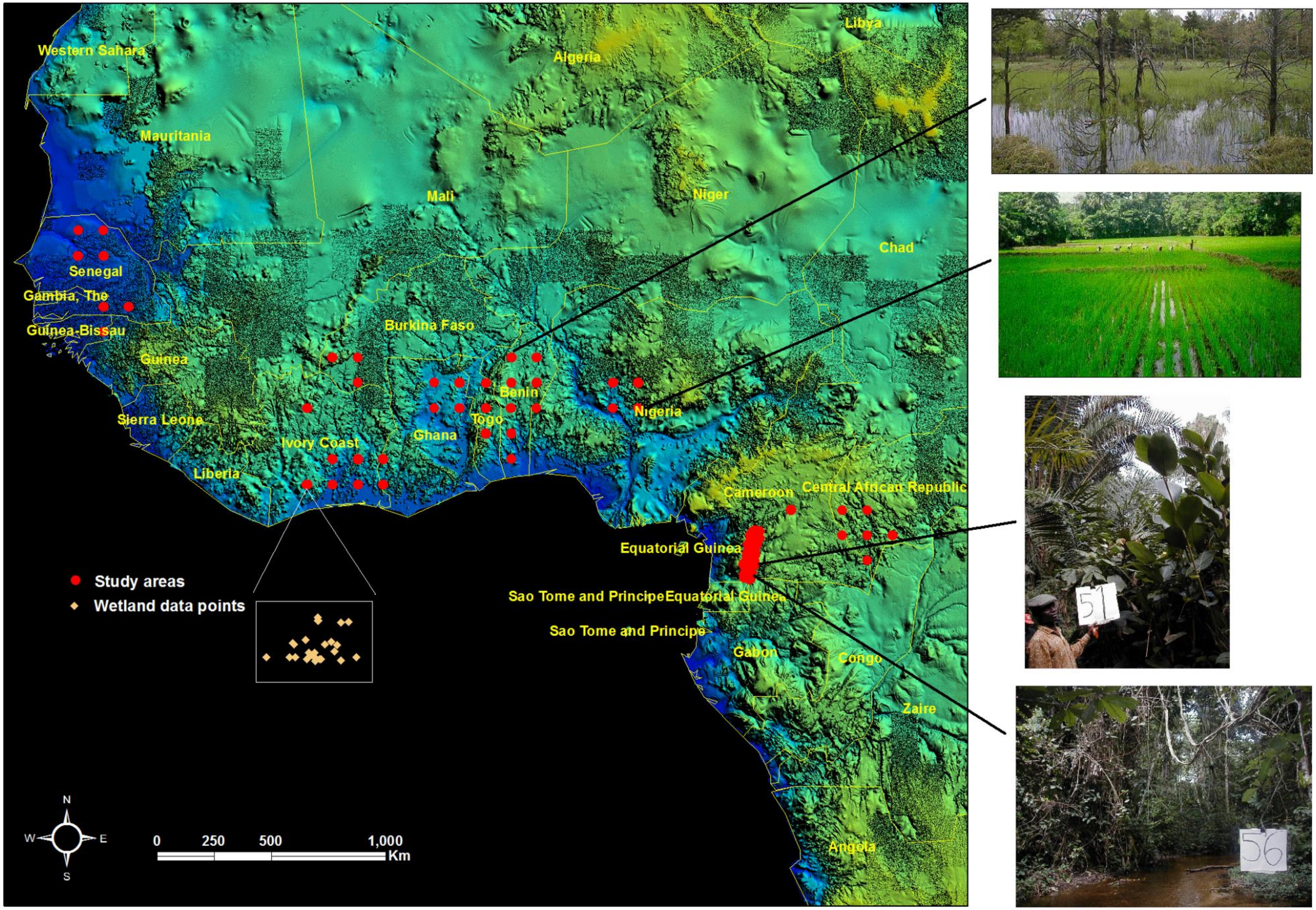



**Color key**

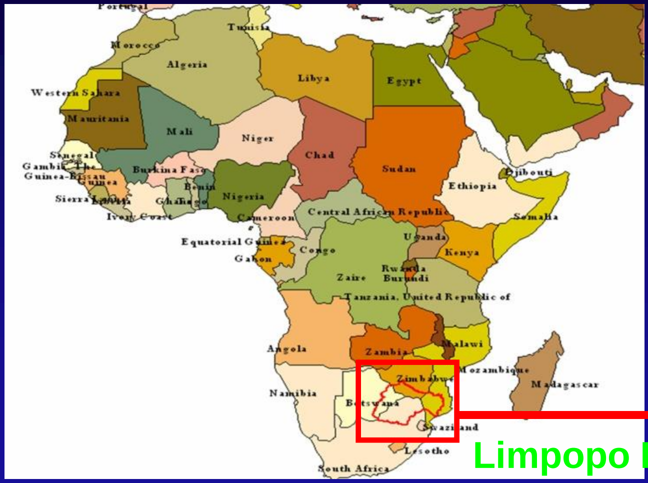
**Cyan = significant farmlands**

**Yellow = scattered farmlands**

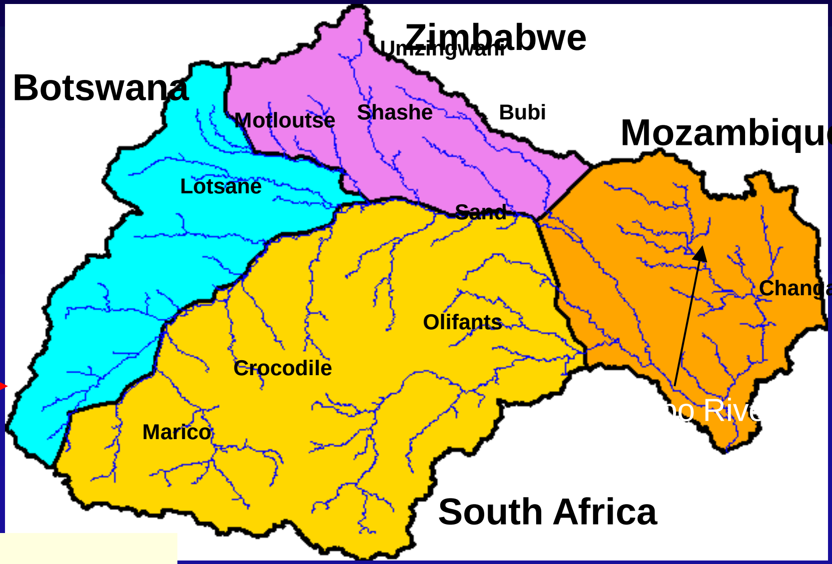
**Magenta = natural vegetation**


Western Sahara
Algeria
Libya
Mauritania
Mali
Niger
Chad
Senegal
Gambia, The
Guinea-Bissau
Guinea
Burkina Faso
Benin
Nigeria
Sierra Leone
Togo
Ghana
Ivory Coast
Liberia
Cameroon
Central African Republic
Equatorial Guinea
Sao Tome and Principe
Equatorial Guinea
Sao Tome and Principe
Gabon
Congo
Zaire
Angola
Study areas
Wetland data points
N
W
E
S
0 250 500 1,000
Km
51
56

# Inland Valleys of Southern Africa using Remote Sensing
## Inland Valleys of South Africa, Mozambique, Zimbabwe, and Botswana




Limpopo River Basin



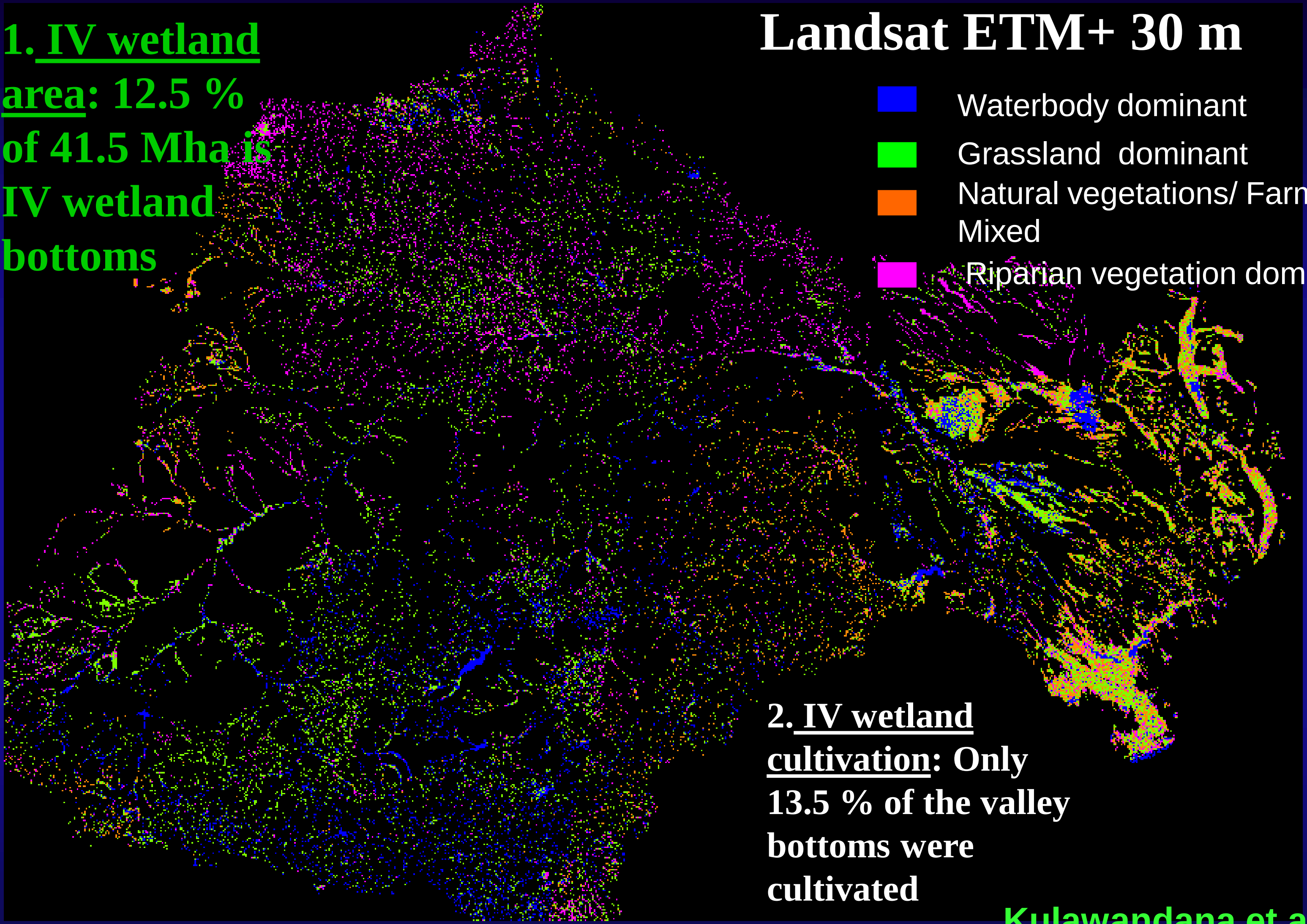

Total basin area = 41.5 Mha

# Distribution of basin

| | Basin area hectares | % of basin area |
|---|---|---|
| South Africa | 18590000 | 44.8 |
| Mozambique | 8750000 | 21.1 |
| Zimbabwe | 6150000 | 14.8 |
| Botswana | 8040000 | 19.3 |

# Inland Valleys of Southern Africa using Remote Sensing

## Inland Valleys of South Africa, Mozambique, Zimbabwe, and Botswana: area and % cultivated

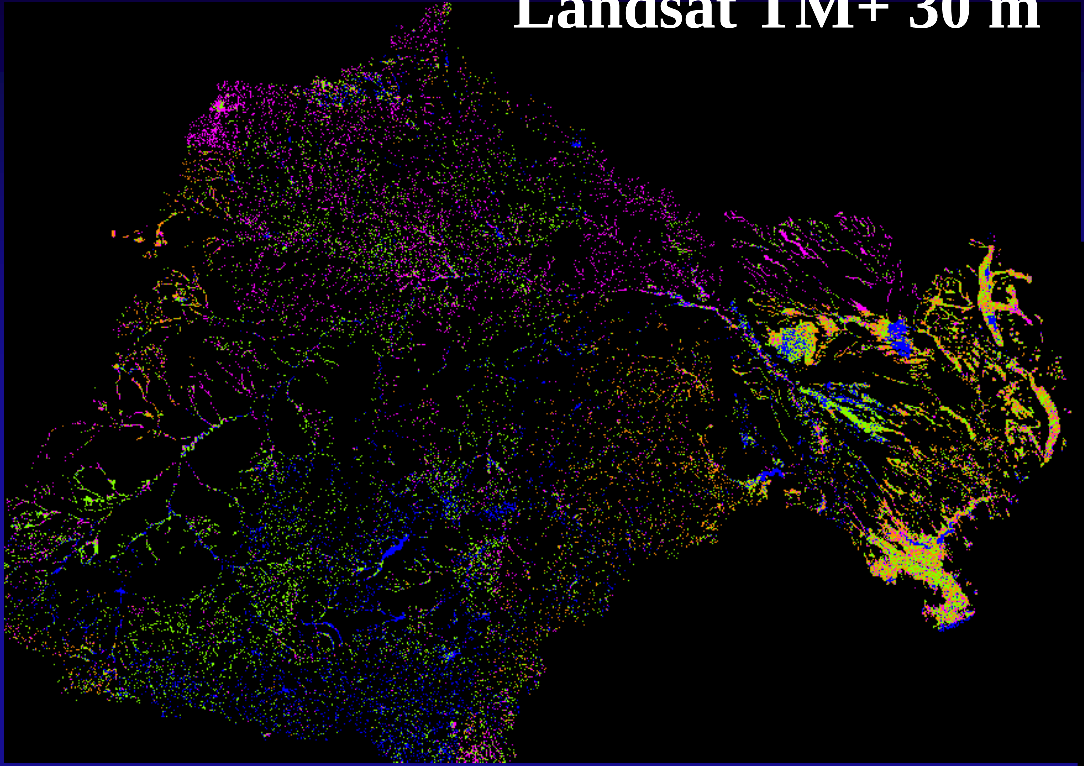



Kulawandana et al., 2007

## Accuracy Assessment

# Inland Valley Wetlands from Semi-automated Methods

### Landsat TM+ 30 m

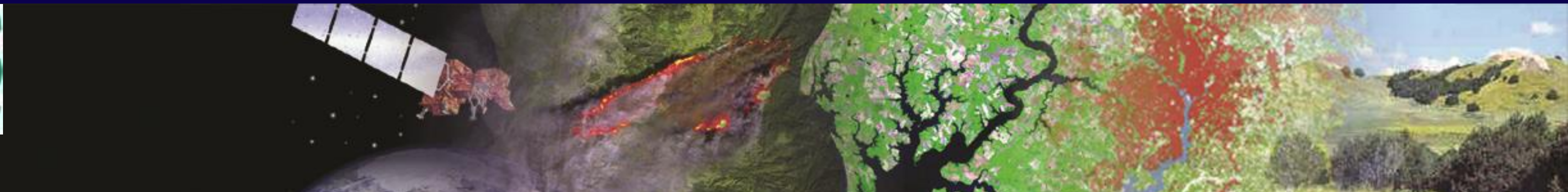


- Waterbody dominant,
- Grassland dominant
- Natural vegetations/ Farmlands Mixed
- Riparian vegetation dominant

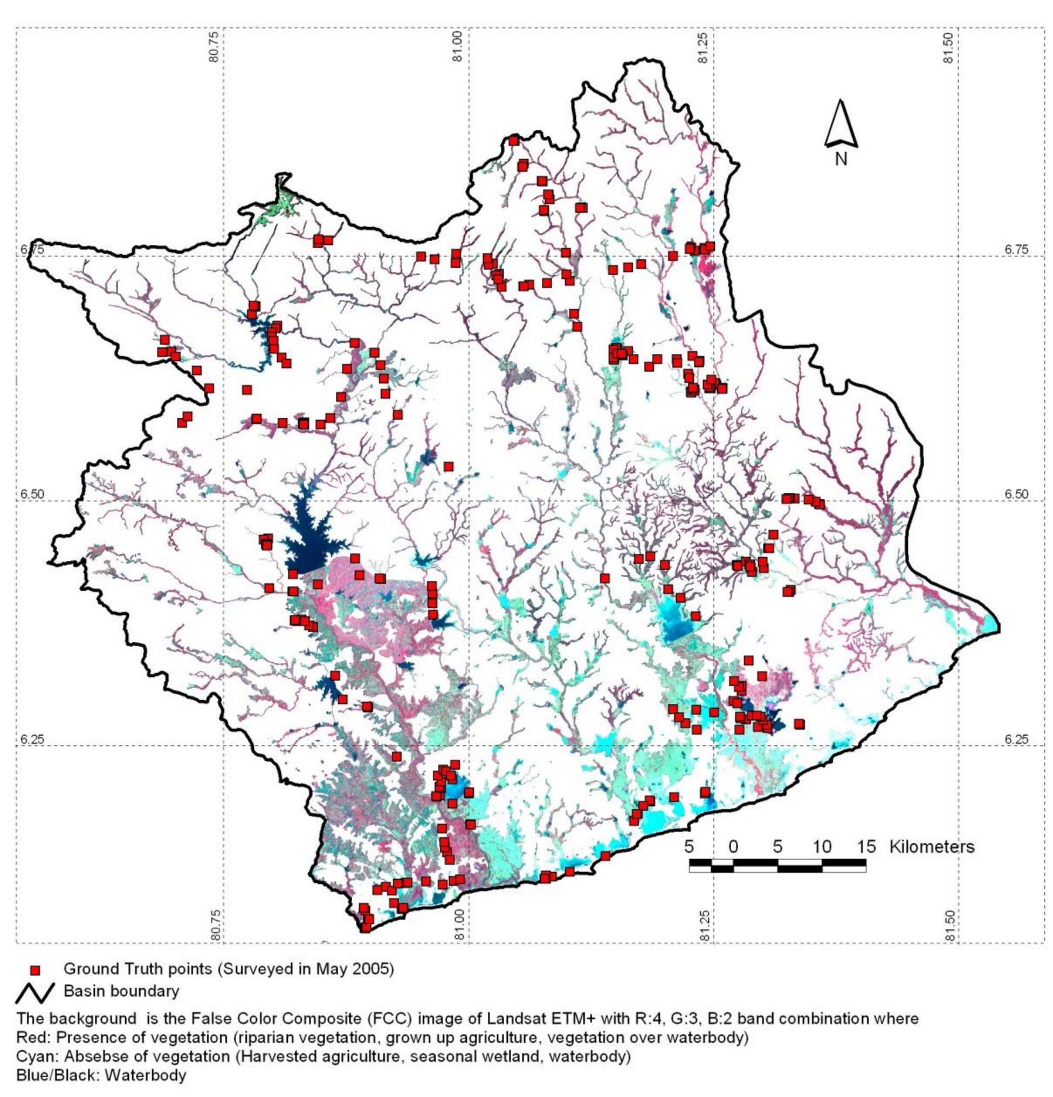
| | No. of points | % |
|---|---|---|
| Completely within the digitized boundaries | 191 | 86.43 |
| Just outside (within 30m) the digitized boundaries | 13 | 7.70 |
| Completely outside the digitized boundaries | 17 | 5.88 |
| **Total** | **221** | **100** |

Kulawandana et al., 2007





# Accuracy Assessment
# Inland Valley Wetlands from Semi-automated Methods




| | |
|---|---|
| Number of wetland GT points | 230 |
| Number of GT points falling inside wetland boundary | 222 |
| Number of GT points falling outside wetland boundary | 8 |
| Overall Accuracy (%) | 96.5 |

**Based on Landsat TM+ 30 m**

Islam, A. 2008 et. al.

# Spatial Modeling for

## Selecting Best Sites for Rice Cultivation

U.S. Department of the Interior
U.S. Geological Survey

# Spatial Data Layers for Best Site Selection

## Key Steps

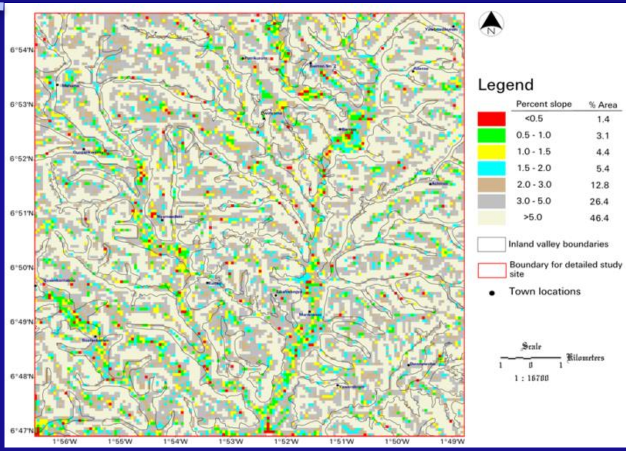
1. Identify spatial data layers;
2. Gather data, harmonize, standardize;
3. Weigh spatial data layers and classes within each data layer;
4. Build model to run spatial datasets to make decisions.

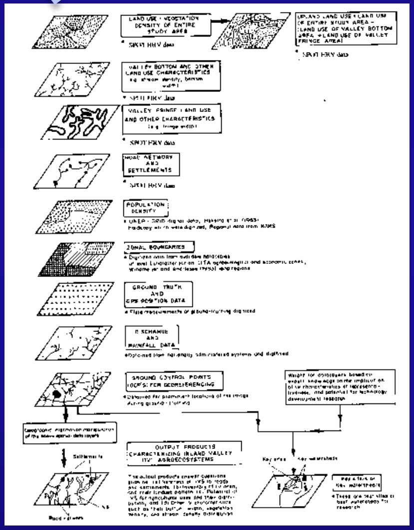
**1a. Biophysical Variables:** Rainfall, ET, LGP, surface water discharge, stream order, slope, vegetation, soil type, soil depth, and soil fertility;

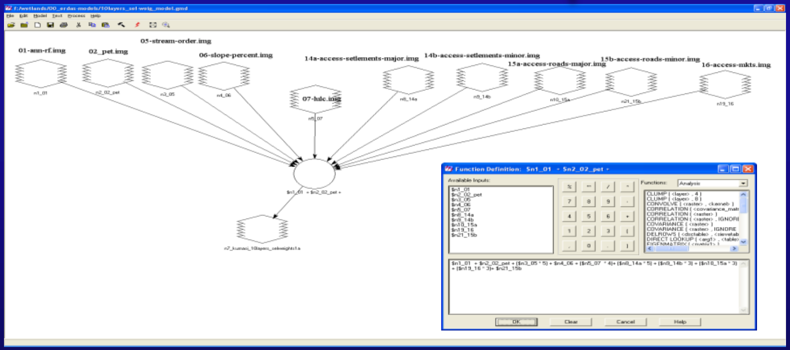
**1b. Technical factors:** agronomic experience, agriculture technology, water management;

**1c. Socio-economic factors:** accessibility settlements, road-network, markets, land tenure, labor force, credit systems, extension system, social customs, gender, rice policy tariff, rice policy subsidy, farmers incentive; and

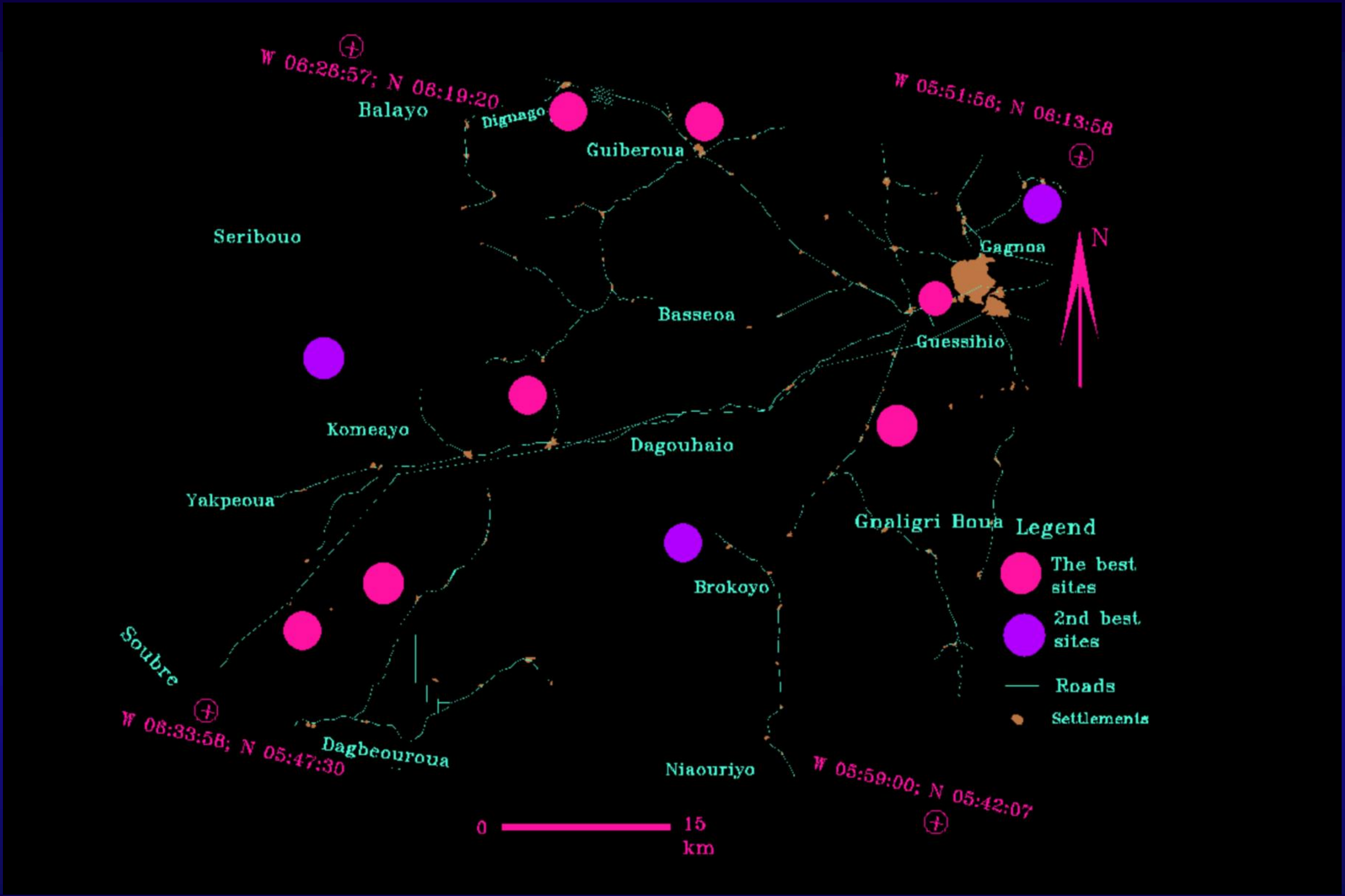
**1d. Eco-environmental factors:** Malaria, Bilhazias, Onchocercasis, species of conservation significance flora and fauna.





# Most Suitable to Least Suitable Areas
## Model results for the Inland Valley wetlands



# Wetland Research in USGS

## Delta Research And Global Observation Network (DRAGON)

Delta Research And Global Observation Network (DRAGON)

# Wetland Research within USGS


The U.S. Geological Survey (USGS) National Wetlands Research Center (NWRC)………..initiated and runs DRAGON……………………………………………………………………………………..

The first DRAGON roundtable meeting was hosted by the USGS National Wetlands Research Center in the fall of 2007.

Most recently the DRAGON Asia Summit was held in Siem Reap, Cambodia, in June 2009.

# Conclusions

# Remote Sensing of Inland Valley Wetlands of Africa

# Conclusions

## 1. Conditions most suitable for green revolution in Africa

- **Area availability:** 8-18 % of geographic area in Africa is IV wetlands;
- **Low cultivation levels:** 7-14 % of the above wetlands are actually cultivated;
- **Rich agroecosystems:** rich soils (fertility and depth), water\moisture availability;
- **Asian experience:** unlike Asia much of IV wetlands un-utilized.

**The above factors make IV wetlands potential land units for green revolution.**

## 2. Conditions most suitable for blue revolution

- **Large proportion of area in low water productivity (WP):** large proportion of world's croplands are in low WP (proven fact). Elsewhere, in the world we have shown an overwhelming proportion (70%) of irrigated croplands are in low WP. It is almost certain the same is true for IV wetlands. This creates an huge opportunity to grow more food from existing allocations of croplands and water.
- **Better WP means "new water":** that can be used for a second crop or expansion of croplands for which water is made available.

**The above factors should help facilitate a blue revolution in Africa.**



# Remote Sensing of Inland Valley Wetlands of Africa
## Conclusions

3. Methods of inland valley wetland mapping, characterization, and classification well established using remote sensing.

4. Most suitable sites for IV wetland cultivation and preservation through spatial modeling developed.

5. Opportunity: We should: (a) produce a wall-to-wall IV wetland map of sub-Saharan Africa (SSA) at sub-meter to 4 meter; and (b) pin-point best areas to: (i) cultivate crops and (ii) preserve environments. This will be of immense benefit to people working on green and blue revolution for Africa.

# Publications

# Remote Sensing of Inland Valley Wetlands of Africa

# Publications


1. Thenkabail P.S., Nolte, C., and Lyon, J.G. 2000a. Remote sensing and GIS modeling for selection of benchmark research area in the inland valley agroecosystems of West and Central Africa. Photogrammetric Engineering and Remote Sensing, Africa Applications Special Issue, 66(6):755-768.

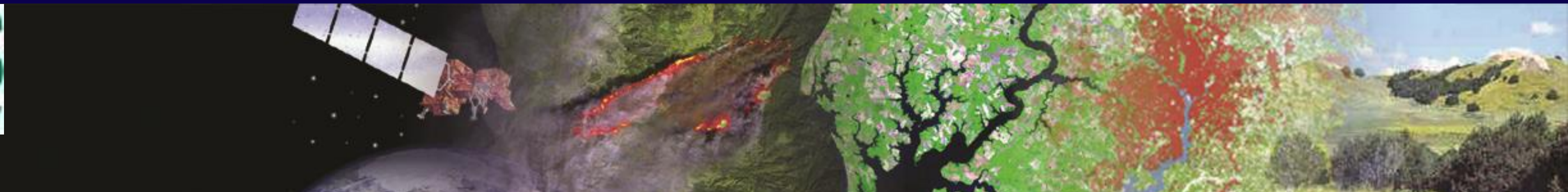
2. Thenkabail S. Prasad, and Nolte, C. 2000. Regional characterisation of inland valley agroecosystems in West and central Africa using high-resolution remotely sensed data. (Book Chapter # 8 Pp. 77-99). in the book entitled: "GIS applications for water resources and watershed management" by John G. Lyon, Pp. 266. Taylor and Francis, London and New York.

3. Islam, Md. A., Thenkabail, P. S., Kulawardhana, R. W., Alankara, R., Gunasinghe, S., Edussriya, C. and Gunawardana, A. 2008. 'Semi-automated methods for mapping wetlands using Landsat ETM+ and SRTM data',International Journal of Remote Sensing,. 29:24,7077 — 7106.

4. Kulawardhana, R. W., Thenkabail, P. S., Vithanage, J., Biradar, C., Islam, Md. A., Gunasinghe, S., Alankara, R. 2007. Evaluation of the Wetland Mapping Methods using Landsat ETM+ and SRTM Data. Journal of Spatial Hydrology (JoSH). 7(2): 62-96. ISSN: 1530-4736.

5. Thenkabail S. Prasad, and Nolte, C. 1996. Capabilities of Landsat-5 Thematic Mapper (TM) data in regional mapping and characterization of inland valley agroecosystems in West Africa. The International Journal of Remote Sensing. 17(8):1505-1538.

6. Thenkabail, Prasad S., and C. Nolte. 1995a. Mapping and Characterising Inland Valley Agroecosystems of West and Central Africa: A Methodology Integrating Remote Sensing, Global Positioning System, and Ground-Truth Data in a Geographic Information Systems Framework. RCMD Monograph No.16, International Institute of Tropical Agriculture, Ibadan, Nigeria. 62 pp.

# Remote Sensing of Inland Valley Wetlands of Africa
# Publications


**7. Thenkabail, Prasad S., and C. Nolte. 1995b. Regional characterisation of inland valley agroecosystems in Save, Bante, Bassila, and Parakou regions in south-central Republic of Benin through integration of remote sensing, global positioning system, and ground-truth data in a geographic information systems framework. Inland Valley Characterisation Report No.1. Resource and Crop Management Division, International Institute of Tropical Agriculture, Ibadan, Nigeria. 60 pp.**

**8. Thenkabail, Prasad S., and C. Nolte 1995c. Regional characterisation of inland valley agroecosystems in Gagnoa, Côte d'Ivoire through integration of remote sensing, global positioning systems, and ground-truth data in a geographic information systems framework. Inland Valley Characterisation Report No.2. Resource and Crop Management Division, International Institute of Tropical Agriculture, Ibadan, Nigeria. 52 pp.**

**9. Thenkabail, Prasad S., and C. Nolte 1995d. Regional Characterisation of Inland Valley Agroecosystems in Sikasso, Mali and Bobo-Dioulasso, Burkina Faso through integration of Remote Sensing, Global Positioning Systems and Ground-Truth Data in a Geographic Information Systems Framework. Inland Valley Characterisation Report No.3. Resource and Crop Management Division, International Institute of Tropical Agriculture, Ibadan, Nigeria. 46 pp.**

**10. Thenkabail Prasad S., and Nolte, C. 1995f. Zooming in on backyard resources. Satellite imagery pinpoints the potential of inland valleys. In the Annual report of International Institute of Tropical Agriculture 1994.**