



***Application of GIS
and Remote Sensing
for Integrated Land Resource
and Land Management Studies***

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Contents

- ✓ Background - Description of INPE
- ✓ Data Integration - Benefits and Challenges
- ✓ Application Examples
- ✓ Conclusions - Some lessons learned in 20 years of Remote Sensing



INPE - brief description

- ✓ National Institute for Space Research
 - » main civilian organization for space activities in Brazil
 - » staff of 1,800 (800 Ms.C. and Ph.D.)
- ✓ Areas of work:
 - » Space Science
 - » Remote Sensing
 - » Meteorology
 - » Space Engineering



Remote Sensing at INPE

- ✓ Landsat Receiving and Processing Station
 - » Operation since 1972
 - » Data from LANDSAT, SPOT, ERS-1, NOAA/AVHRR
- ✓ Remote Sensing Applications
 - » Research and methodology development
 - » Ms.C degree on Remote Sensing (since 1974)
- ✓ Image Processing and GIS
 - » Research and software development
 - » Integrated Image Processing-GIS software



Environmental activities at INPE

- ✓ Numerical Weather Prediction Centre
 - » NEC SX-3 supercomputer (3.2 GFlops)
 - » medium-range forecast and climate studies
- ✓ China-Brazil Earth Resources Satellite
 - » Scheduled for launch in 1996
 - » 6 bands (3 visible, 1 NIR, 2 MIR) at 20 m resol.



Integration Remote Sensing - GIS

“A geographical information system brings together spatial information and places it in a novel context”

“ Remote sensing provides timely and up-to-date information to a GIS which could not be available otherwise”

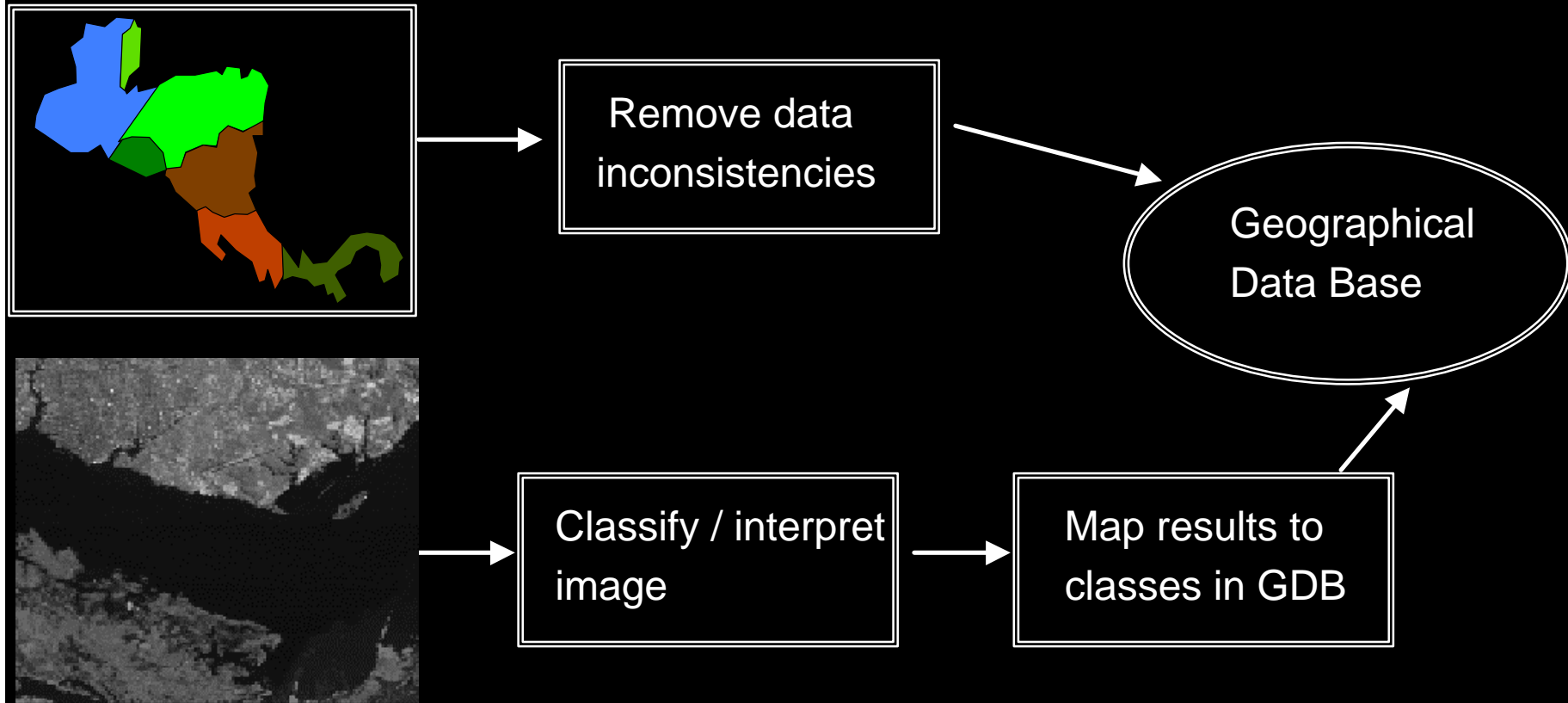


Information Integration and GIS: benefits

- ✓ Interdisciplinary perspective on spatial analysis problems
- ✓ Wider set of spatial operations to data set
- ✓ Combine satellite imagery (up-to-date) with existing data sets



Information integration process



Information integration challenges

- ✓ Coherent methodology for geographical data base definition and handling
- ✓ Removal of data inconsistencies and errors
- ✓ Precise geocoding of satellite imagery
- ✓ Merging of technologies: GIS, Image Processing and Spatial Data Bases



Selected Applications

- ✓ Amazonia deforestation mapping
- ✓ Ecological-economic zoning
- ✓ Land reform and settlement
- ✓ Geological mapping
- ✓ Urban water quality



Amazonia deforestation mapping

- ✓ Legal Amazonia: more than 5 million km²
- ✓ INPE: deforestation assessments since 1988
 - » use of LANDSAT TM and MSS images
 - » comprehensive surveys
- ✓ Objectives:
 - » measurement of yearly rate of deforestation
 - » building a geographical database

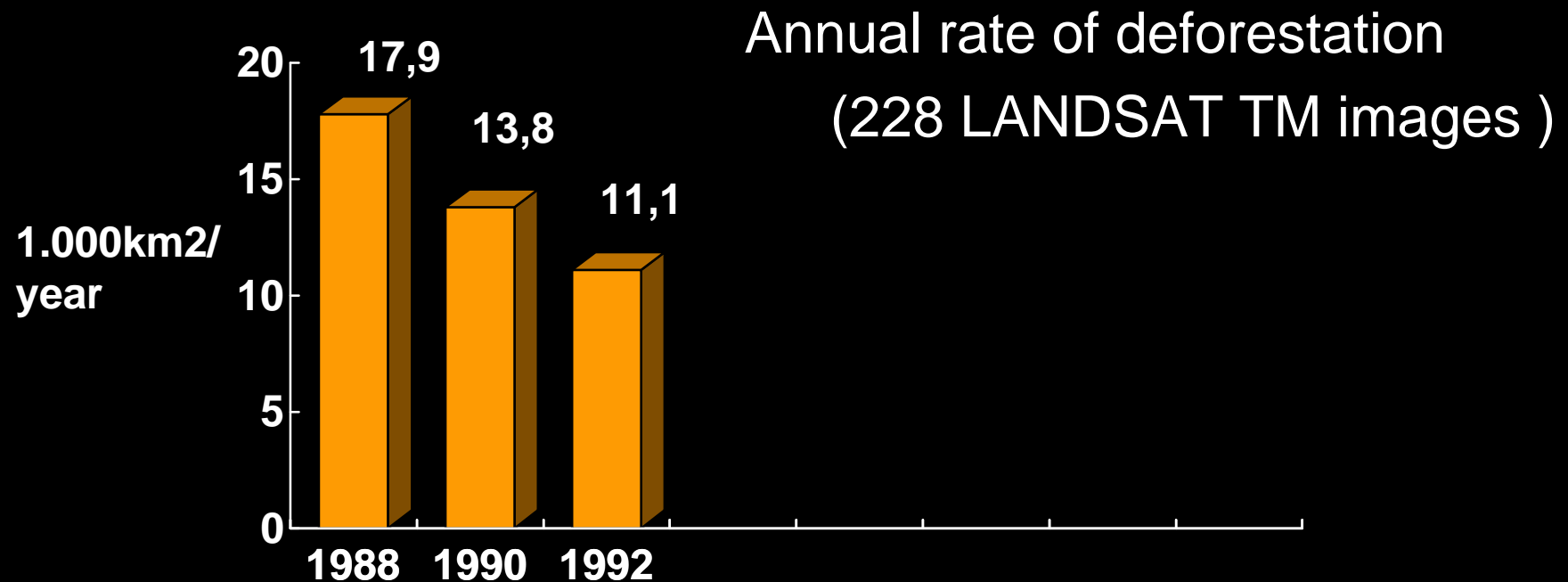


Amazonia deforestation mapping

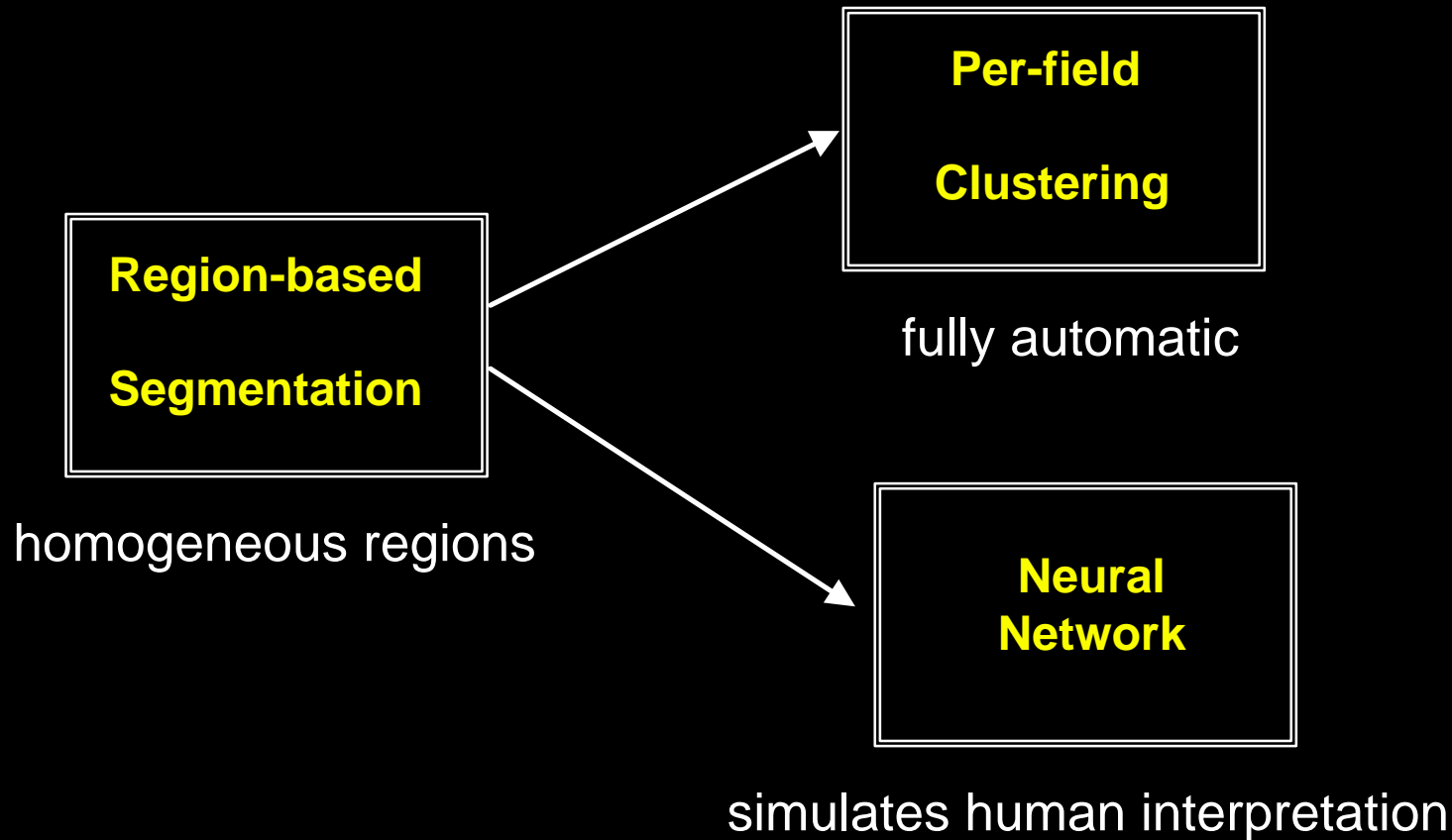
- ✓ Current surveys
 - » manual interpretation
 - » 3 land cover types: forest, non-forest, deforestation
- ✓ Global change surveys and continuous monitoring
 - » require automatic interpretation of images
 - » estimation of re-growth areas



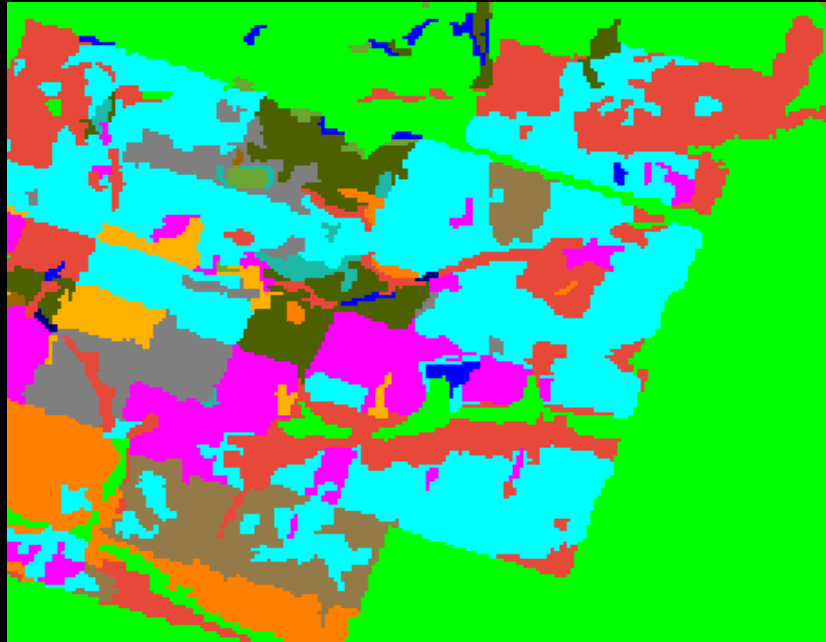
Amazonia deforestation mapping



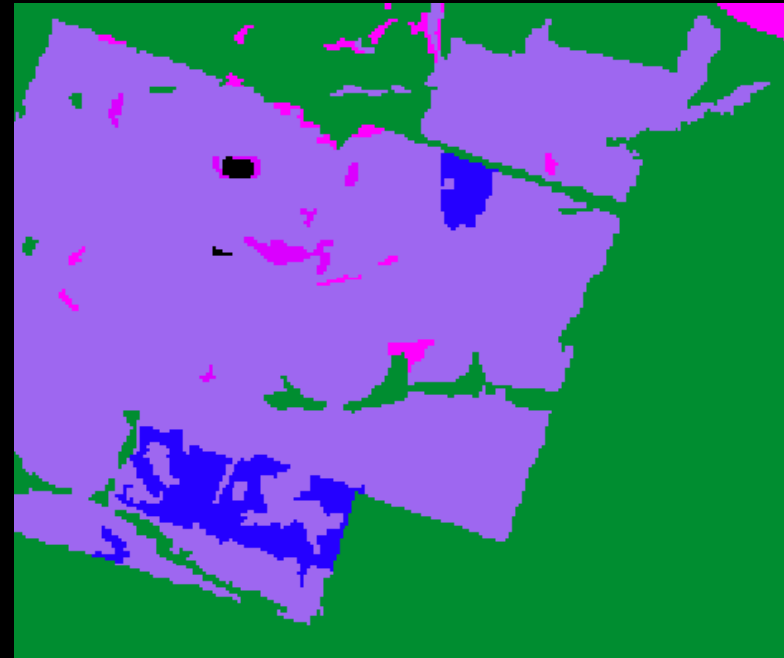
Amazonia deforestation mapping: innovative techniques



Amazonia deforestation mapping



Classified image
(segmentation + neural network)



Deforestation map

Ecological-economical zoning

- ✓ Brazilian Government program
 - » (Secretariat of Strategic Affairs)
- ✓ Objective: indicate regions for economic development
- ✓ Principles: sustainable development (UNCED '92)
- ✓ Zoning of entire brazilian territory (8.5 M km²)
 - » macro scale (1:1,000,000)
 - » detailed scale (1:250,000)



Ecological-economical zoning

- ✓ Sustainable development requires zoning for homogenous regions:
 - » stable, subject to change, undergoing change
- ✓ Zoning is combination of factors:
 - » physical (soils, geomorphology, vegetation)
 - » social and economic (human actions)
- ✓ Remote sensing: valuable input
 - » timely information source
 - » homogeneous regions delineation

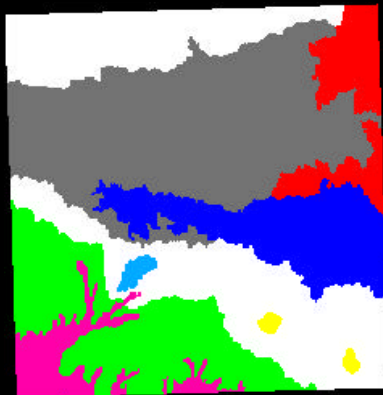


Zoneamento Ecológico-Econômico

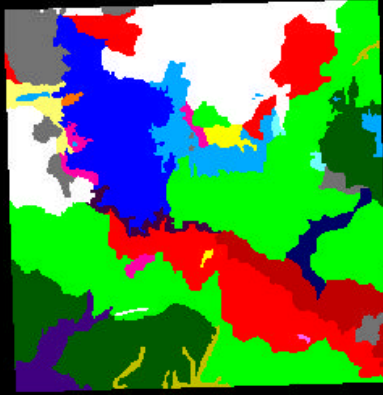
DIAGNÓSTICO AMBIENTAL E SÓCIO-ECONÔMICO

Exemplo: Carta de Vulnerabilidade

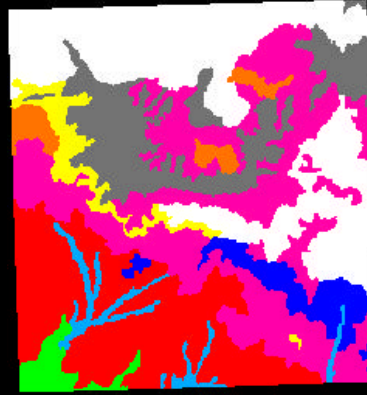
geologia



geomorfologia



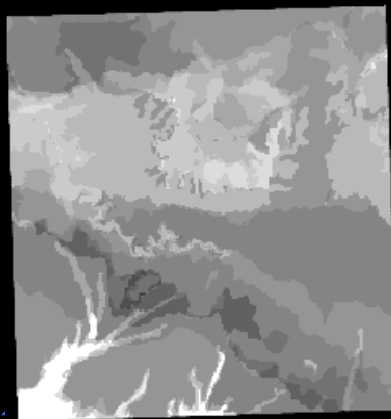
pedologia



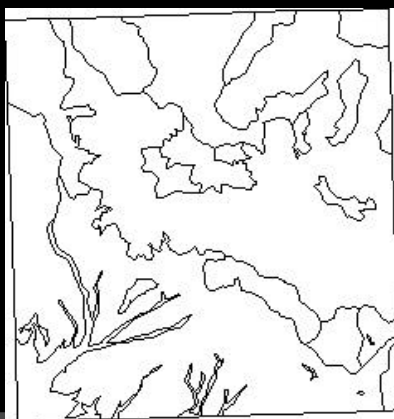
vegetação



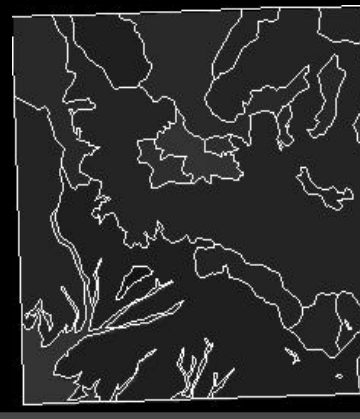
média



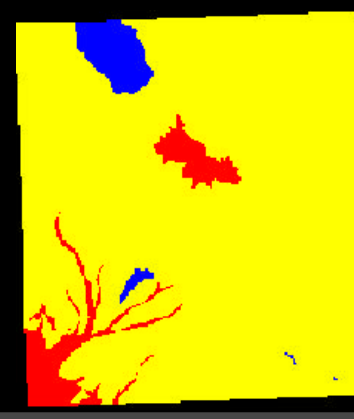
UTB



media zonal



vulnerabilidade

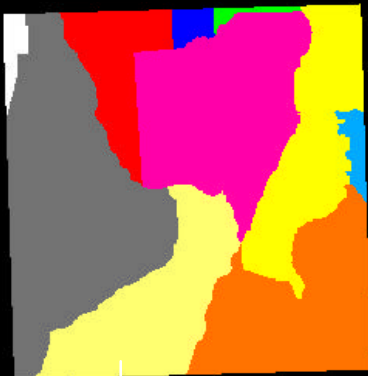


Zoneamento Ecológico-Econômico

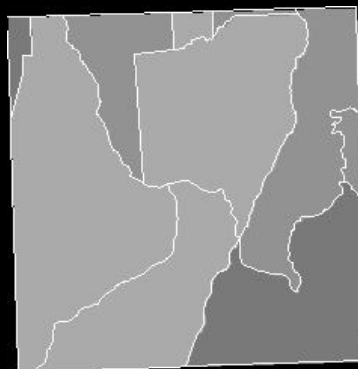
DIAGNÓSTICO AMBIENTAL E SÓCIO-ECONÔMICO

Exemplo: Carta de Potencialidade Social e Econômica

municípios



media zonal



potenc. soc. econ.



Land reform and settlement

- ✓ Land reform is a major issue in Brazil
- ✓ Enormous social pressure
- ✓ Constitution assures right for government to confiscate “non-productive” land and distribute it
- ✓ Problem: how to establish land status ?
 - » satellite images show land use evolution

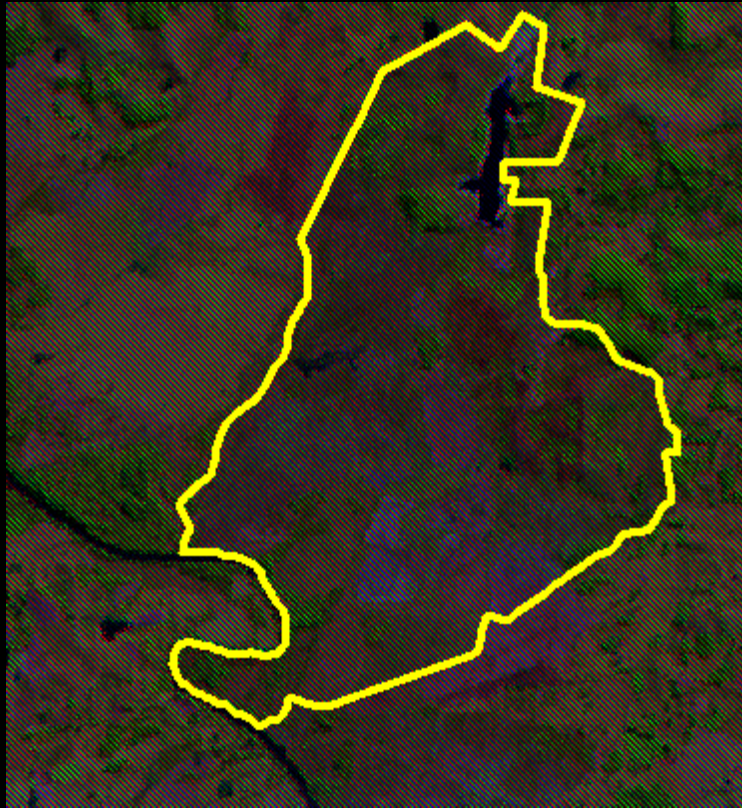


Land reform and settlement

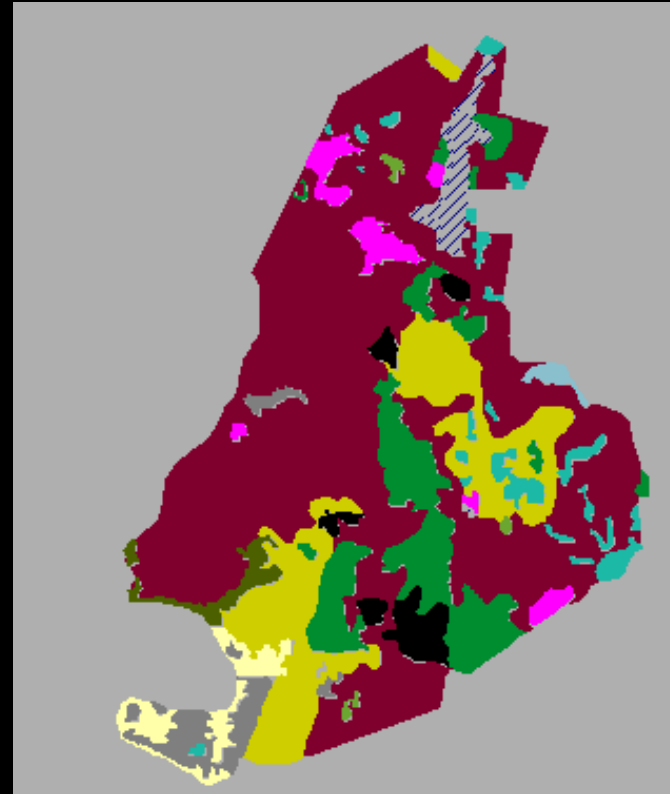
- ✓ Brazil's Institute for Colonization and Land Reform
 - » rural cadastral survey of medium-large properties
 - » integration to GIS in process
- ✓ Satellite imagery: essential component
 - » multi-temporal evolution of farms



Land Reform Applications



Landsat TM - 1988

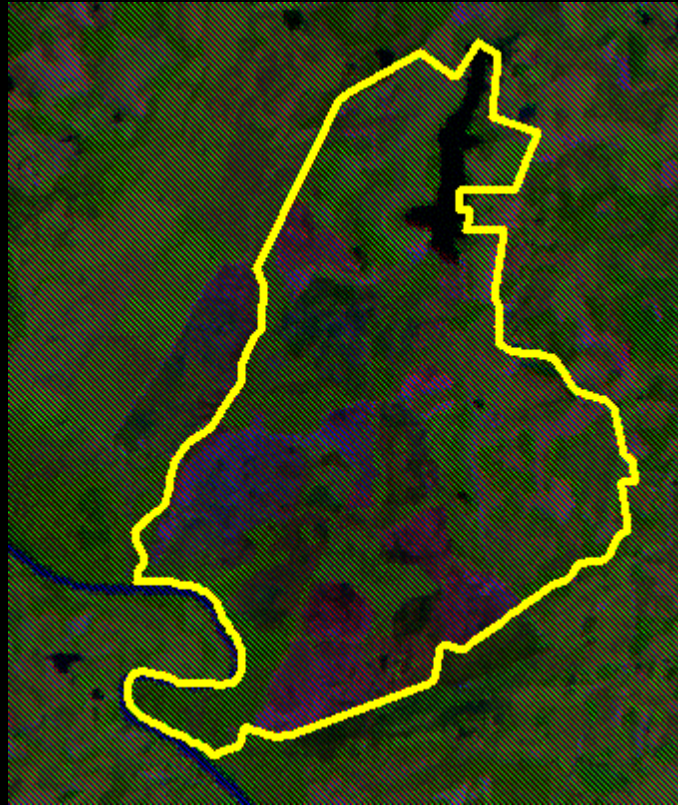


Land Use Map 1988

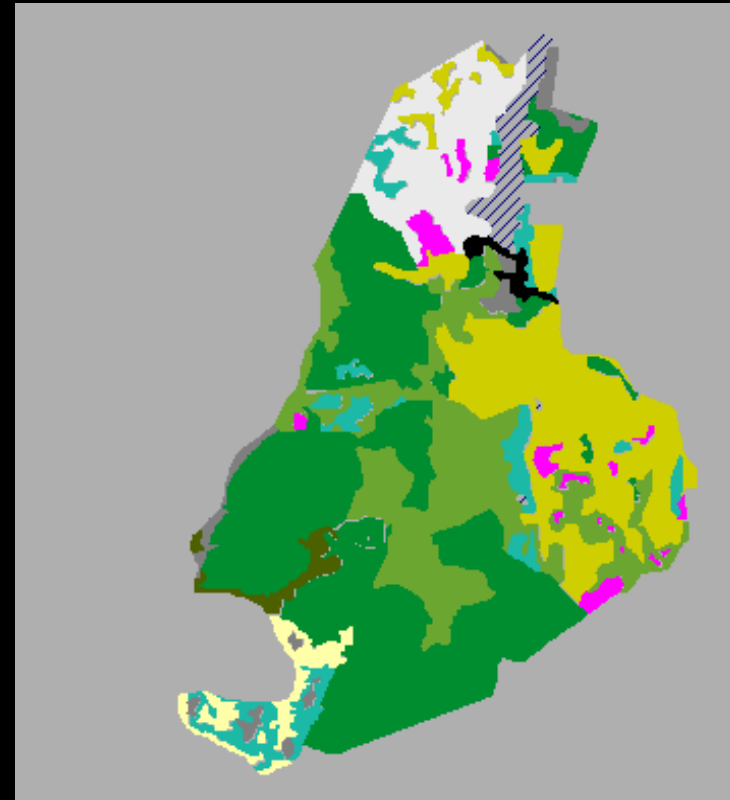
■ non-productive land



Land Reform Applications



Landsat TM - 1993



Land Use Map 1993

 agriculture

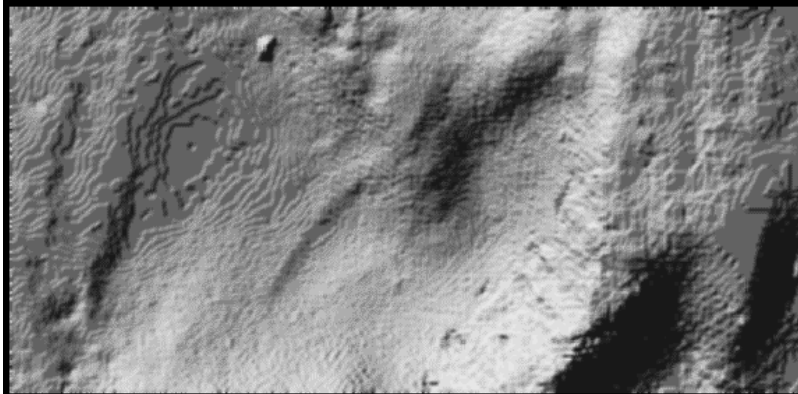


Geological mapping

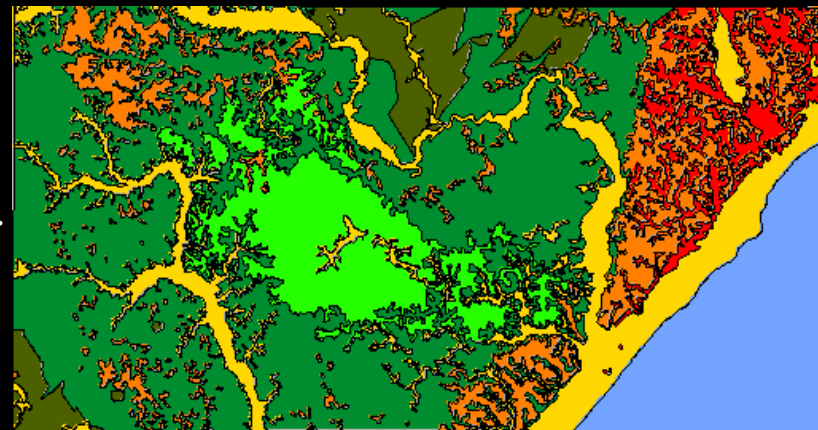
- ✓ GIS: integration of geophysical and geological data
- ✓ Remote sensing imagery
 - » visible/infra-red: geo-botanical anomalies
 - » radar: structural analysis of data
- ✓ Data fusion and visualisation techniques



Geological Mapping

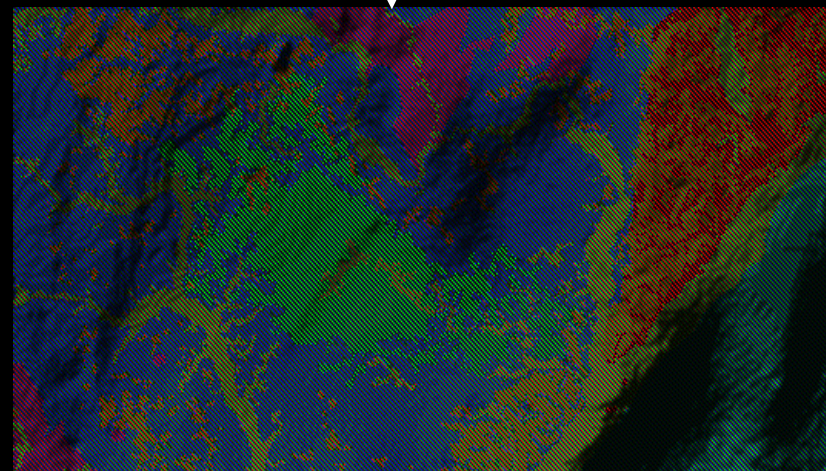


Geophysical data



Geological map

Data fusion

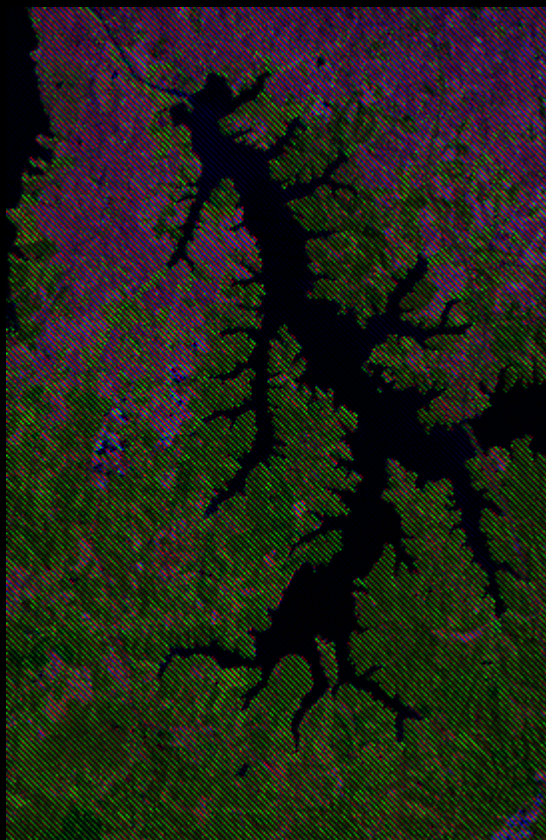


Urban water reservoir monitoring

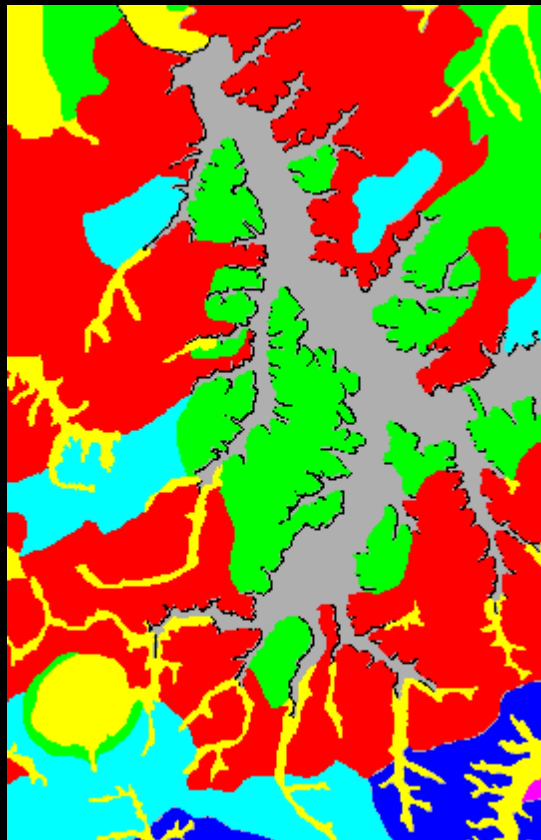
- ✓ São Paulo metropolitan area: 11,000,000 people
- ✓ Water reservoirs: protected under law
 - » monitoring of illegal constructions
 - » measurement of water quality and pollution
- ✓ Billings reservoir: provides water for 30% of city
 - » assessment to determine critical areas



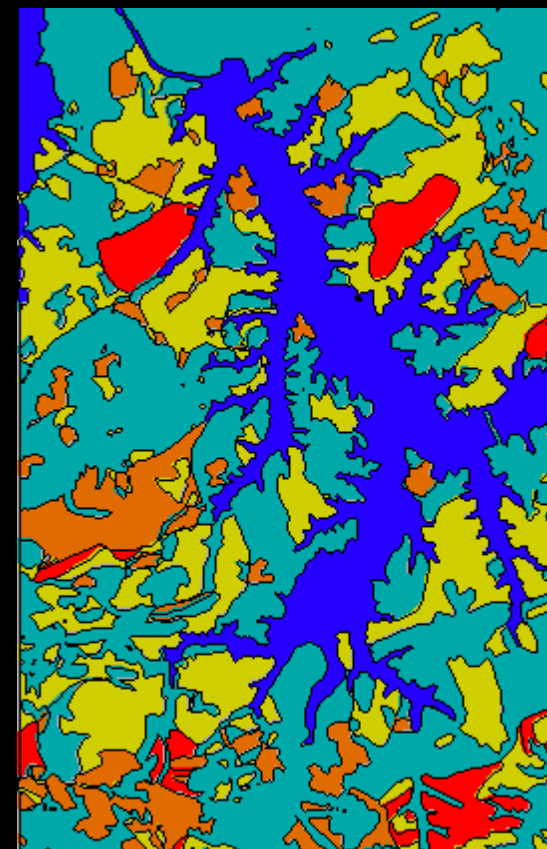
Urban water reservoir monitoring



LANDSAT TM-1993



Geomorphology



Critical areas map

 very critical

INPE's approach to integration of GIS and Remote Sensing

- ✓ Technological development
 - » advanced software for data handling
 - » combine GIS, Image Processing and Spatial data base
- ✓ Research work
 - » production of skilled specialists
 - » emphasis on high-level training (e.g. Ms.C.)
- ✓ Synergy among R & D personnel



SPRING's User Interface

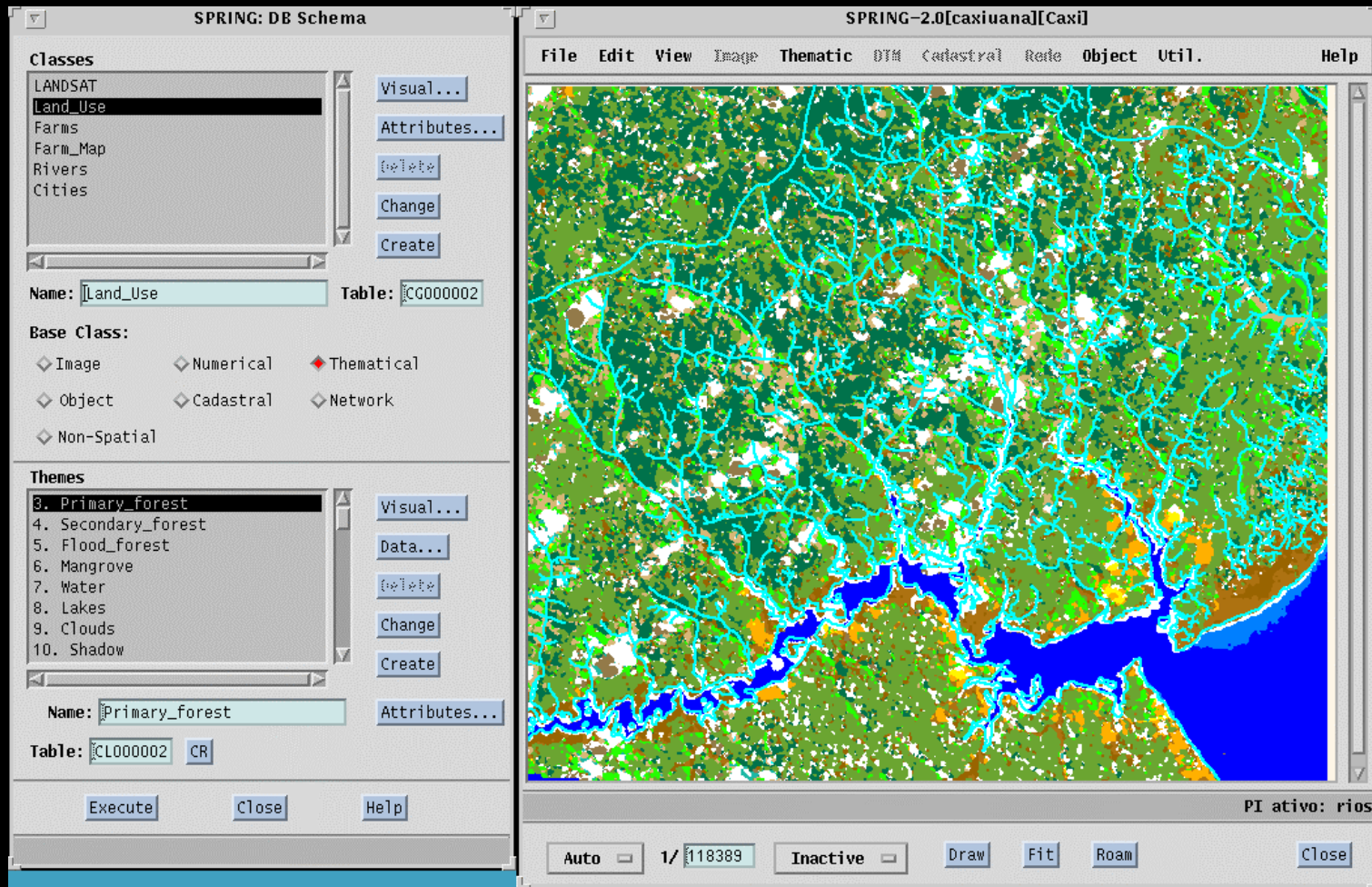


Image Segmentation

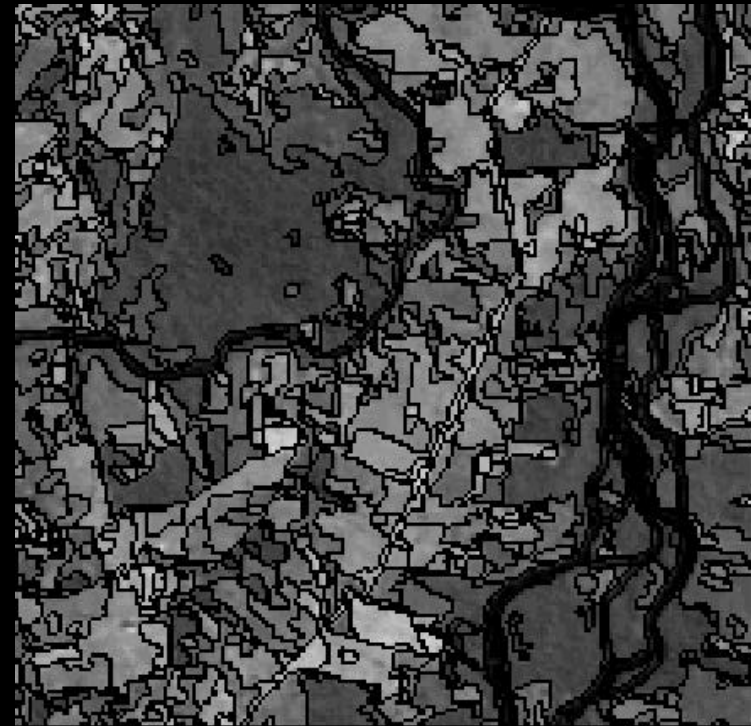
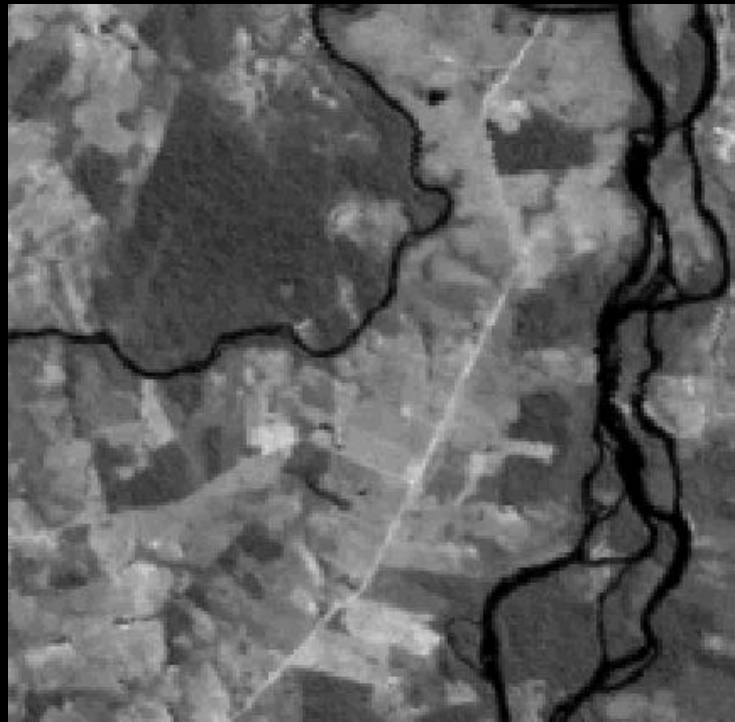


Image Restoration



Some lessons learned in 20 years of Remote Sensing

- ✓ Importance of data receiving/processing stations
 - » direct access to satellite imagery
- ✓ Emphasis on applied research
 - » graduate program as a important basis for establishing local expertise
- ✓ Technological development helps effective use
 - » “GIS software is ahead of users”



Some lessons learned in 20 years of remote sensing

“The build-up of skilled local experts is a fundamental and necessary step for effective use of GIS and Remote Sensing technologies”

“ UN, World Bank and related financing organizations should consider giving priority to actions where local research and development work is involved”

