Investigating land-use/cover changes along the East-West Economic Corridor in Vietnam, Laos, and Thailand

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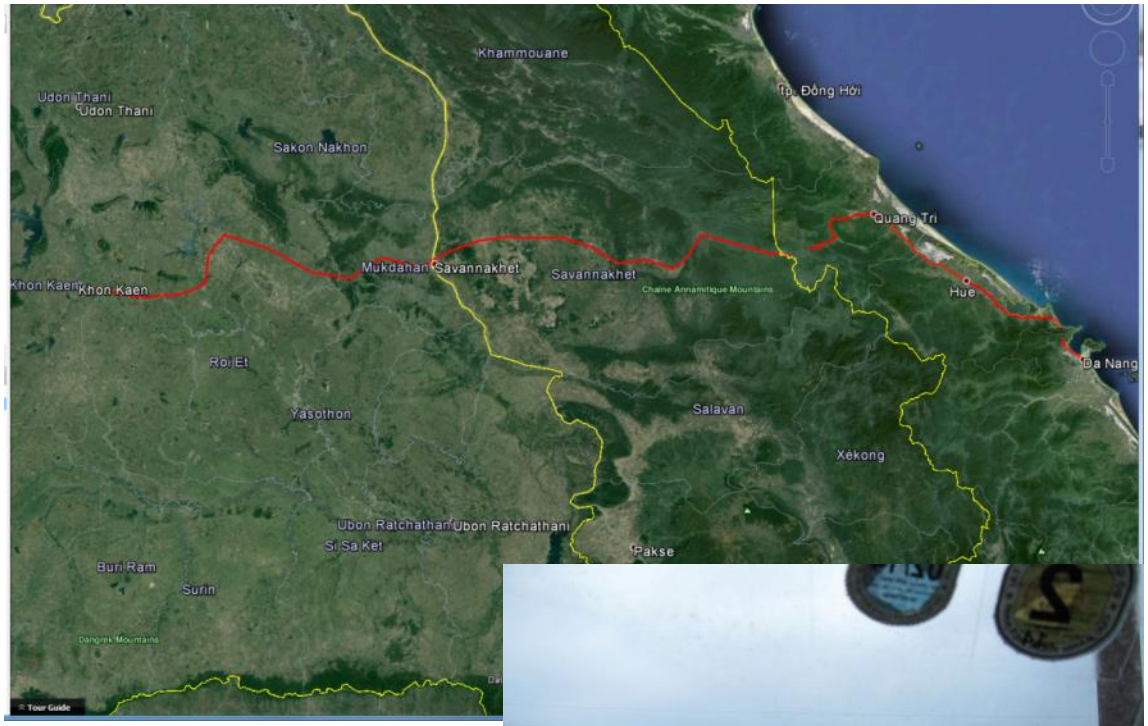
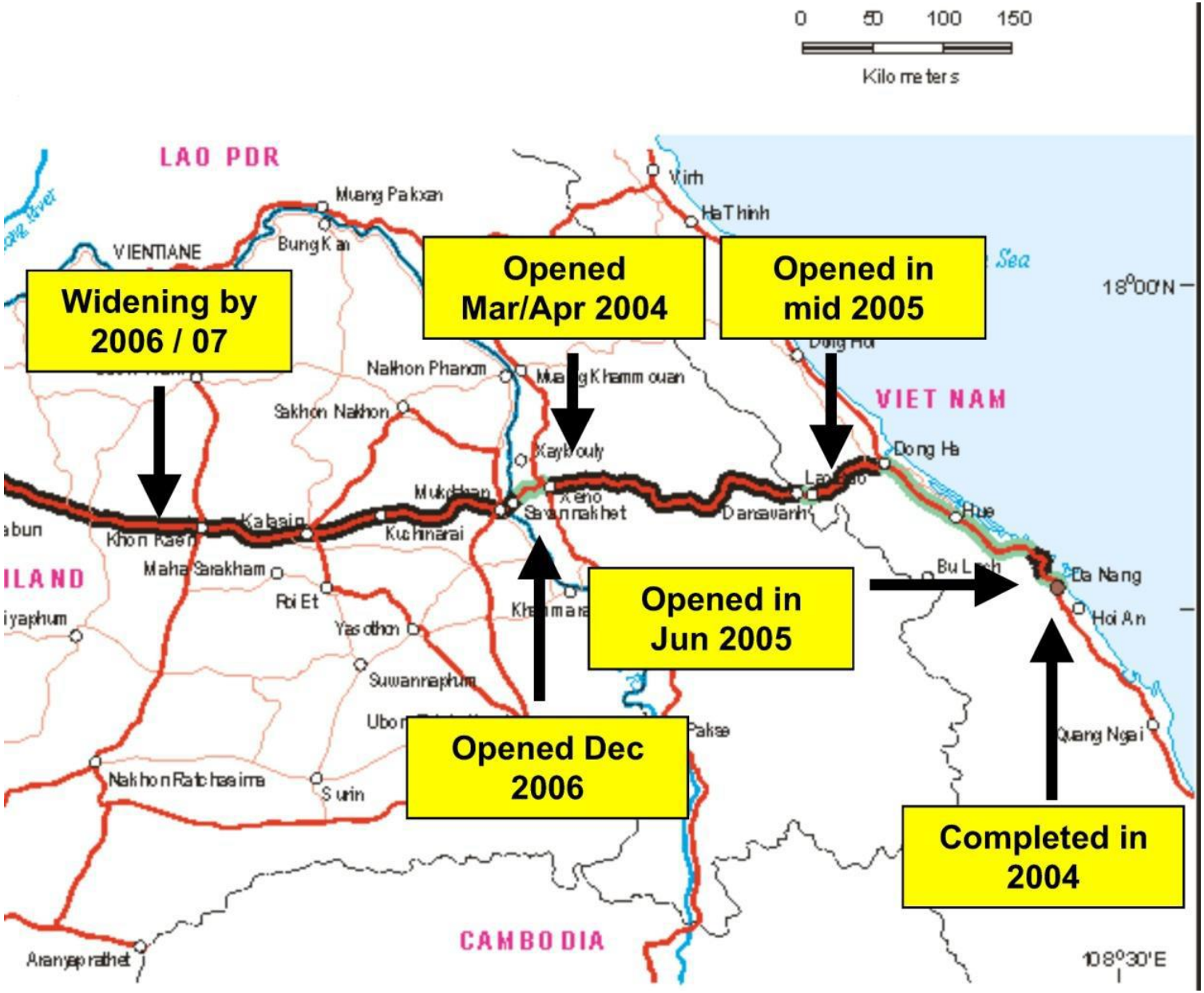
Objective

- Research question: what, if any, is the impact of improved transportation routes on land-use/land-cover change in the EWEC?
  - Have rural and urban land-use/cover changes taken place within the corridor?
    - What are the drivers of these changes?
  - Has urban expansion/urbanization taken place? What is the nature of urbanization (extension of already urban areas, infilling, or rural urbanization)?
    - What are the drivers of these changes?
  - Are cross-border “teleconnections” evident in the corridor? What are they? Are they related to roads or other types of connectivity?

Study Area:
The East West Economic Corridor from Khon Kaen, Thailand to Da Nang, Vietnam

- Initiated in 1992 as part of ASEAN Free Trade Area
- Objective: improve the regions connectivity and key sectors of the economy through improving the transportation infrastructure
- Funded by ADB, Japan, local countries




0 50 100 150
Kilometers
LAO PDR
VIENTIANE
Muang Pakxan
Bung Kan
Nakhon Phanom
Sakhon Nakhon
Khon Kaen
Kalasin
Kuchinarai
Maha Sarakham
Roi Et
Yasothon
Suwannaphum
Nakhon Ratchasima
Surin
Aranyaprathet
CAMBODIA
Vinh
Ha Thinh
Sea
18°00'N
VIET NAM
Dong Ha
Hue
Da Nang
Hoi An
Quang Ngai
108°30'E
Widening by 2006 / 07
Opened Mar/Apr 2004
Opened in mid 2005
Opened in Jun 2005
Opened Dec 2006
Completed in 2004

Background – conditions in the EWEC

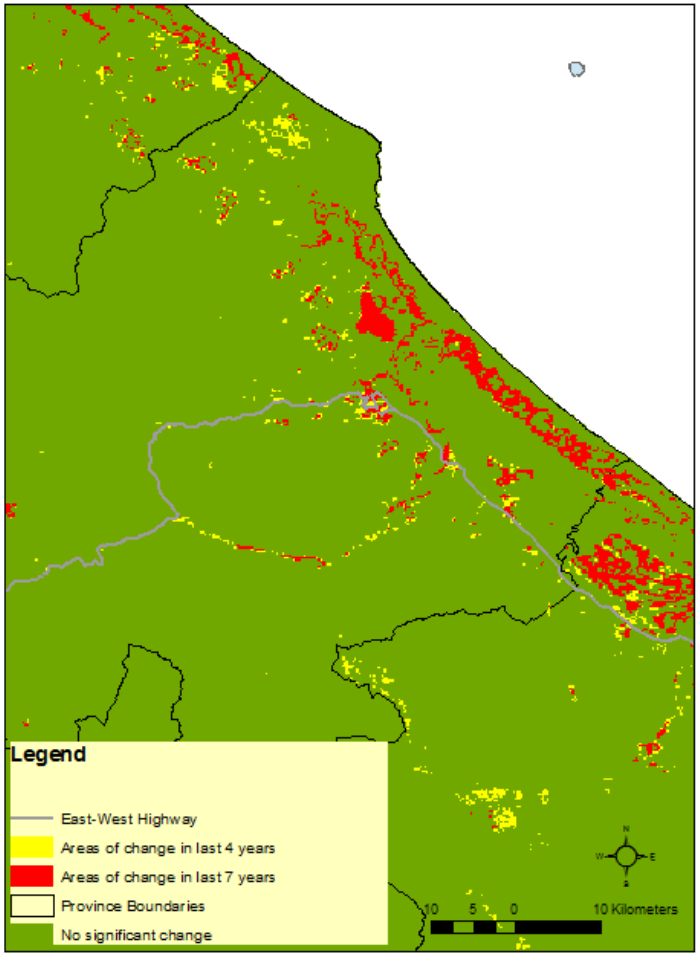
- Central Vietnam
  - Poorest region of the country
  - Two historical urban areas (Da Nang, Hue)
- Southern Laos
  - One of poorest regions of Laos
  - Largest Province
  - One urban area (Savannakhet)
- Northeast Thailand
  - Poorest region of Thailand
  - Poor agricultural potential
  - Not well connected to capitol
  - Largest urban area is Khon Kaen

Methods

- Fieldwork
  - Ground truth data collection
  - Interviews with province and district officials
    - Targeted interviews
    - Impact of EWEC from their perspective
    - Recent changes – drivers of those changes from their perspective
  - Village/commune level research
    - Focus group interviews
    - Semi-structured interviews
    - Random sample of households (n=30)
    - Transects
    - Livelihood systems
    - Recent changes
- Land-use/cover change analysis
  - Hypertemporal analysis of 212 scenes MODIS EVI data from 2002 to 2014 to identify areas of recent change – (Kmeans unsupervised clustering, analysis of change in harmonic signature)
  - Landsat multi-date analysis:
    - Stacked NDVIs (1986 – present) (unsupervised clustering)
    - Individual NDVI image thresholding
    - Year-to-year change
    - Identify details of recent changes
    - Longer change trends (1986 to present)
  - High resolution image analysis
    - Ground truth for medium resolution data
    - Evidence to support changes

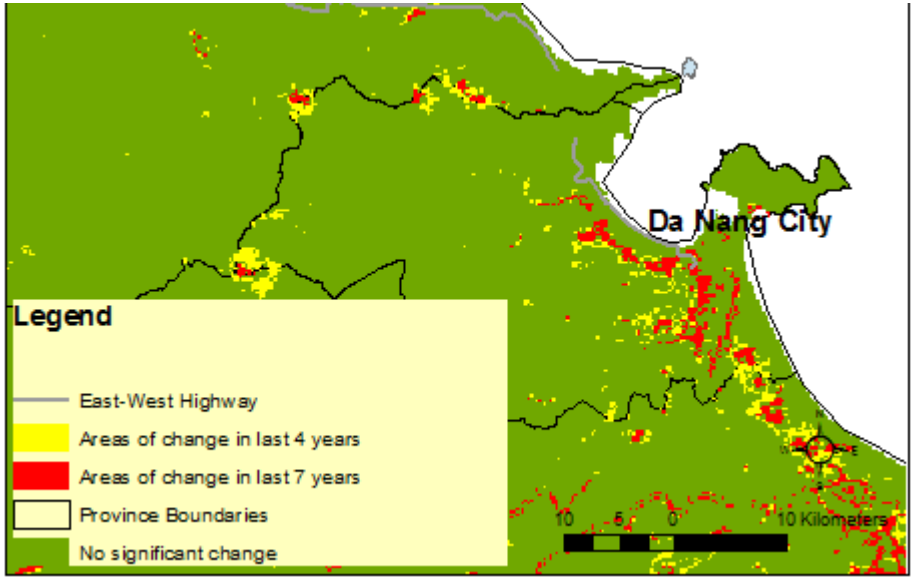
Results: Vietnam

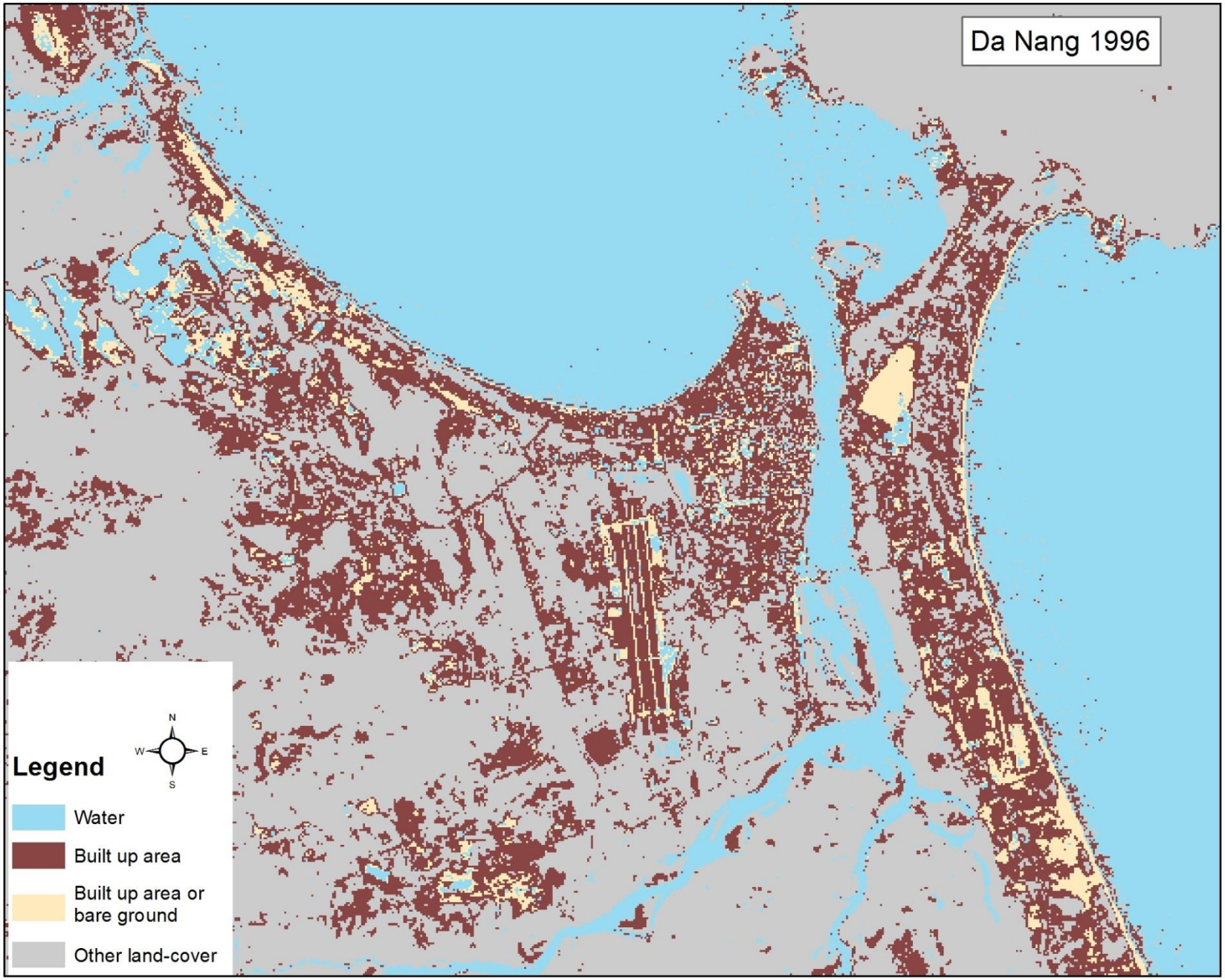
- Hypertemporal analysis
  - Identified areas of change
  - Evidence of urban infilling and expansion from 2006 to 2014
  - Evidence of rural land cover changes 2006 to 2014
- Cluster busting is being done to further investigate areas

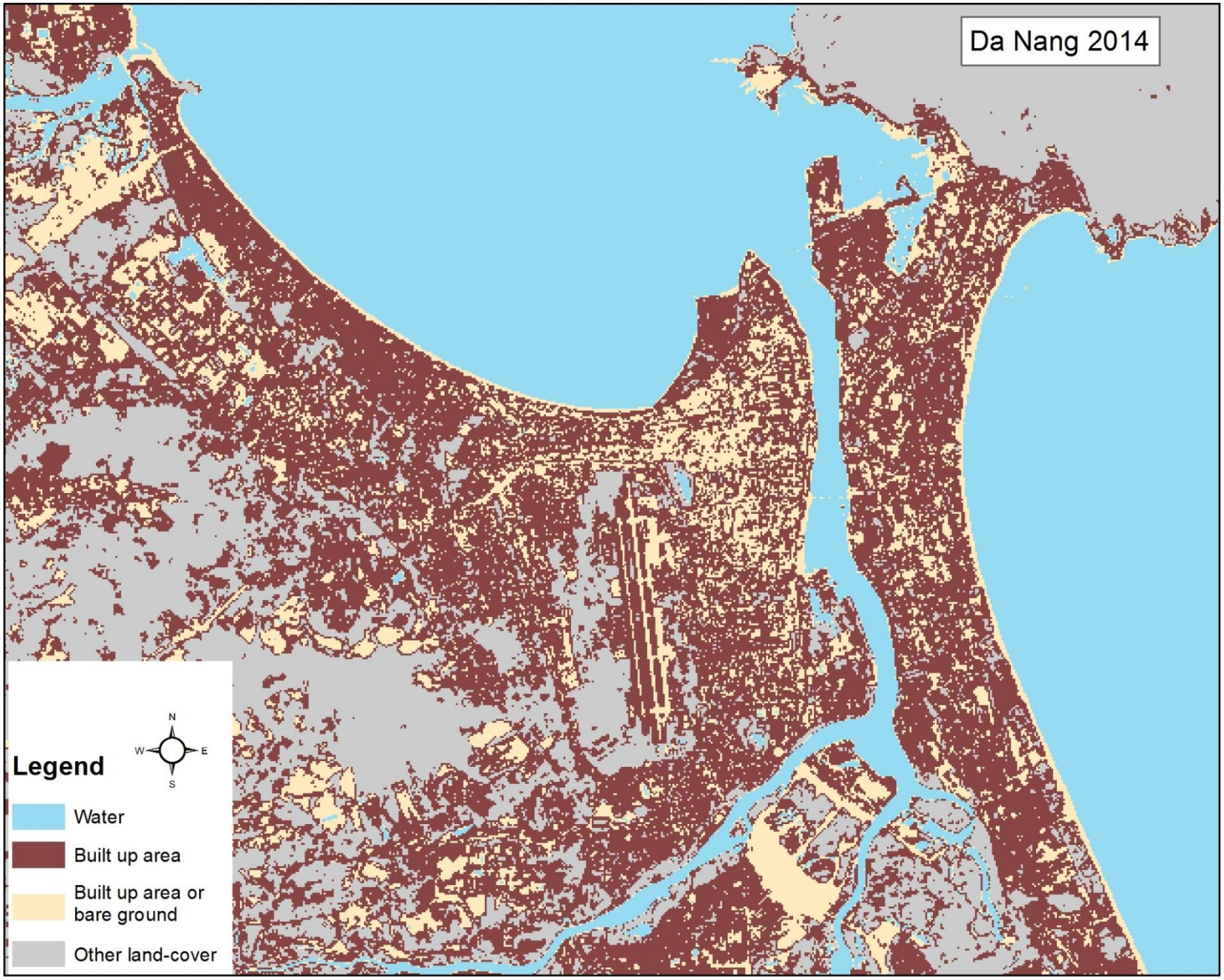


Urban Areas in Vietnam

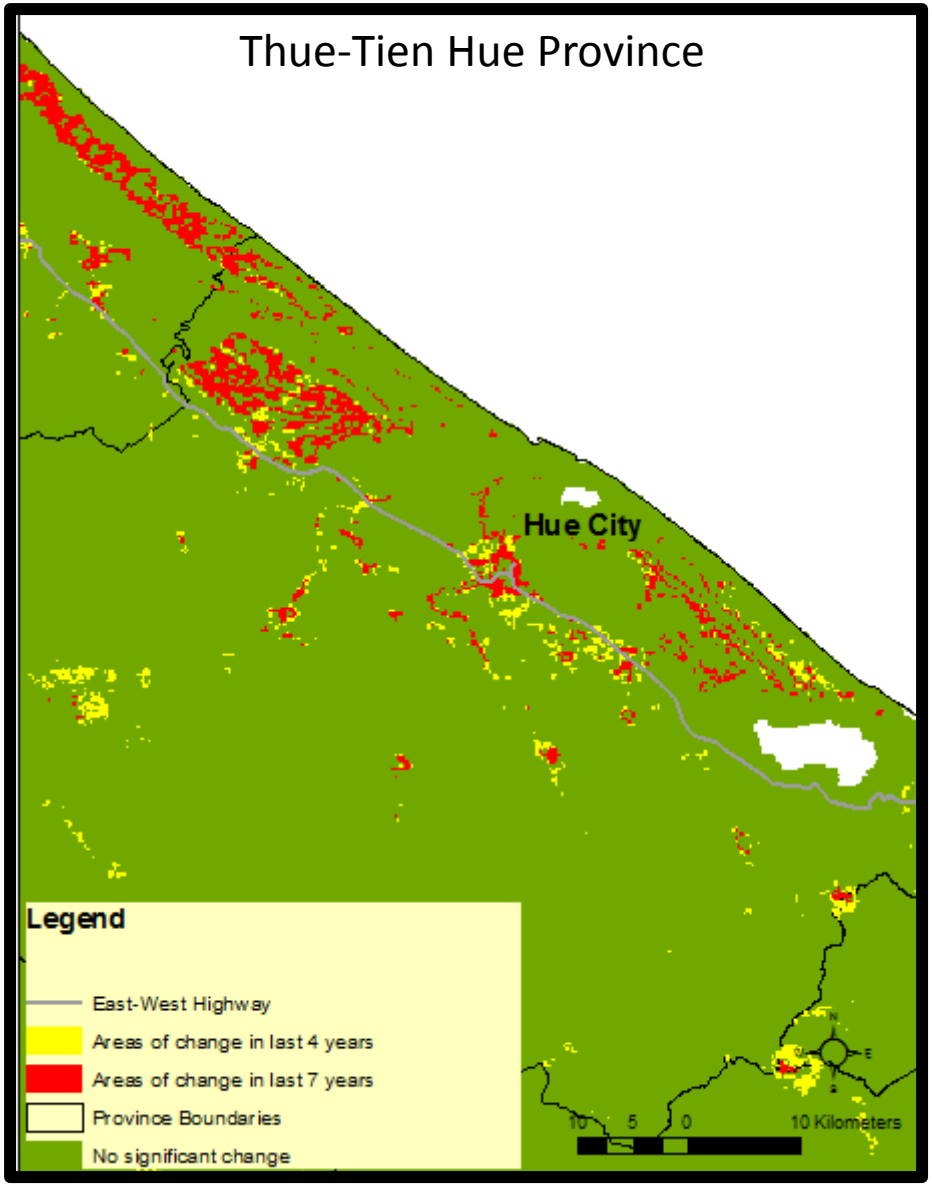
- Da Nang
  - Expansion of residential areas
  - Infilling of urban areas
  - New industrial zones
  - Only 2 rural districts left in the Da Nang area

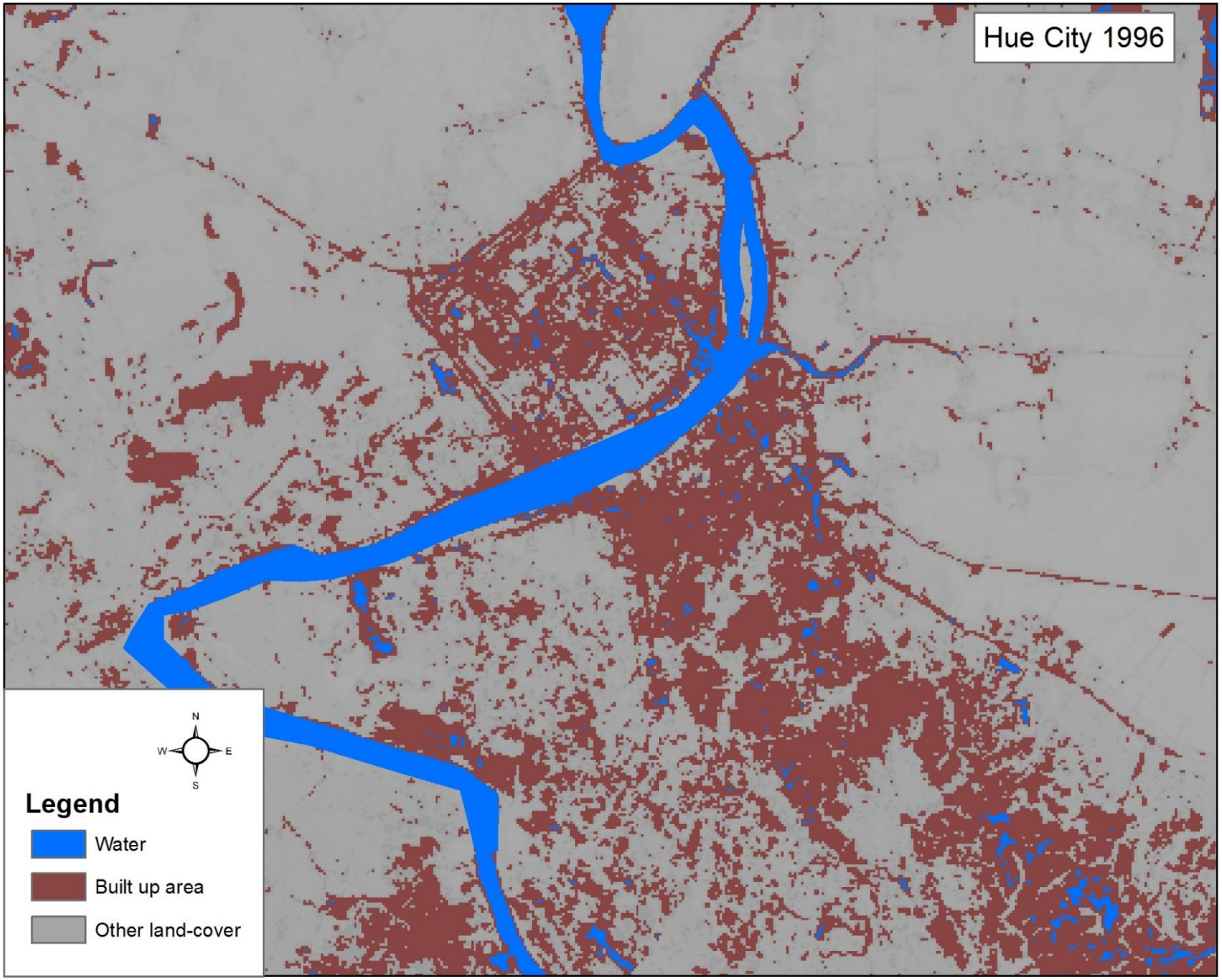


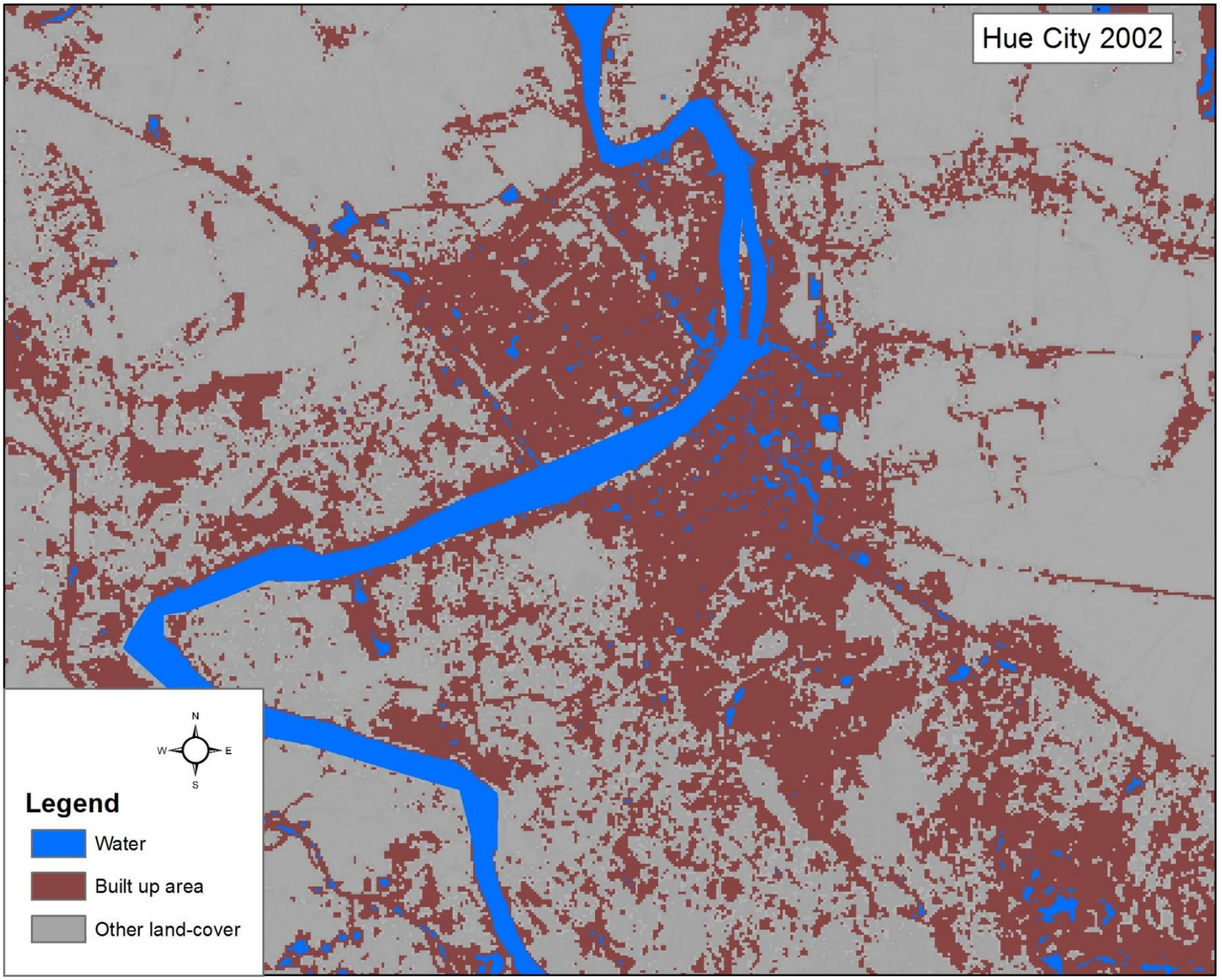

Da Nang 1996
Legend
N
W
E
S
Water
Built up area
Built up area or bare ground
Other land-cover

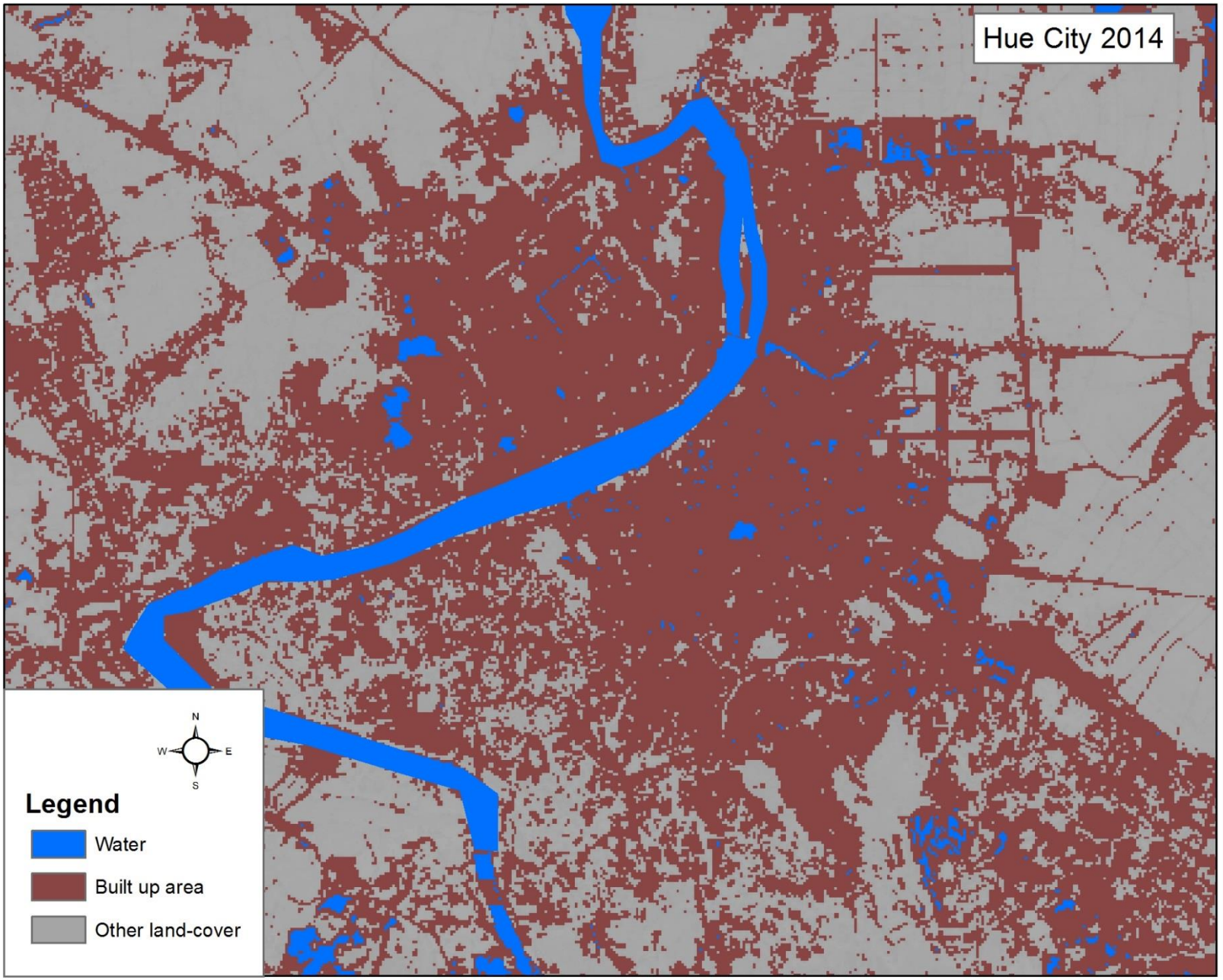

Da Nang 2014
Legend
N
W
E
S
Water
Built up area
Built up area or bare ground
Other land-cover

- Hue
  - Urban growth in last decade
  - Infilling of urban areas
  - Expansion of city to southeast and northwest

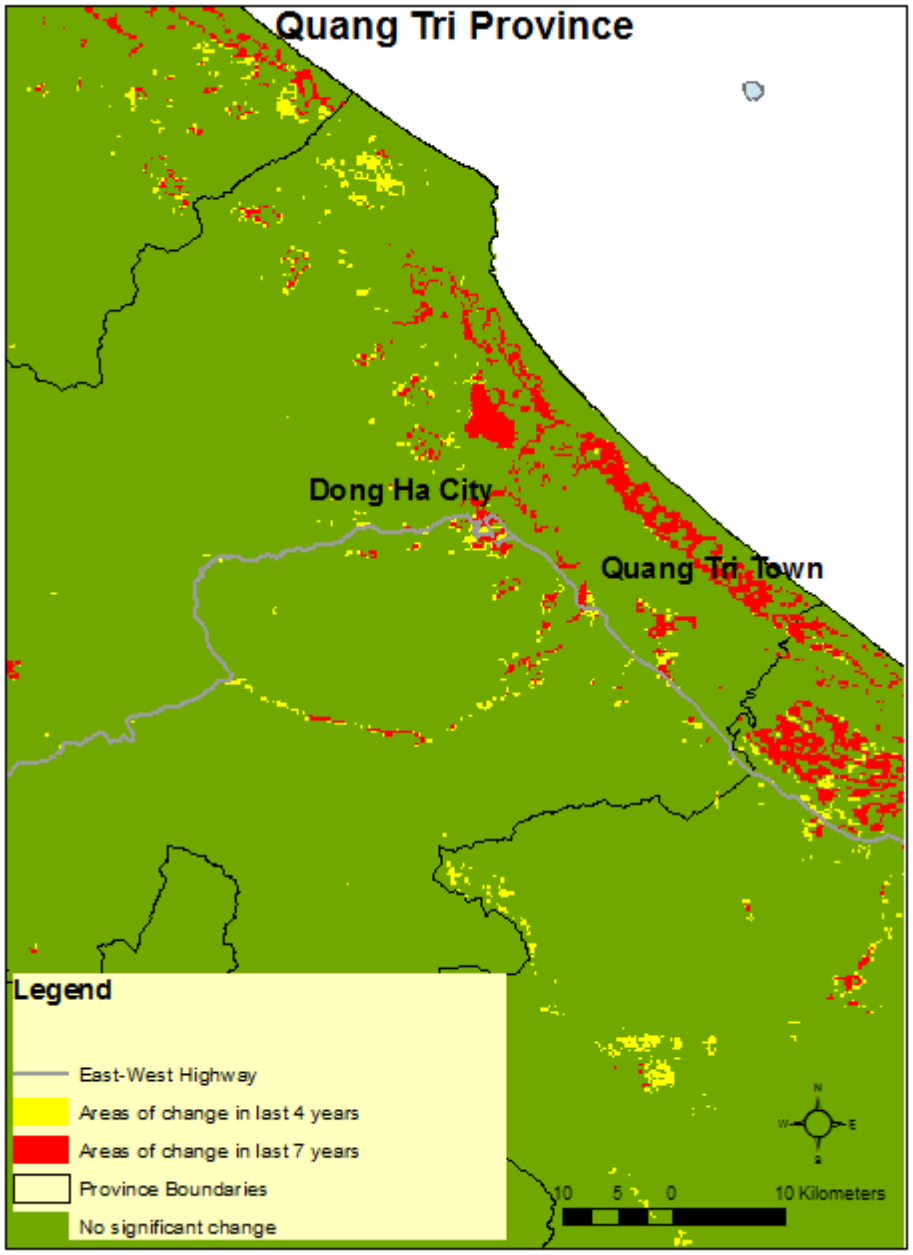


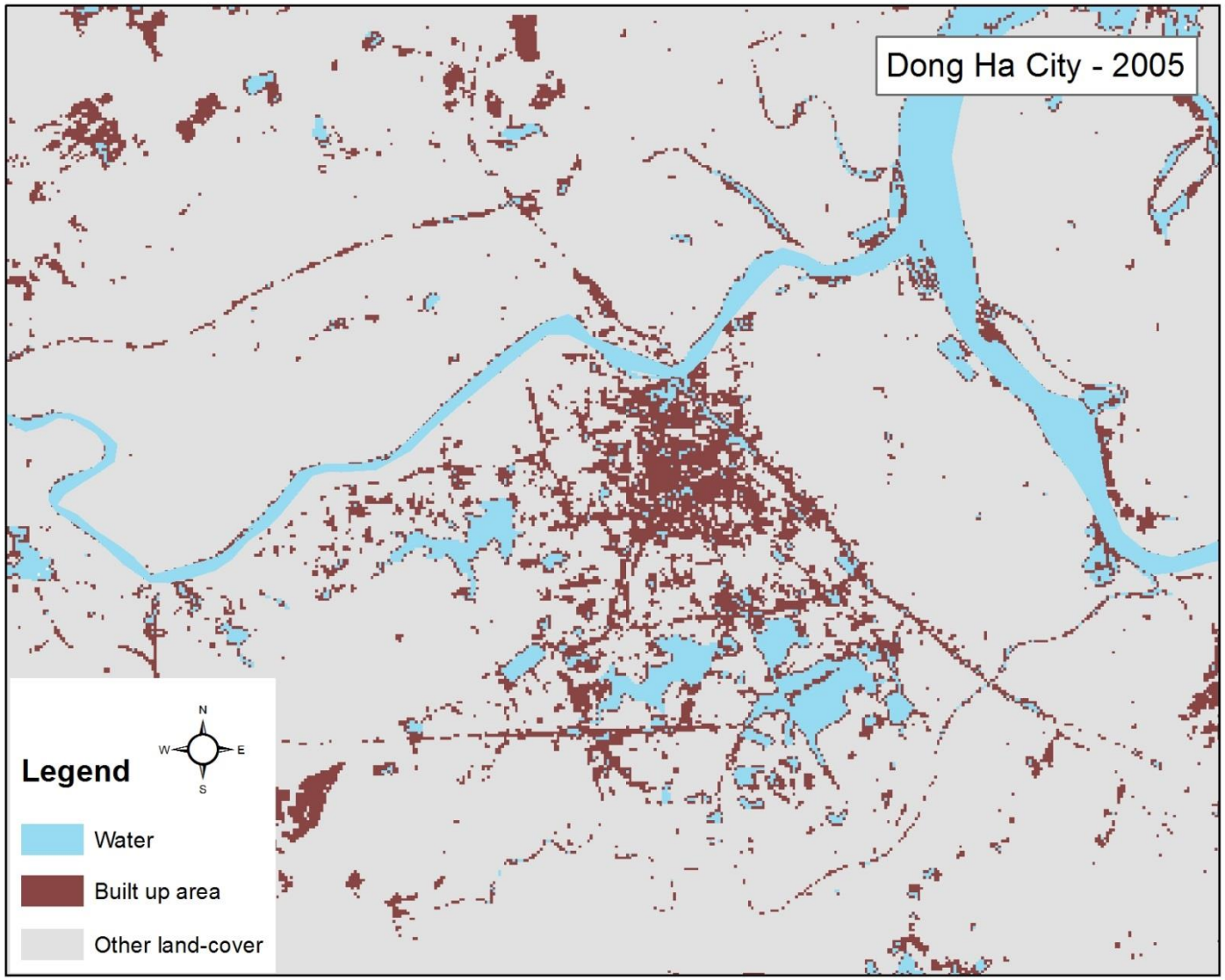

Hue City 1996
N
W
E
S
Legend
Water
Built up area
Other land-cover

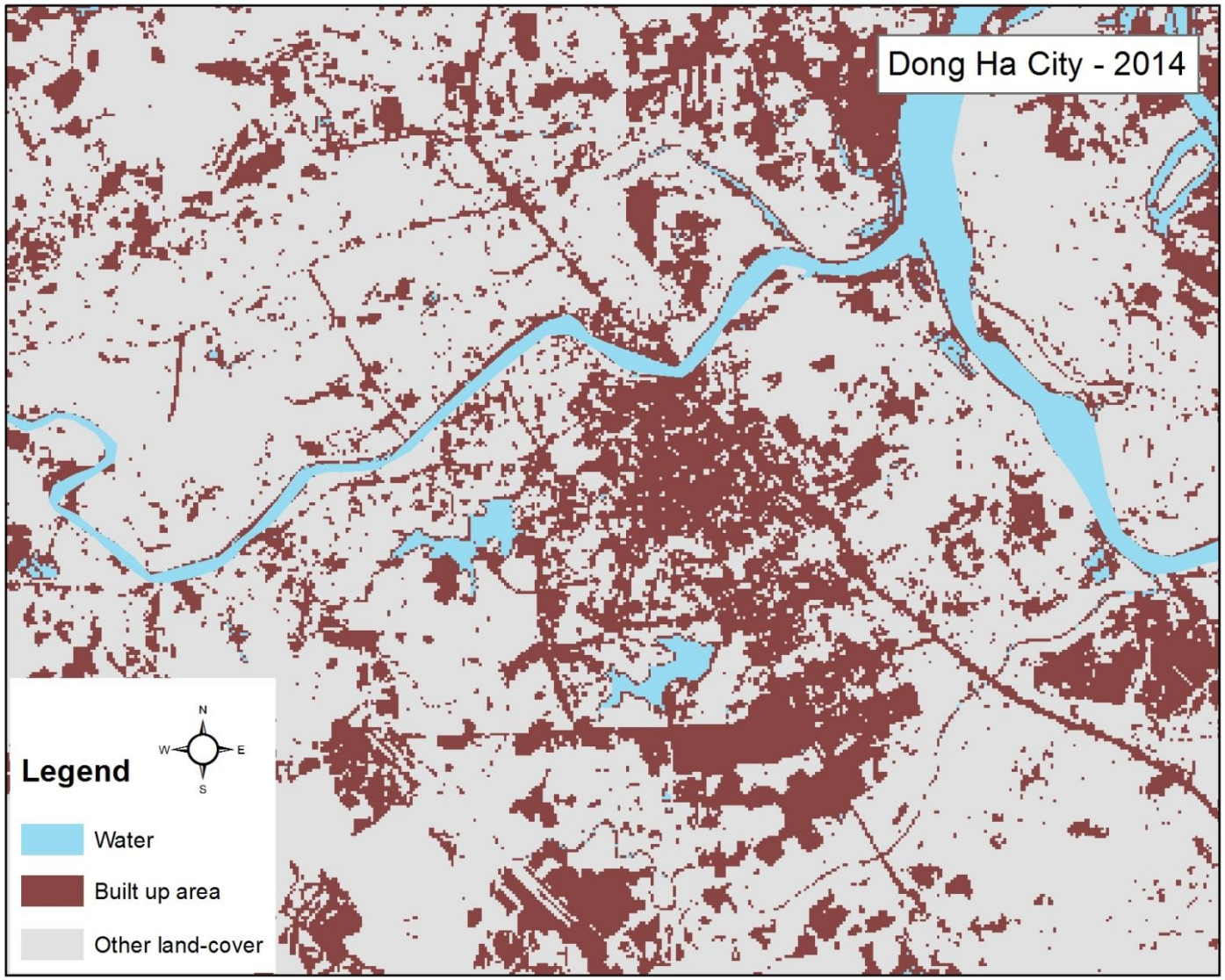

Hue City 2002
N
W
E
S
Legend
Water
Built up area
Other land-cover


Hue City 2014
N
W
E
S
Legend
Water
Built up area
Other land-cover

- Dong Ha, Quang Tri Province
  - Dong Ha newly constructed in last 20 years
  - Extension of city to south (industrial zones)
  - Some infilling (residential)




Dong Ha City - 2005
Legend
N
W
E
S
Water
Built up area
Other land-cover

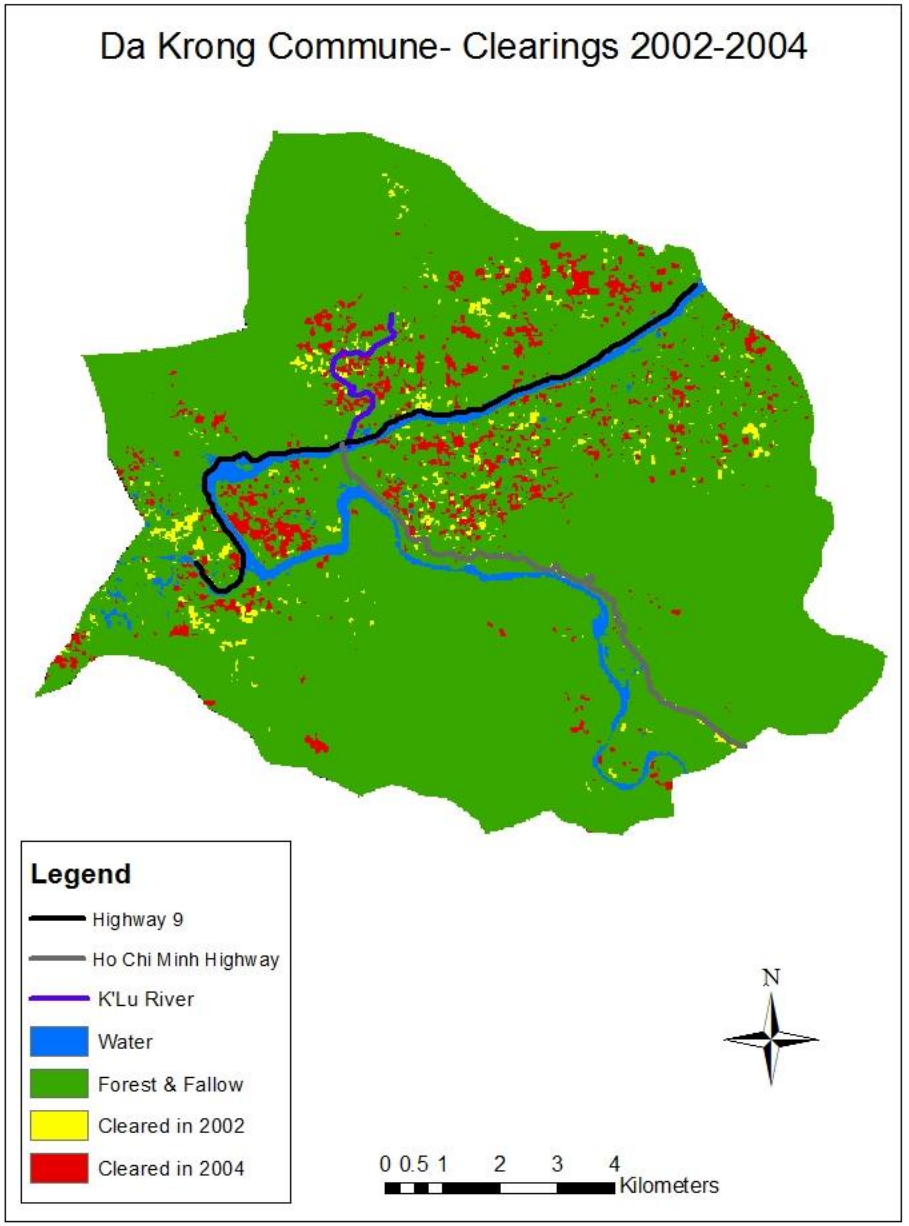

Dong Ha City - 2014
Legend
N
W
E
S
Water
Built up area
Other land-cover

Changes in Rural Areas in Quang Tri

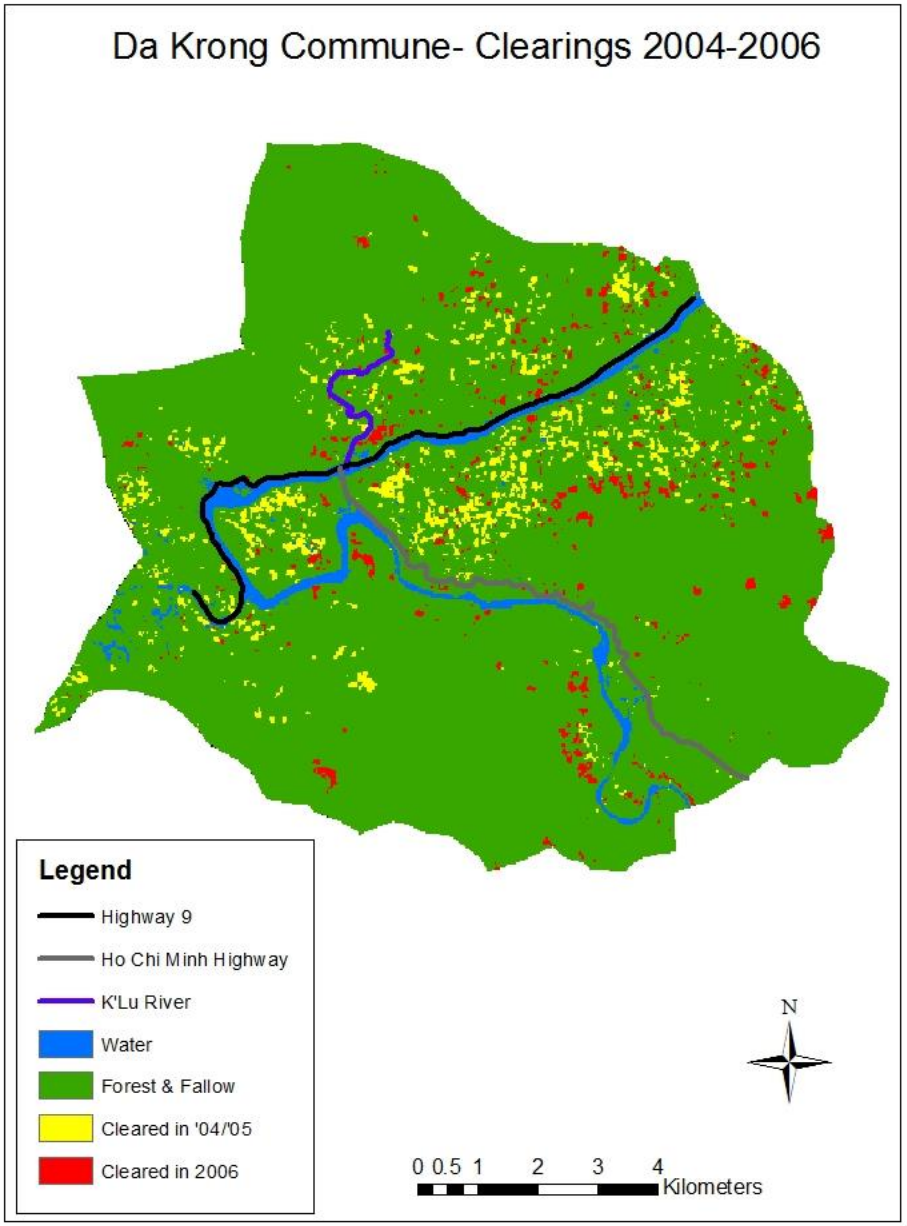
- General trends
  - Highway 9 upgraded
  - Secondary roads connecting Highway 9 to villages built and/or upgraded
  - Changes in agricultural crops / farming system
    - Cassava for industrial purposes – replacing upland rice in swidden systems; replacing acacia trees on upland fields
    - Acacia trees replacing upland rice on some upland fields
- Question: are these changes evident on the landscape?
  - Evidence from two cases

Case 1 – near main corridor road

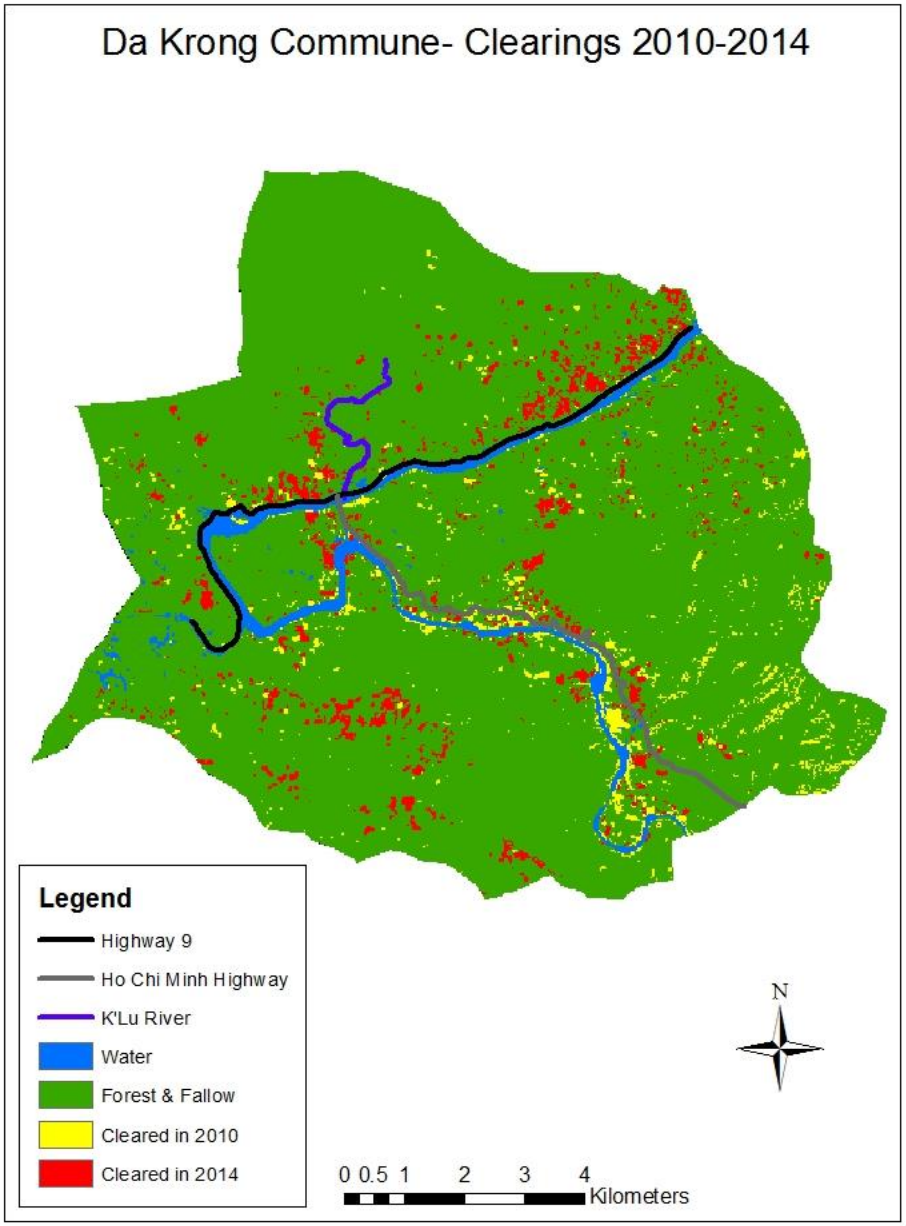
- stacked NDVI (available Landsat 5, 7, 8 – all images from March and April)
- unsupervised classification (K-means)
- interpreted to indicate land-cover change and direction of change



Case 1


Da Krong Commune- Clearings 2004-2006
Legend
Highway 9
Ho Chi Minh Highway
K'Lu River
Water
Forest & Fallow
Cleared in '04/'05
Cleared in 2006
N
0 0.5 1 2 3 4
Kilometers

Case 1

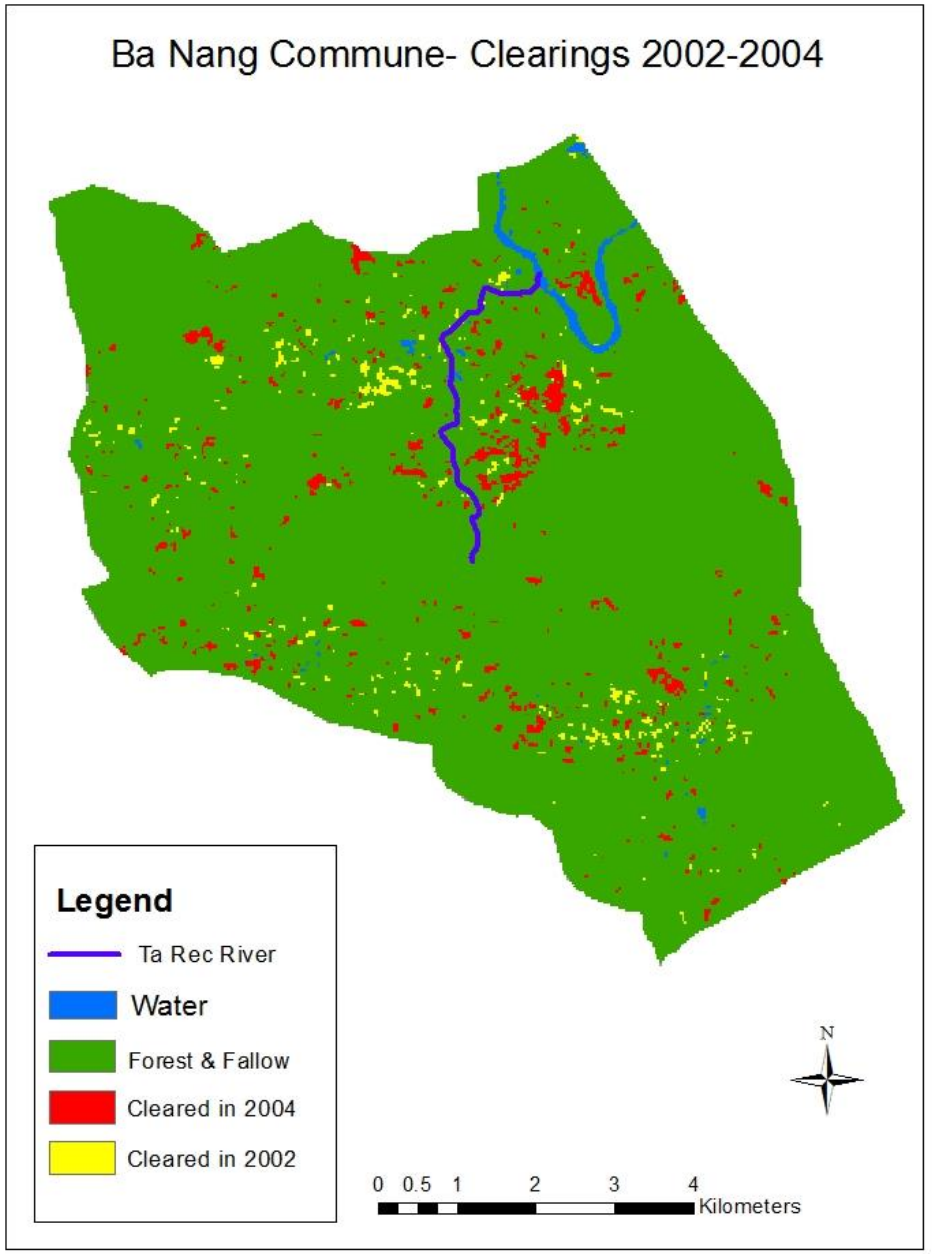

Da Krong Commune- Clearings 2010-2014
Legend
Highway 9
Ho Chi Minh Highway
K'Lu River
Water
Forest & Fallow
Cleared in 2010
Cleared in 2014
N
0 0.5 1 2 3 4
Kilometers

- Case 1
  - Decrease in upland rice;
  - Upland fields moved from distant mountain areas to the roadside; overall decrease in upland fields (?!)
  - Houses/village center moved nearer to road, building material change, paved over paths, electricity

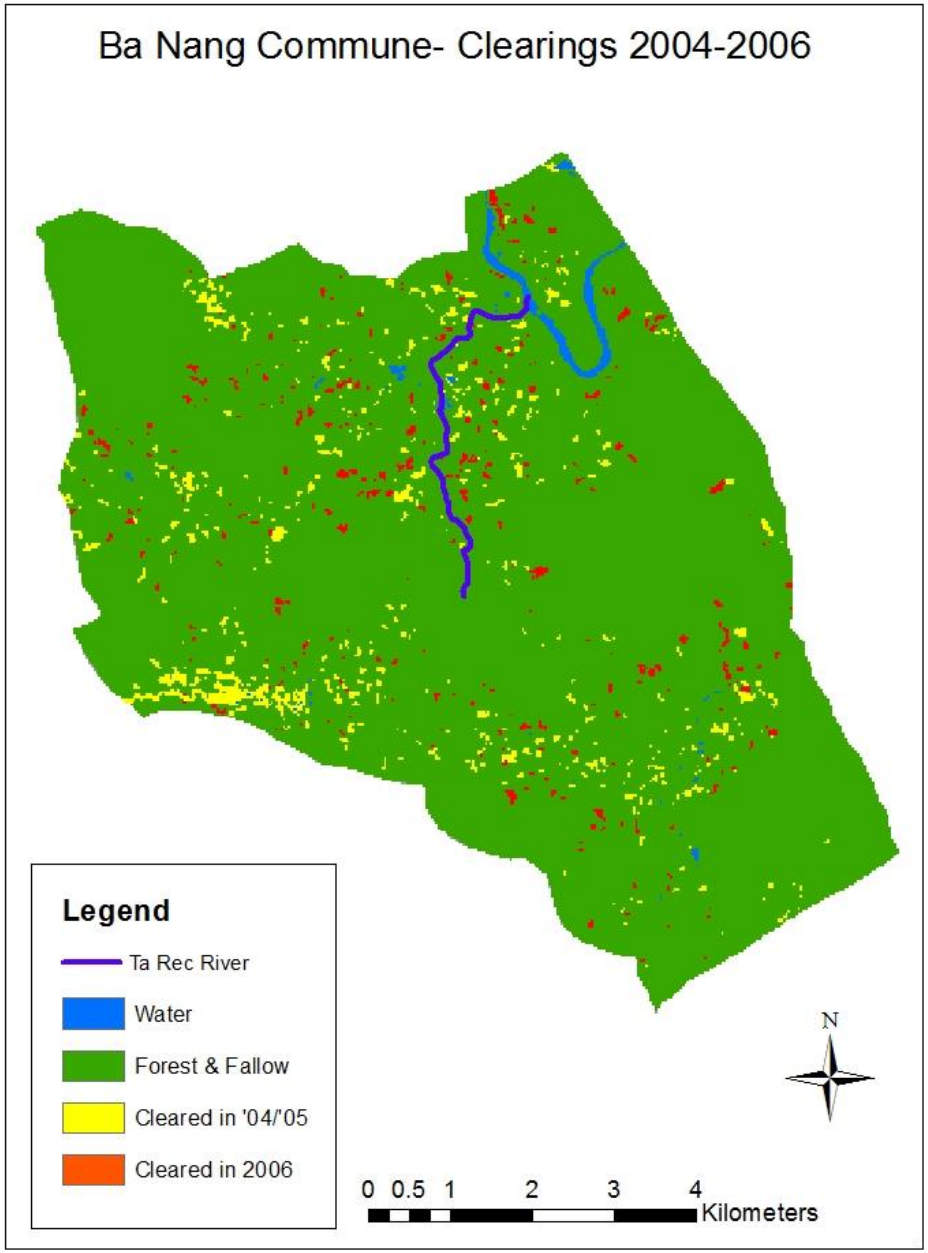
  Drivers
    - Better connectivity (road upgrades)
    - Information (middlemen, extension agents)
    - introduction of hybrid cassava from Dong Ha Starch Factory

Case 2 – recently connected to corridor roads

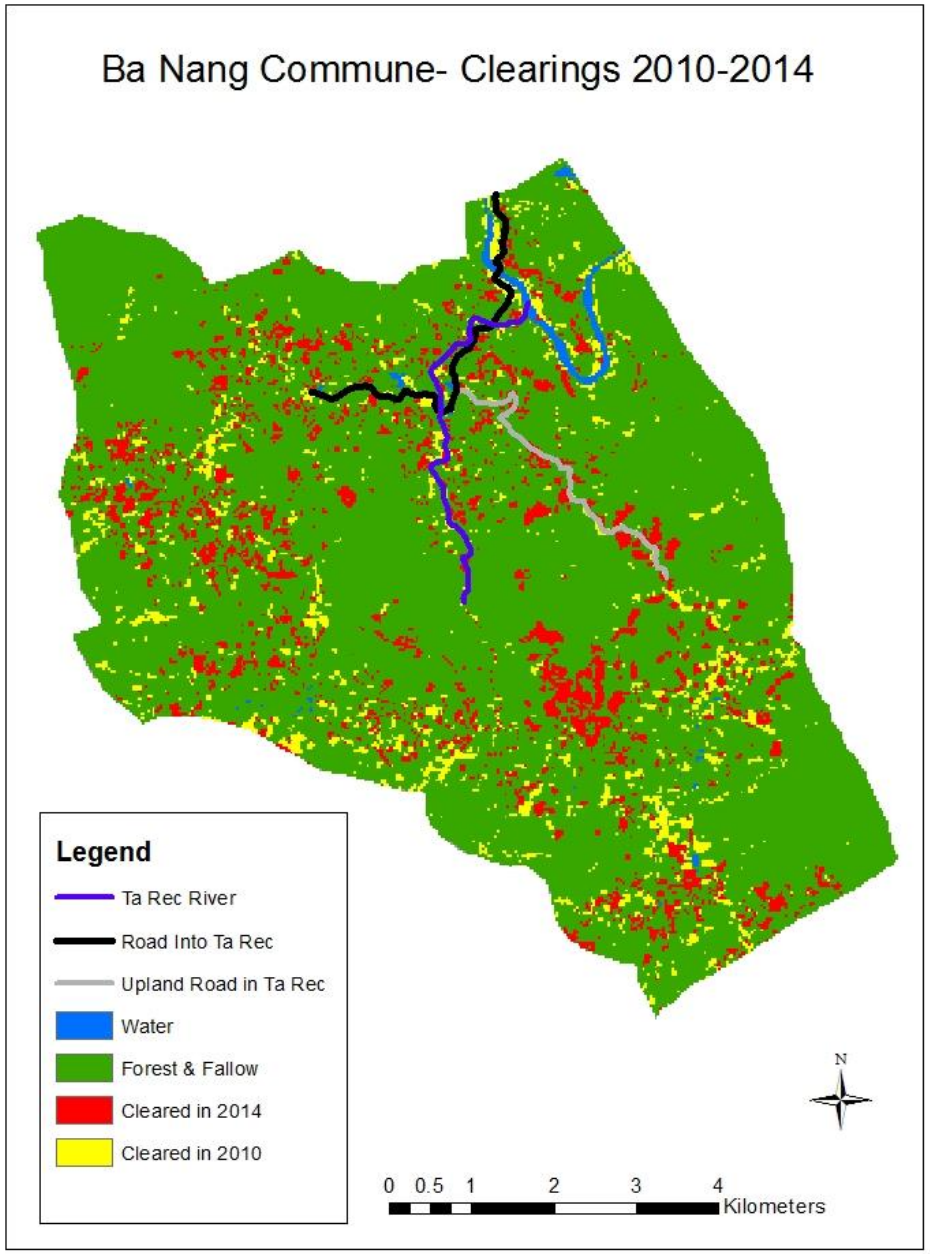
- stacked NDVI (available Landsat 5, 7, 8 – all images from March and April)
- unsupervised classification (K-means)
- interpreted to indicate land-cover change and direction of change



Case 2


Ba Nang Commune- Clearings 2004-2006
Legend
Ta Rec River
Water
Forest & Fallow
Cleared in '04/'05
Cleared in 2006
N
0 0.5 1 2 3 4
Kilometers

Case 2


Ba Nang Commune- Clearings 2010-2014
Legend
Ta Rec River
Road Into Ta Rec
Upland Road in Ta Rec
Water
Forest & Fallow
Cleared in 2014
Cleared in 2010
N
0 0.5 1 2 3 4
Kilometers

- Case 2
  - Expansion of paved roads in commune/village
  - Expansion of upland fields
  - Introduction / expansion hybrid cassava

  Drivers
    - Better connectivity (road extension, road upgrades)
    - Information (middlemen, extension agents)
    - introduction of hybrid cassava from Dong Ha Starch Factory, acacia extension agents, wood processing companies

Laos – Results from fieldwork

- Savannakhet City has grown – evidence it is further expanding
- Industrial zones created
- Increased tourism
- Rural factories have been built along East-West Highway
- New university

Changes in Urban Areas

- Savannakhet City
  - Industrial zone expansion
  - Edge expansion
  - Infrastructure upgrades
  - Drivers
    - Connectivity with Thailand
    - Tourism
    - Factories
    - University

Changes in Rural Areas – 2 cases

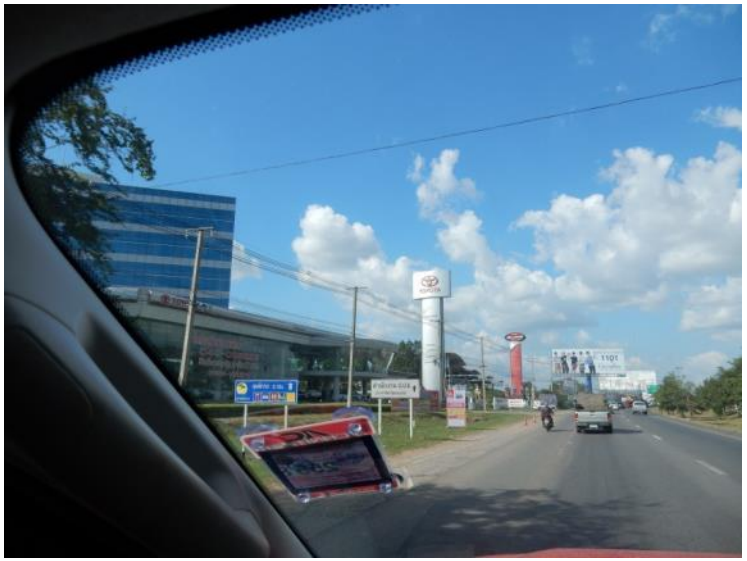
- Case 1 – near main corridor road
  - Changing farming system; new crops integrated into swidden/fallow
    - Banana
    - cassava,
    - Actinodaphne cochinensis tree (locally ‘yam bon’ in Vientam ‘boiloi’)
  - Drivers
    - Connectivity (road extension, upgrade of road conditions)
    - Information (middlemen, extension agents)
    - Introduction ‘industrial’ banana (from Vietnam)
    - Introduction hybrid cassava (from Vietnam)
    - Demand for ‘boiloi (from Vietnam)

- Case 2 - near upgraded secondary road
  - Changing farming / livelihood system; new crops and activities integrated into swidden/fallow
    - Swidden rice transitioning to wet paddy
    - Actinodaphne cochinensis tree (locally ‘yam bon’ in Vientam ‘boiloi’)
    - Cattle

  Recent
    - “industrial banana”
    - Hybrid cassava
  - Drivers
    - Connectivity (road extension, upgrade of road conditions)
    - Information (middlemen, extension agents)
    - Cattle buyers (gained access after bridge built on secondary road from Vietnam)
    - Demand for ‘boiloi’ (from Vietnam)
    - Introduction ‘industrial’ banana (from Vietnam – banana ‘blight’ in Vietnam)
    - Introduction hybrid cassava (from Vietnam)

Changes in Urban Areas – Thailand (from interviews)

- In-filling of open areas within the cities
  - Residential mainly
  - Services
- Multi-local urban expansion – not continuous / concentric along edges
- Drivers
  - improved access to Bangkok
  - Political considerations



Changes in Rural Areas – Northeast Thailand

- Factories are being placed in NE Thailand rural areas
  - Large factories – agribusiness (starch factories, dairy, sugar, rice mills); non-agribusiness (Panasonic)
  - Small family run 'factories' (statue making) proliferating along roads
  - Changes in farming / livelihood systems (family members working in local factories, not on land)

  Drivers
    - Improved connectivity (road access)
    - Information
    - Weather in Bangkok area (recent consecutive year flooding)
  - Questions
    - What is the impact on farming - Do families decrease cropping? Increase? Or change annual crops to tree crops (less work)?
    - How do village infrastructures change?

Conclusions (so far) Cross border teleconnections – urban areas

- Vietnam
  - Da Nang and Hue – investment from outside of Vietnam (China, Japan, U.S.) and other locations in Vietnam (Hanoi and HCMC); demand from other locations for starch, tourist services
  - Dong Ha – political considerations (Hanoi); international and national investment / international and national demand (starch company, wood processing)
- Savannakhet
  - Investments from Thailand, university (government investment), tourism (especially cross-border for visas from Thailand)
- Khon Kaen
  - Investment from other areas in Thailand (pushed out by floods), international

Cross-border teleconnections (and cross-border urban to rural areas)

- Vietnam
  - Industrial crops (cassava, acacia)
  - Rural urbanization (especially in K'lu - the beginnings of this?)
- Laos
  - Cross-border trade in cattle (Laos -> Vietnam)
  - Banana (disease pushed crop out of Vietnam, needed for food processing industry in Vietnam)
  - Hybrid cassava introduced from Vietnam
  - Demand for Actinodaphne cochinensis from Vietnam
  - Factories from Thailand (industrial zones and sugar factories in rural areas); Factories from Vietnam (starch factory and wood processing)
- Thailand
  - Factories in rural areas (relocating from other parts of the country);
  - Rural urbanization (livelihoods and consumer tastes)

Overall Results and Conclusions (to date)

- EWEC has increased connectivity between countries
- Changes in farming and livelihood systems in rural areas – leading to changes in both the land-use and the land-cover (image analysis for Vietnam; evidence from interviews in Laos)
- Expansion and infilling of urban areas – evident in the image analysis (for Vietnam)
- Rural urbanization on-going in Thailand, starting in Vietnam, is Laos next?
- Tourism is a driver in all three countries
- External investments and international trade demands are drivers in Vietnam and Laos
- Overt government policies are drivers in Vietnam and Thailand
- Cross-border investments are direct drivers in Laos and indirect drivers in Vietnam
- Crop disease transmission is a driver in Vietnam/Laos

What does all this mean regarding trees on the landscape?

Other activities of the project

- Presentation of initial results to provincial governments in Da Nang, Hue, Dong Ha

Two Trainings at Savannakhet University

Basics of remote sensing

and satellite image processing

Fieldwork

- Collection of socio-economic data collection
- Groundtruthing with GPS

Training of Students

- Master's student at CSU
  - participated in fieldwork
  - using data collected and analysis of Landsat Imagery in his thesis work.
  - Master's Thesis: (working title) Teleconnections and land-use / cover changes in one village in central Vietnam (to be completed Fall 2015)
- Ph.D. student at Khon Kaen University
  - Ph.D. student at Khon Kaen University is benefiting from analysis done in conjunction with this project (focus on changing rural livelihoods in Northeast Thailand) results are being incorporated into Ph.D. Dissertation

Initial Outputs

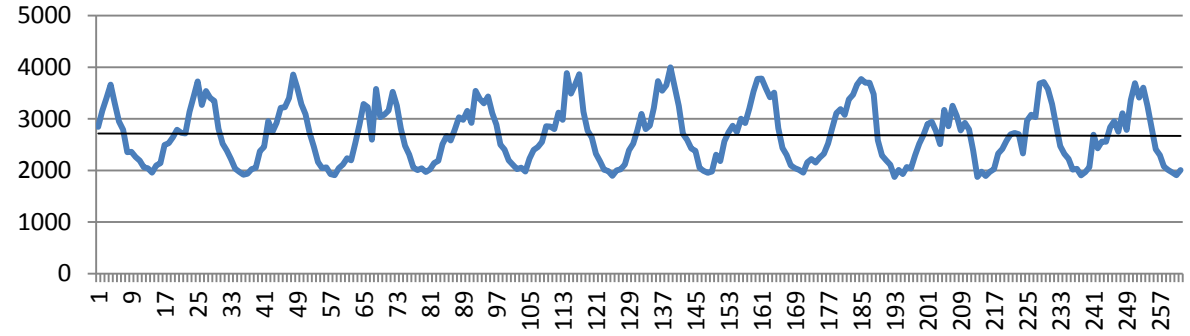
Presentations

- Leisz, S. (2014) Road development, rural and urban land-cover changes and urban expansion. *Urban Land Teleconnections from Concept to Implementation, Urban Transitions and Transformations, 2nd International UGEC Conference,* November 6 – 8, 2014, Howard Civil Service International House, Taipei, Taiwan.
- Leisz, S. (2015) Rethinking the relationship between roads / connectivity and land-use/cover changes in the East-West Economic Corridor. South Dakota State University, March 16, 2015.
- Papers (in preparation – more to come)
  - Shirai, Y., A.T. Rambo (submitted) Structure and Income sources of rural households in a rice-growing village in Northeast Thailand. Journal of Southeast Asian Studies. Kyoto University.
  - Nguyen Thi Bich Yen (draft) Sự thay đổi hệ thống cây trồng thích ứng với phát triển cơ sở hạ tầng và điều kiện khí hậu: trường hợp nghiên cứu ở thôn Tà Lang, xã Hải Phúc, huyện Đakrông, tỉnh Quảng Trị (Changing cropping systems as a function of the development of infrastructure and: case studies in the village of Ta Lang, Hai Phuc, Đakrông district, Quang Tri province)
  - Working Title: Rethinking the role of roads and land-use/cover changes, the case of the East-West Highway from Da Nang, Vietnam, to Khon Kaen, Thailand.
  - Working Title: Cross-border teleconnections and land-use changes, the case of Vietnam and Laos.
  - Working Title: Teleconnections across scales, the case of Quang Tri Province in Vietnam.

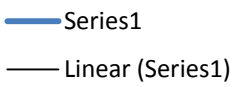
Thanks to:

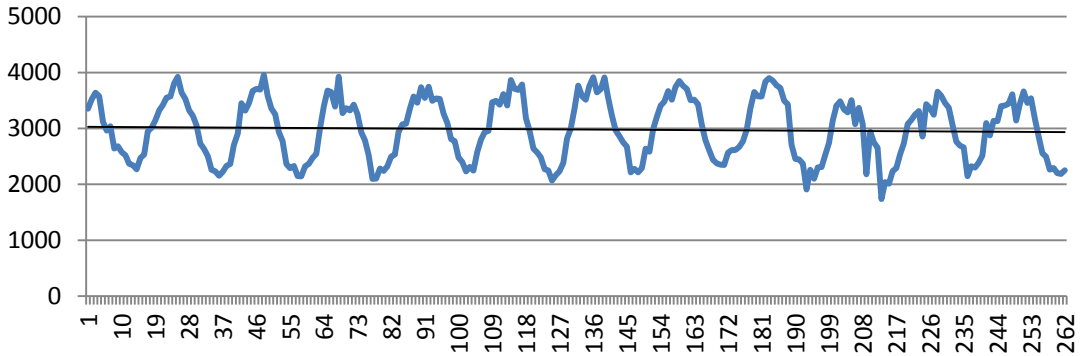
- Partners at Vietnam National University of Agriculture (previously Hanoi University of Agriculture)
- New Partners at Faculty of Agriculture and Environment at Savannakhet University
- Partners at Khon Kaen University
- Villagers in Vietnam, Laos, and Thailand who hosted us, and
- Local administrators in Vietnam, Laos, and Thailand who met with us and provided information and feedback
- The NASA LCLUC Program for its support of this project

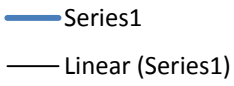
Example Analysis



Areas of no change







Areas of some change in last 4 years

Areas of change in last 7 years