Assessing Spatial Patterns of WEF Nexus of Hydro Dams in the Mainland Southeast Asia

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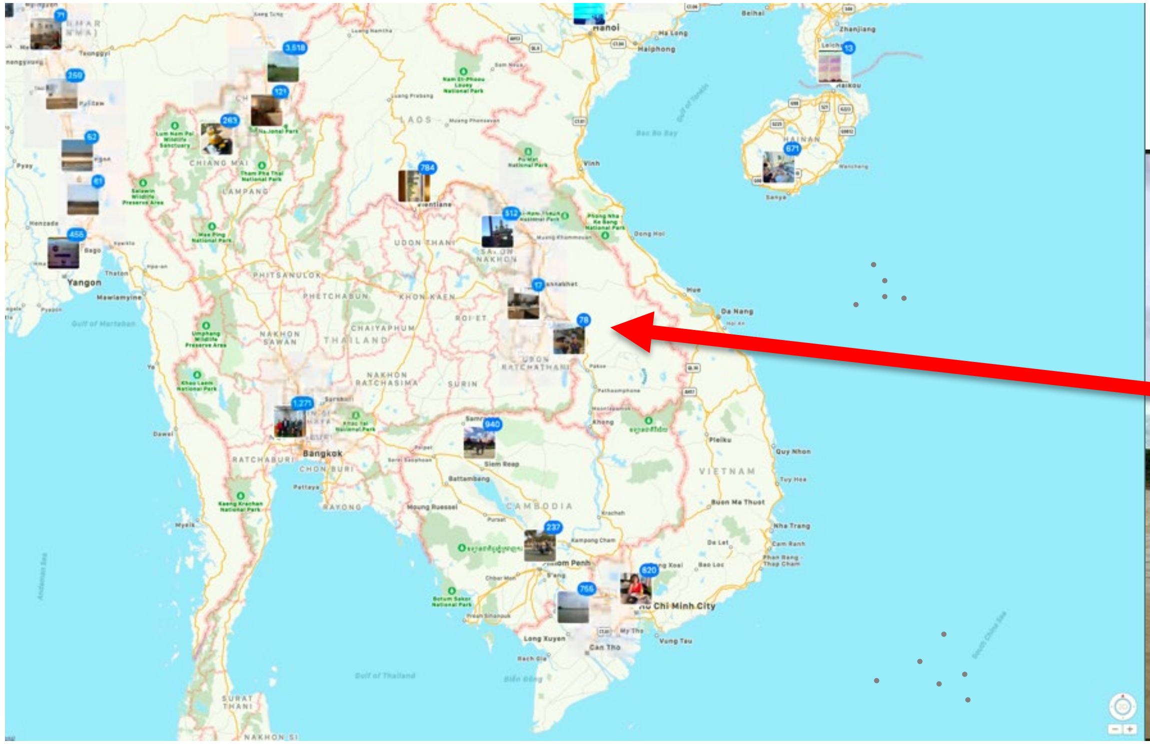
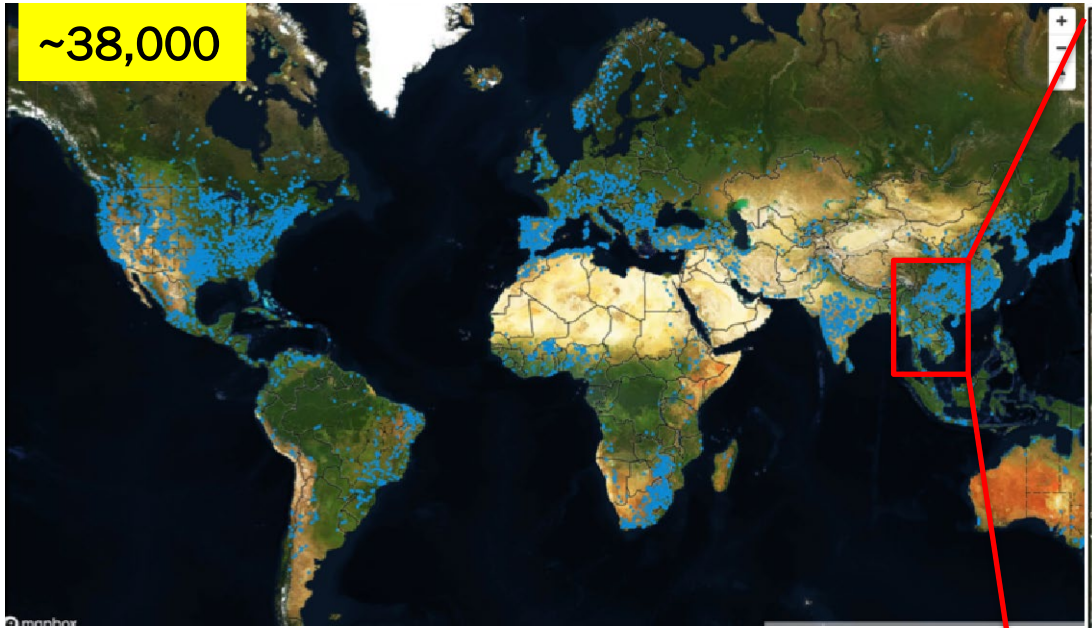
International Meeting on Land Cover/Land Use Change (LCLUC) in South/Southeast Asia and Synthesis, 31st January, February 1st, and 2nd, 2024, Hanoi, Vietnam

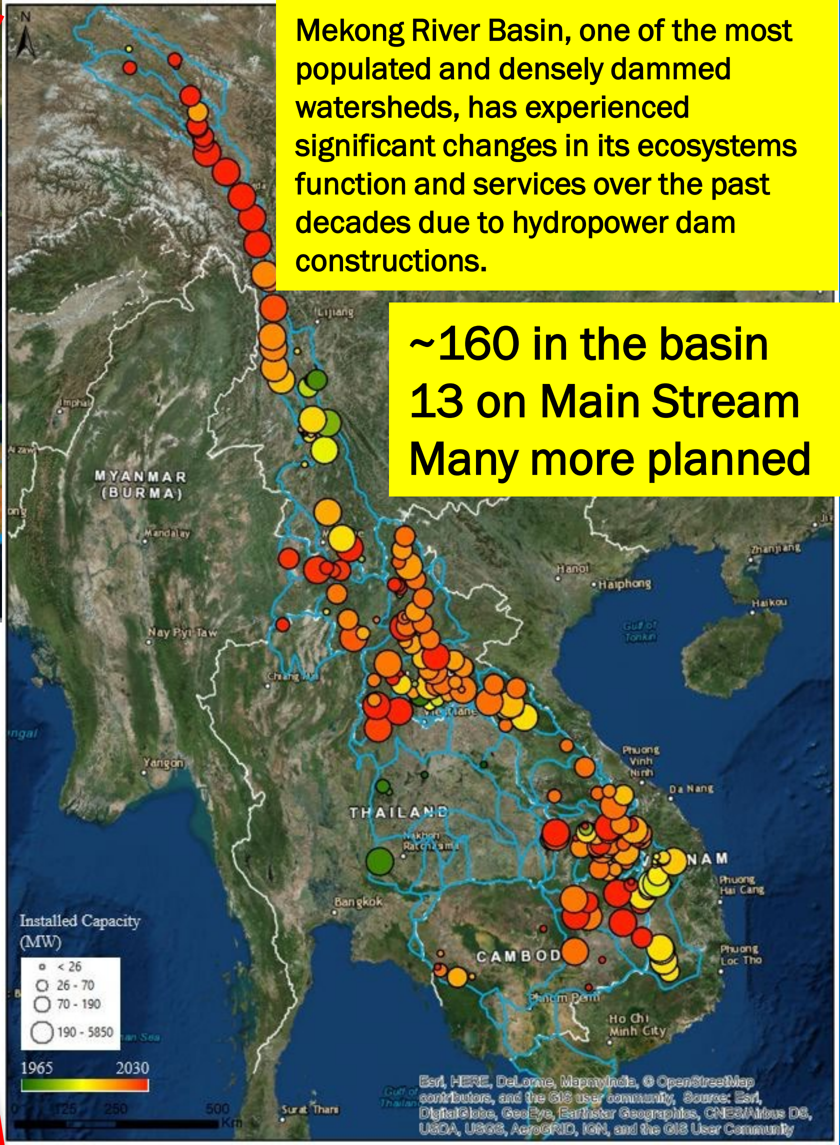


HYDRO DAMS

- A type of land use that is rarely mapped on LULC products;
- Huge impacts on water resources
- Significant implications to water-energy-food nexus;
- Important socioeconomic consequences;
- Very controversial in biological, hydrological and ecological impacts;
- Number of dams are increasing around the globe.



Global Reservoir and Dam Database (GRanD)



Mekong River Basin, one of the most populated and densely dammed watersheds, has experienced significant changes in its ecosystems function and services over the past decades due to hydropower dam constructions.

~160 in the basin
13 on Main Stream
Many more planned

Global hydro dams (above figure) represents a unique land use/cover type that have directly altered global water distribution, availability, accessibility and cycle, benefiting some (irrigated agriculture and hydropower energy sectors) while disrupting other ecosystem services such as fish habitat and biodiversity. And yet there is little research on the trade-offs and synergies among the benefits of hydro dams and negative impacts on the livelihoods of local communities.

A NASA LCLUC Project

With support from NASA LCLUC program, a group of scientists from Michigan State University, Virginia Tech. University, and Applied Geospatial Resolutions, together with more than a dozen scientists, engineers, decision makers and managers, developed a water-energy-food nexus approach that integrated satellite and ground-based observations, hydrological and ecological models, and socio-economic models to better understand the nexus of water, energy and food and how it affects the livelihoods of local communities.

Water Resources, Uses, and Services

1) Understanding human and climate impacts on wetland/Rice ecosystems in the Lower Mekong River Basin

2) Assessing the impacts of dams on the dynamic interactions among distant land use and rural communities in the Lower Mekong River Basin

US Co investigators:

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Vu Ngoc Ut


Lisa Robelo


Aiko Endo


Claudia Pahl-Wostl


Anik Bhaduri

From Bangkokpost, March 18, 2018

Mekong researchers seek ways to improve dams

16 Mar 2018 at 14:21 791 viewed 0 comments

WRITER: THOMSON REUTERS FOUNDATION

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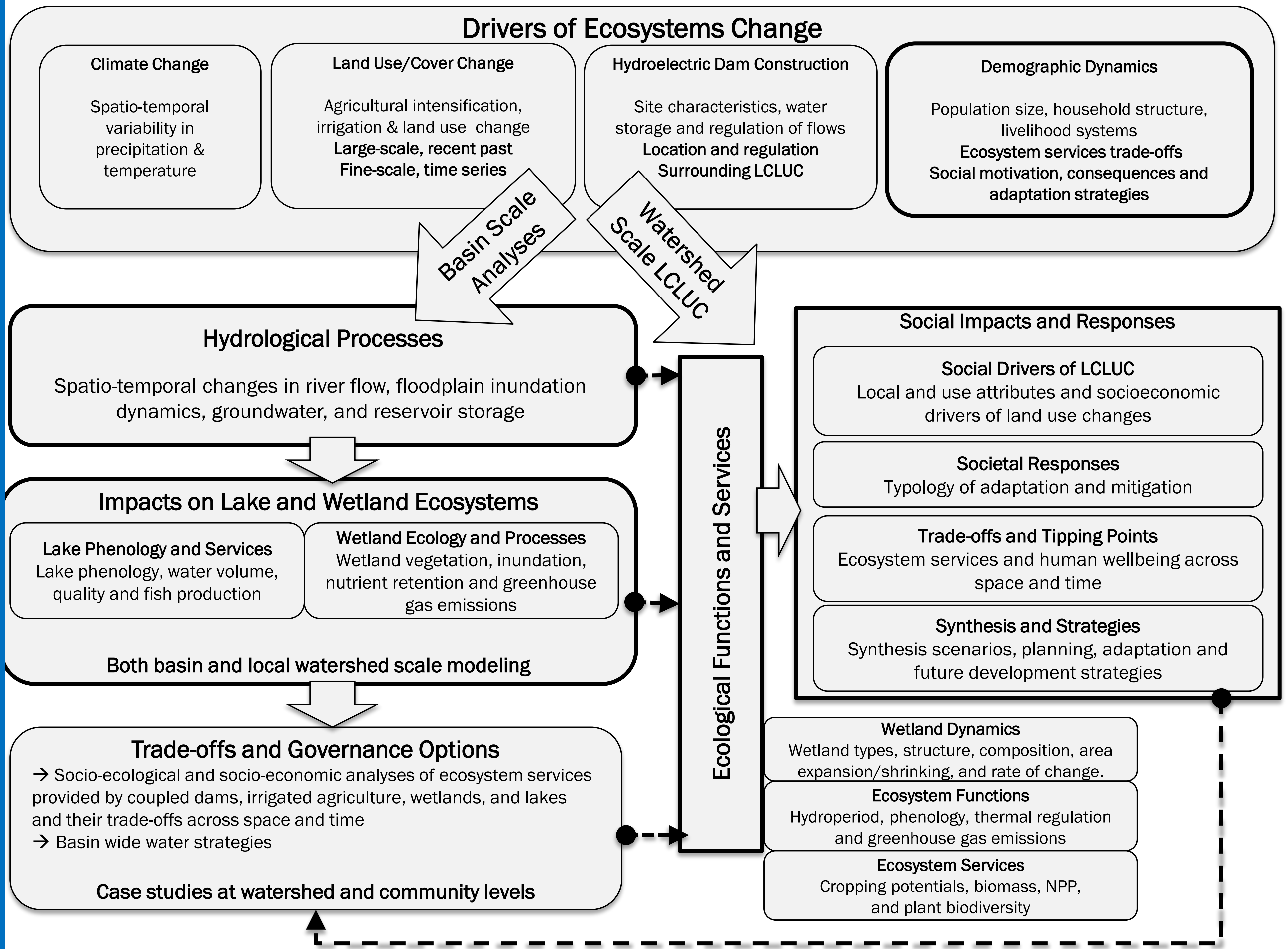
Our team hopes to generate the needed information and knowledge to help develop pathways to improve dams (management) and reduce negative societal impacts.

WEF Nexus approach to model the dynamic interactions among water, energy, food and land uses that have significant implications to the livelihoods of local communities. Some are benefited by the dams and water availability while others negatively affected by ecological degradation of the very ecosystem services that they have relied on for centuries.



Environmental Research 158 (2017) 24–32

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Hydro-dam – A nature-based solution or an ecological problem: The fate of the Tonlé Sap Lake

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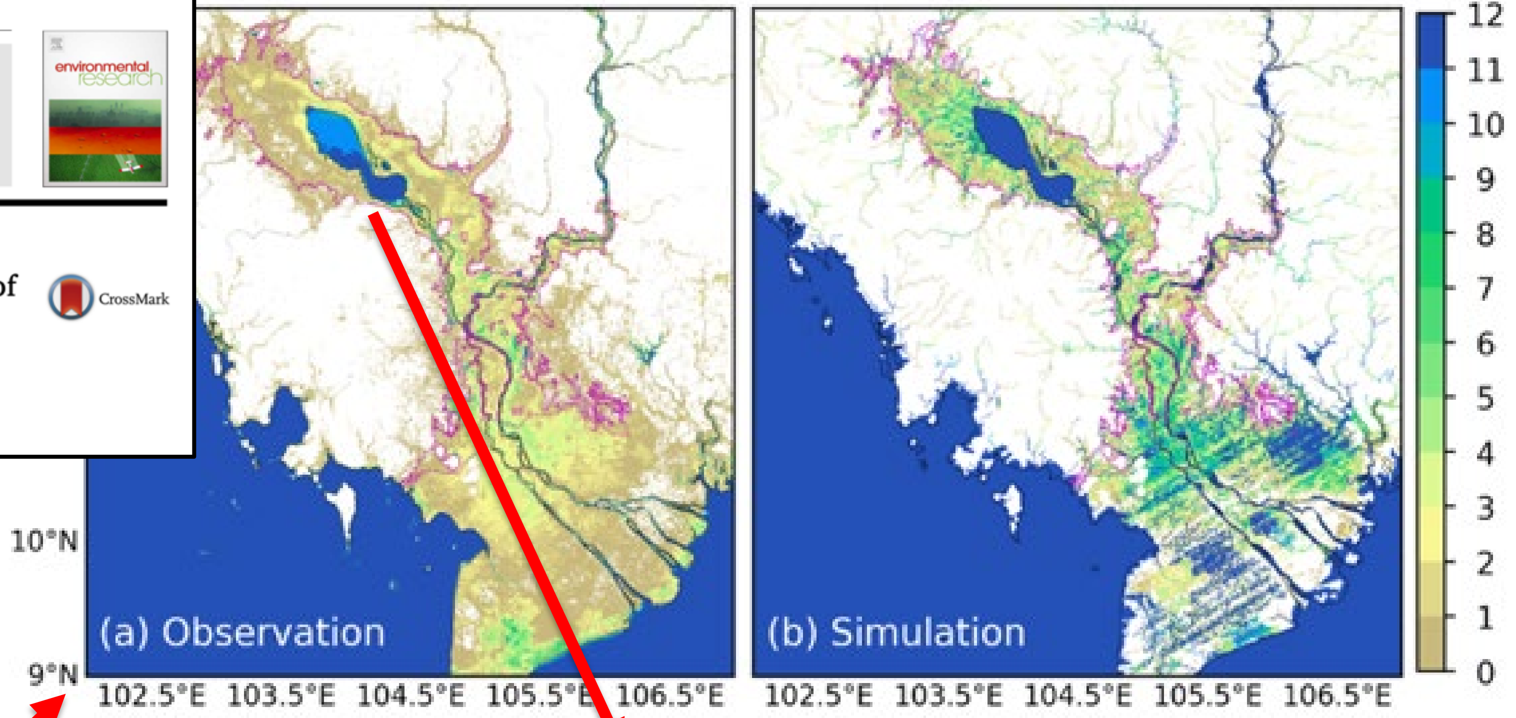
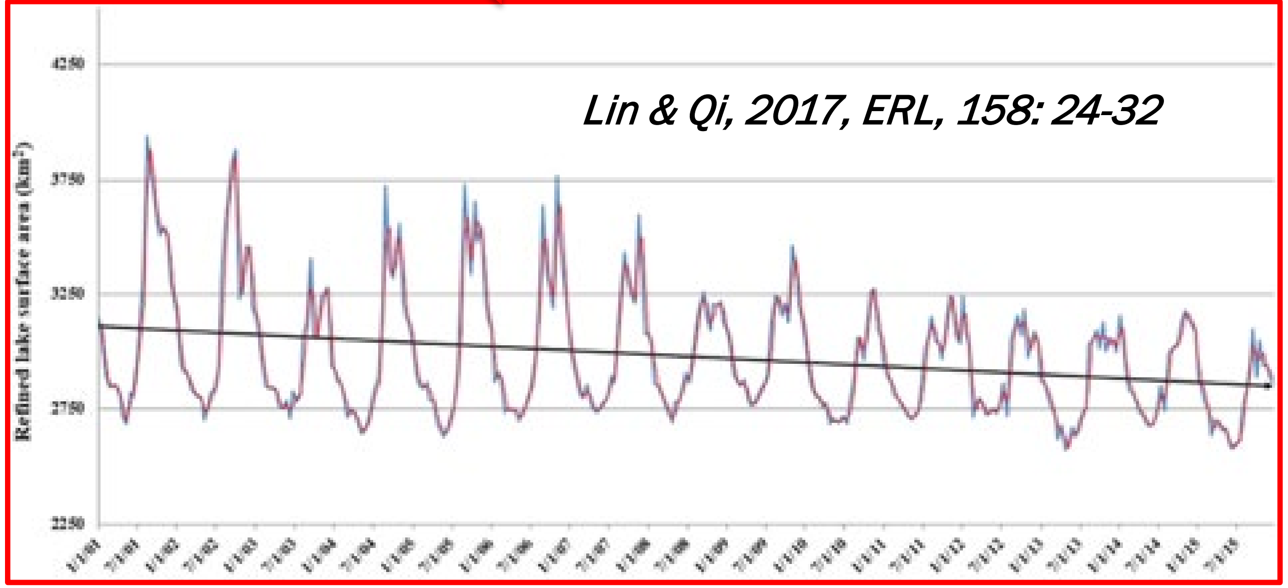
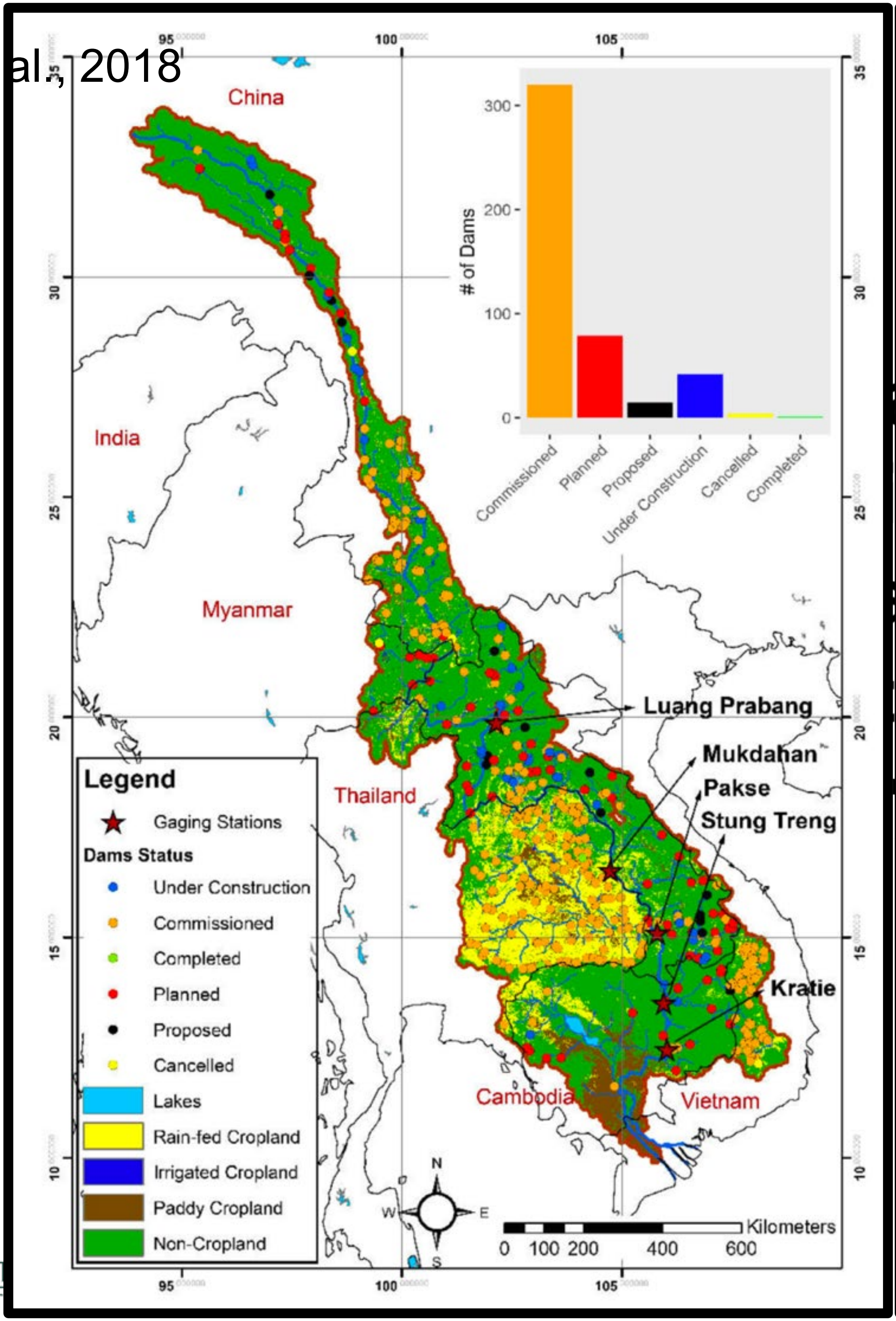
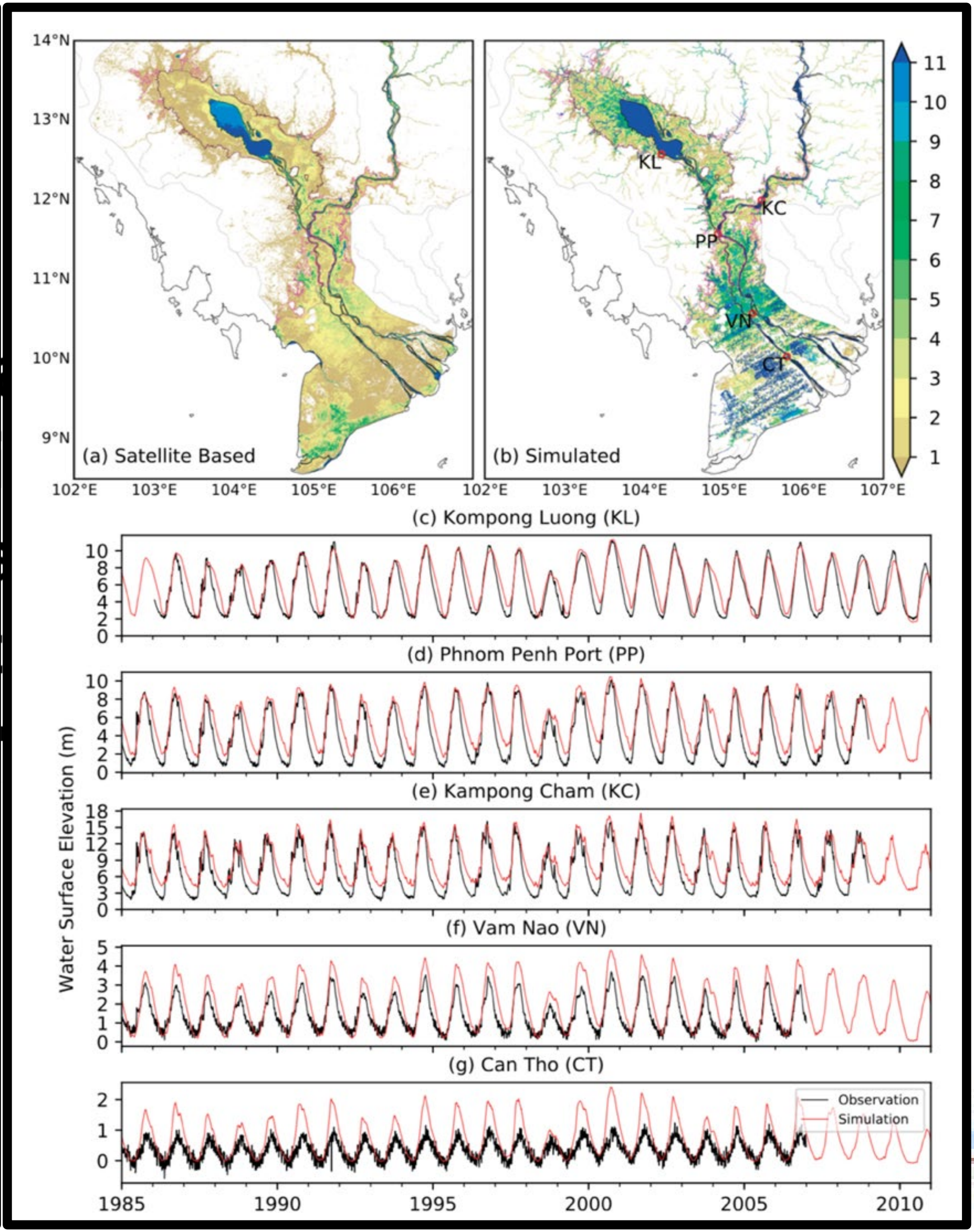




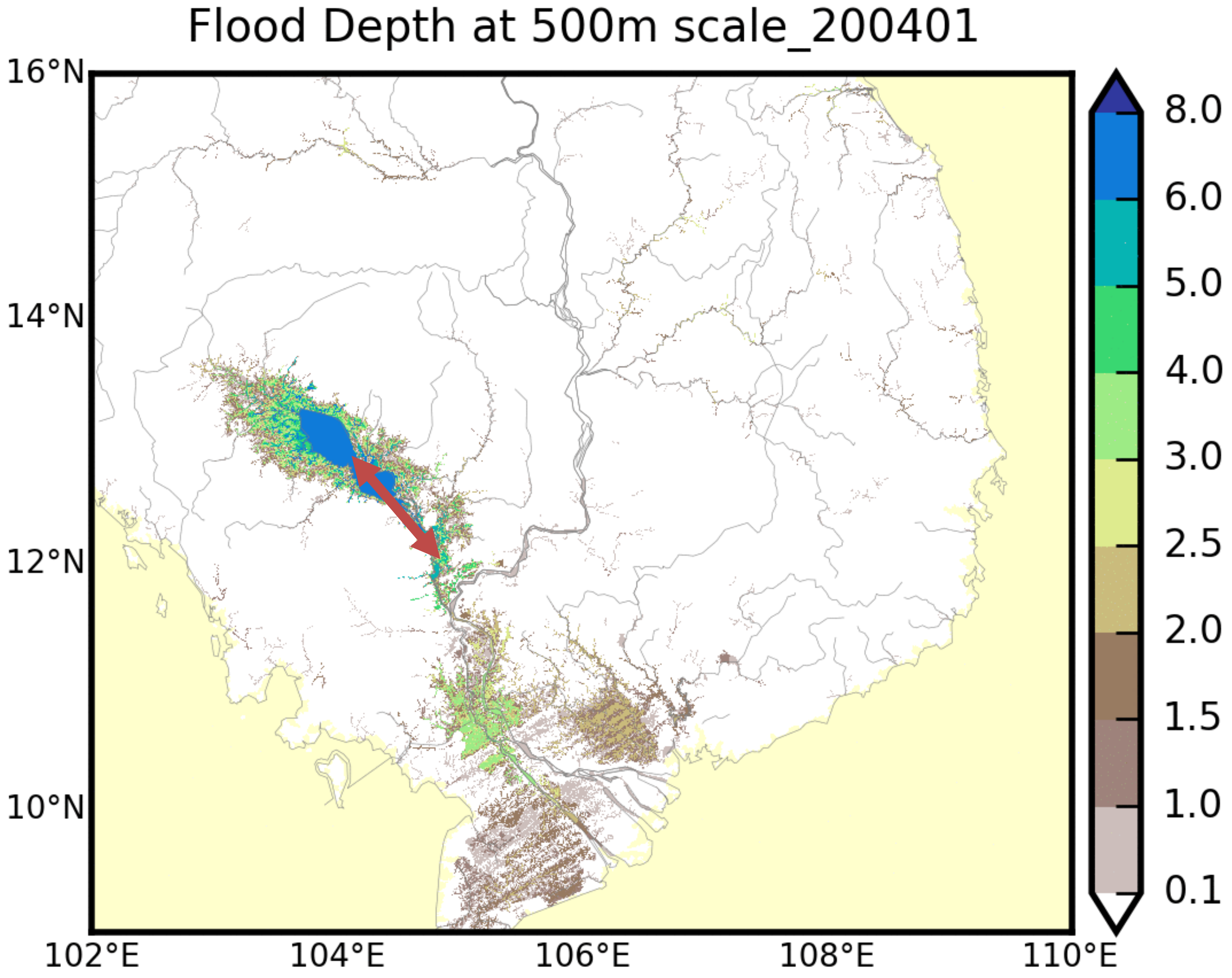
Lin & Qi, 2017, ERL, 158: 24-32

Pokhrel et al., 2018



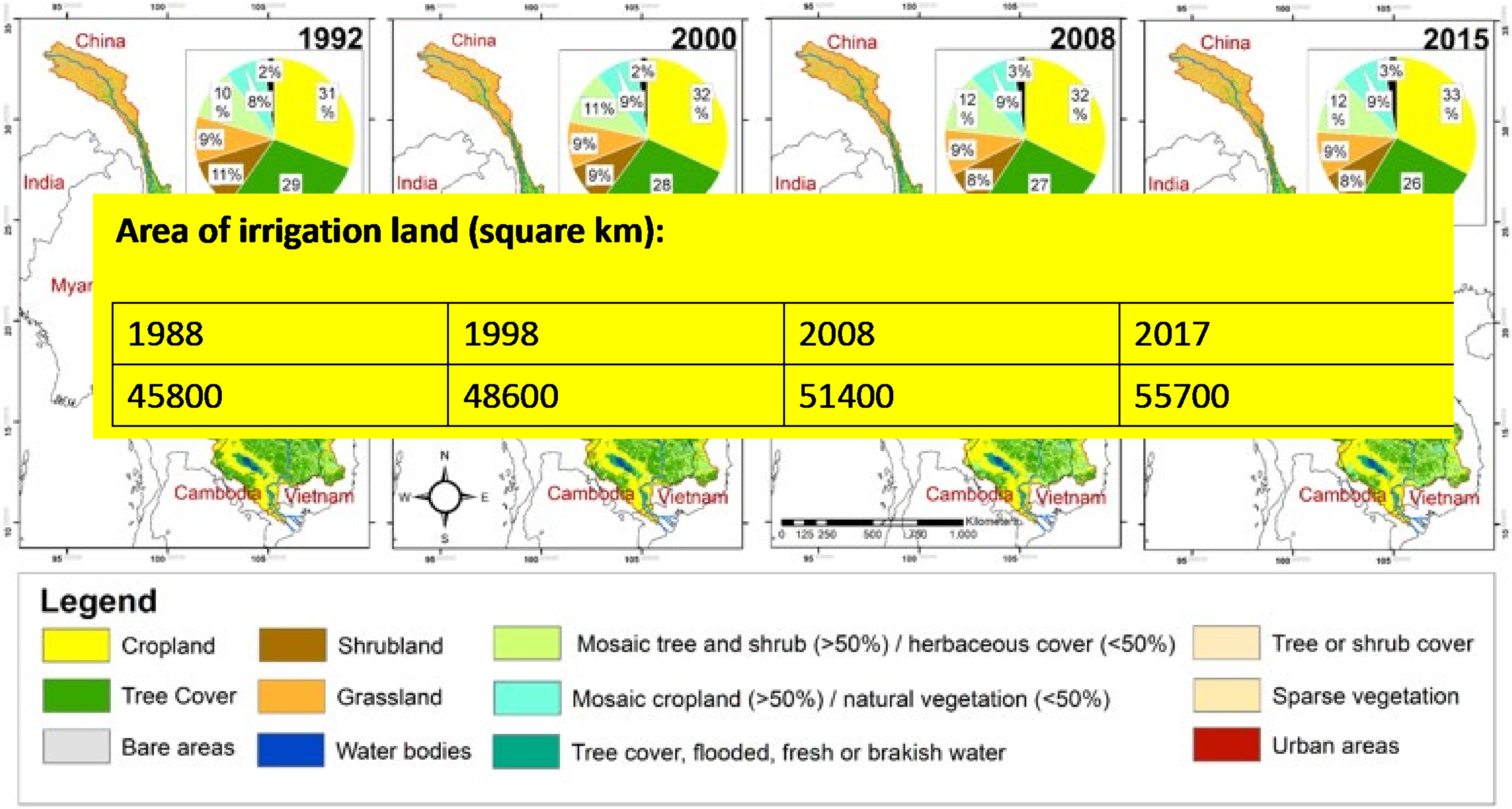


Two-way Water Flow in Tonle Sap River



Pokhrel et al. 2019

INTEGRATING LAND USE CHANGE IN MODELING



Area of irrigation land (square km):

1988	1998	2008	2017
45800	48600	51400	55700

Southeast Asia?

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ELSEVIER

Characterization of the impacts of hydro-dams on wetland inundations in Southeast Asia

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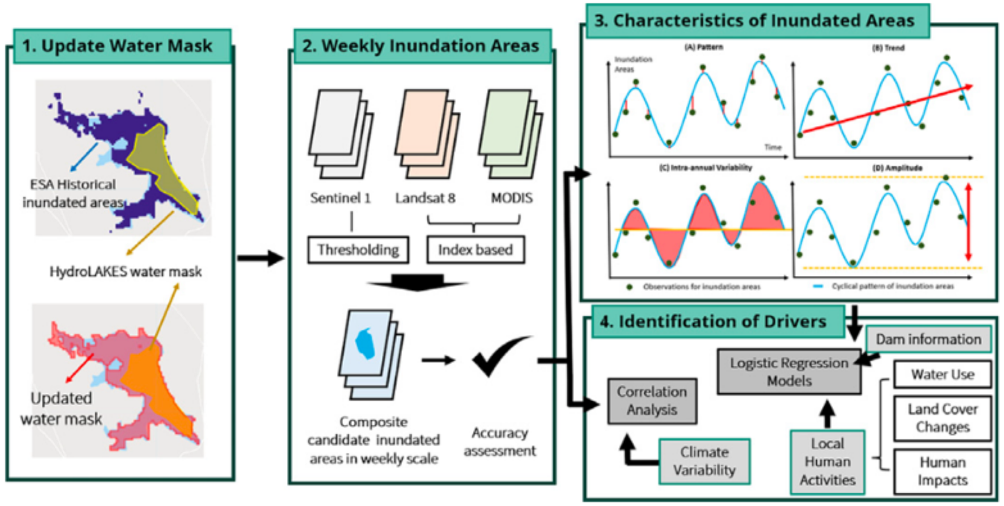
HIGHLIGHTS

- A multi-sensor approach overcame limitations in detecting wetland inundations.
- Impacts of dams on wetlands were separated from those of climate and human activity.
- Location and distance of dams cause different alterations of wetland inundations.
- Southeast Asian wetlands are under the pressure of dams.

GRAPHICAL ABSTRACT



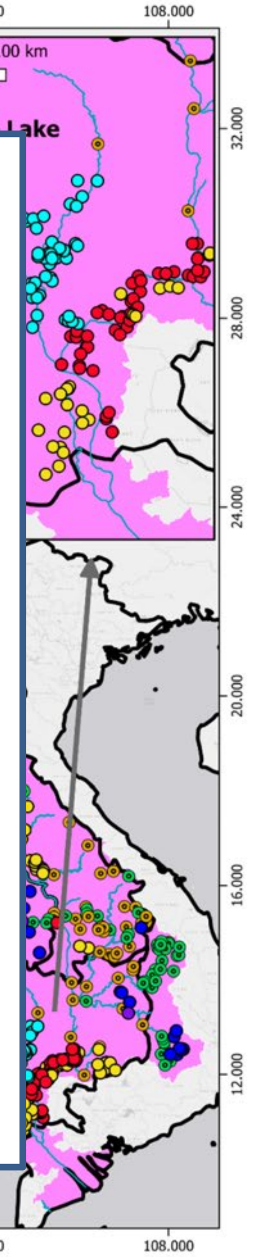


Fig. 1. Natural wetlands and hydro-dams in Mekong, Salween, and Irrawaddy Basins. The distance was decided based on the watershed boundaries from HydroBASINS. No-dam is wetlands outside of the watersheds with dams.

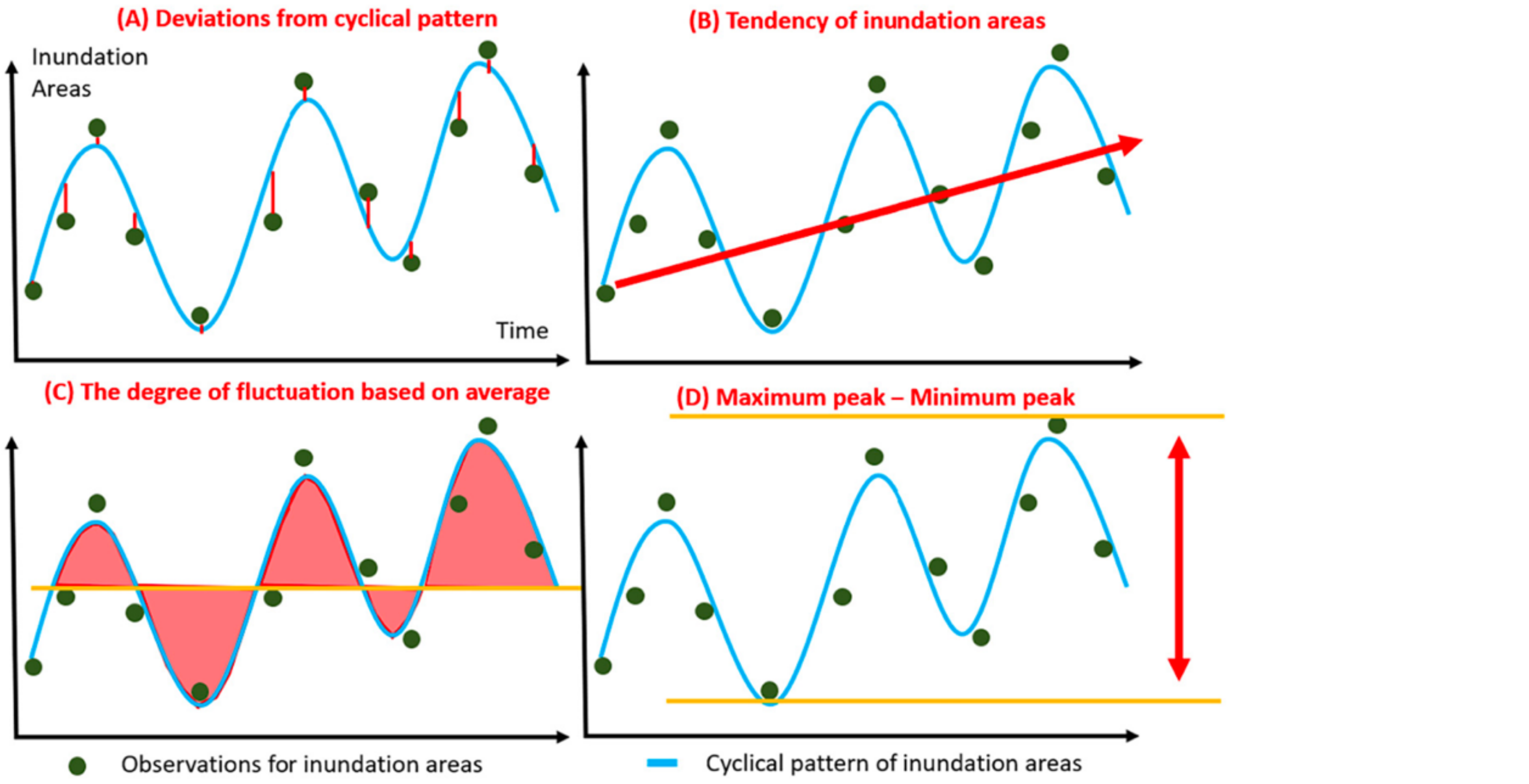
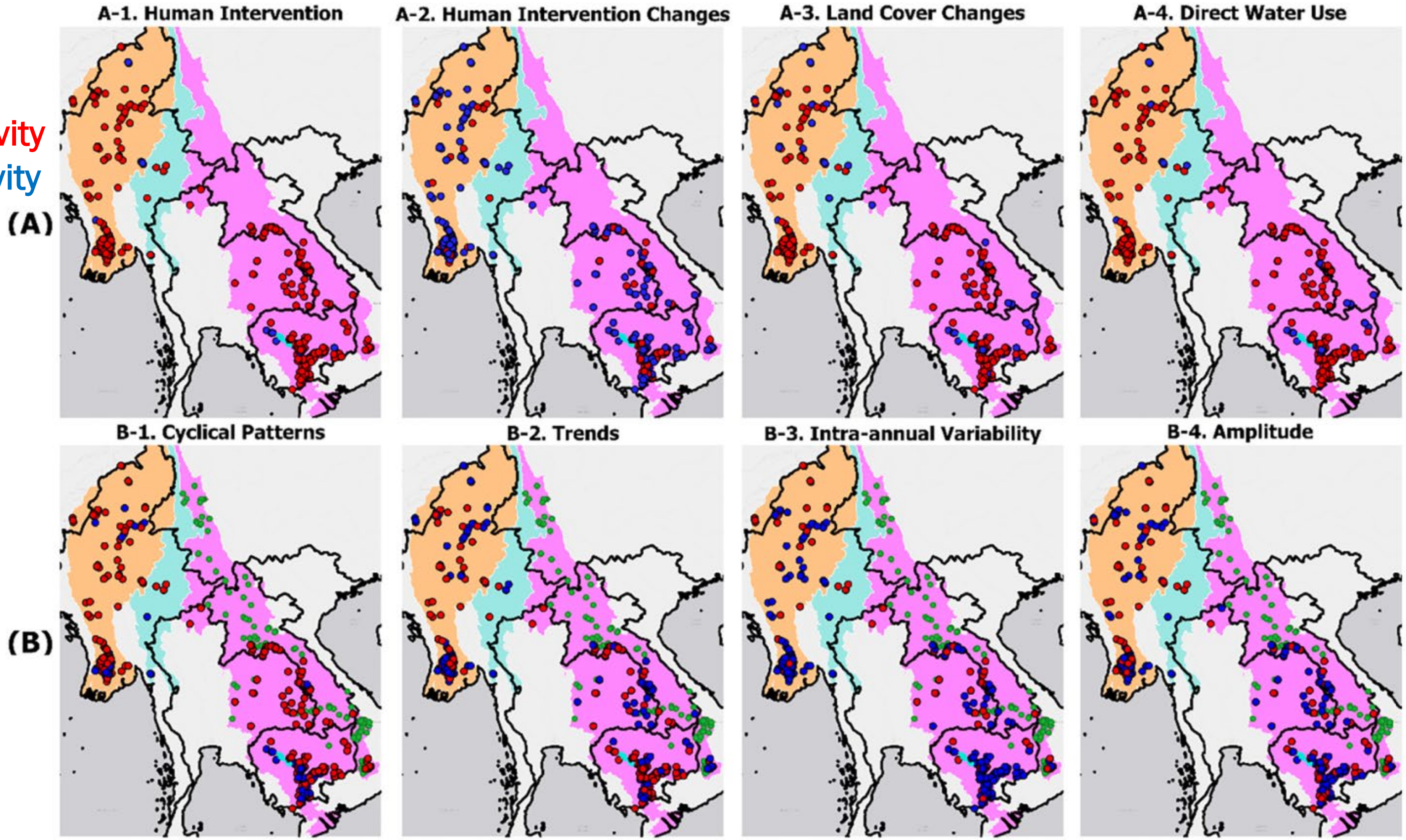


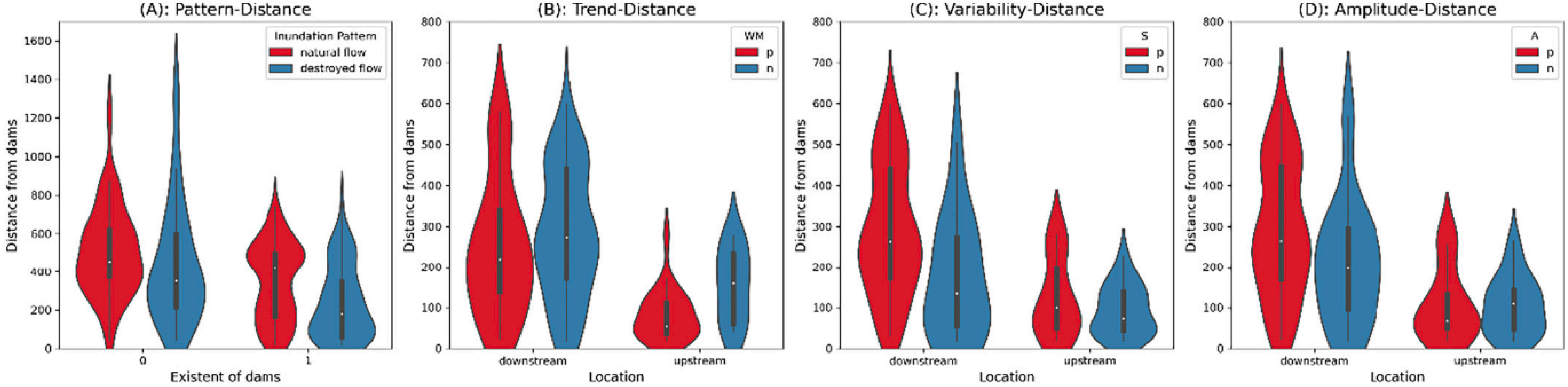
Fig. 2. Characteristics of wetland inundations that were considered in this study: natural patterns (A), trends (B), intra-annual variability (C), and amplitude (D) of inundations. The inundation patterns of the wetlands show a seasonally cyclical pattern. The natural pattern was measured by the deviations from the cyclical pattern (A), trend was measured by the tendency of inundation changes (B), intra-annual variability was measured by the fluctuations in inundation patterns (C), and amplitude was measured by the difference between maximum and minimum peaks (D).

Red – Presence of human activity
Blue – Absence of human activity



Red – Disturbed wetlands
Blue – Undisturbed wetlands
Green: Commissioned dams

Fig. 3. Maps of local human activities on wetlands (A) and changes in characteristics of wetland inundations (B). Maps in (A) show human intervention (A-1), hu intervention changes(A-2), land cover changes(A-3), and water use (A-4). The red circle indicates the presence of local human activities, and the blue circle indicates absence of local human activities. For a map in (B) - cyclical patterns of the inundation (B-1), red circles are wetlands which destroyed the cyclical patterns, and circles are wetlands with keeping the natural pattern. For trends (B-2), intra-annual variability (B-3), and amplitude (B-4) of inundations, red circles indicate the decre and blue circles indicate the increase. For four maps in (B), green circles are showing the commissioned dams. (For interpretation of the references to colour in this fig legend, the reader is referred to the web version of this article.)


(A): Pattern-Distance
(B): Trend-Distance
(C): Variability-Distance
(D): Amplitude-Distance
Inundation Pattern
natural flow
destroyed flow
WM
S
A
p
n
Distance from dams
Existent of dams
Location
downstream
upstream
0
1
0
200
400
600
800
1000
1200
1400
1600
100
300
500
700

Applied Geography 136 (2021) 102588

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Quantifying spatiotemporal impacts of hydro-dams on land use/land cover changes in the Lower Mekong River Basin

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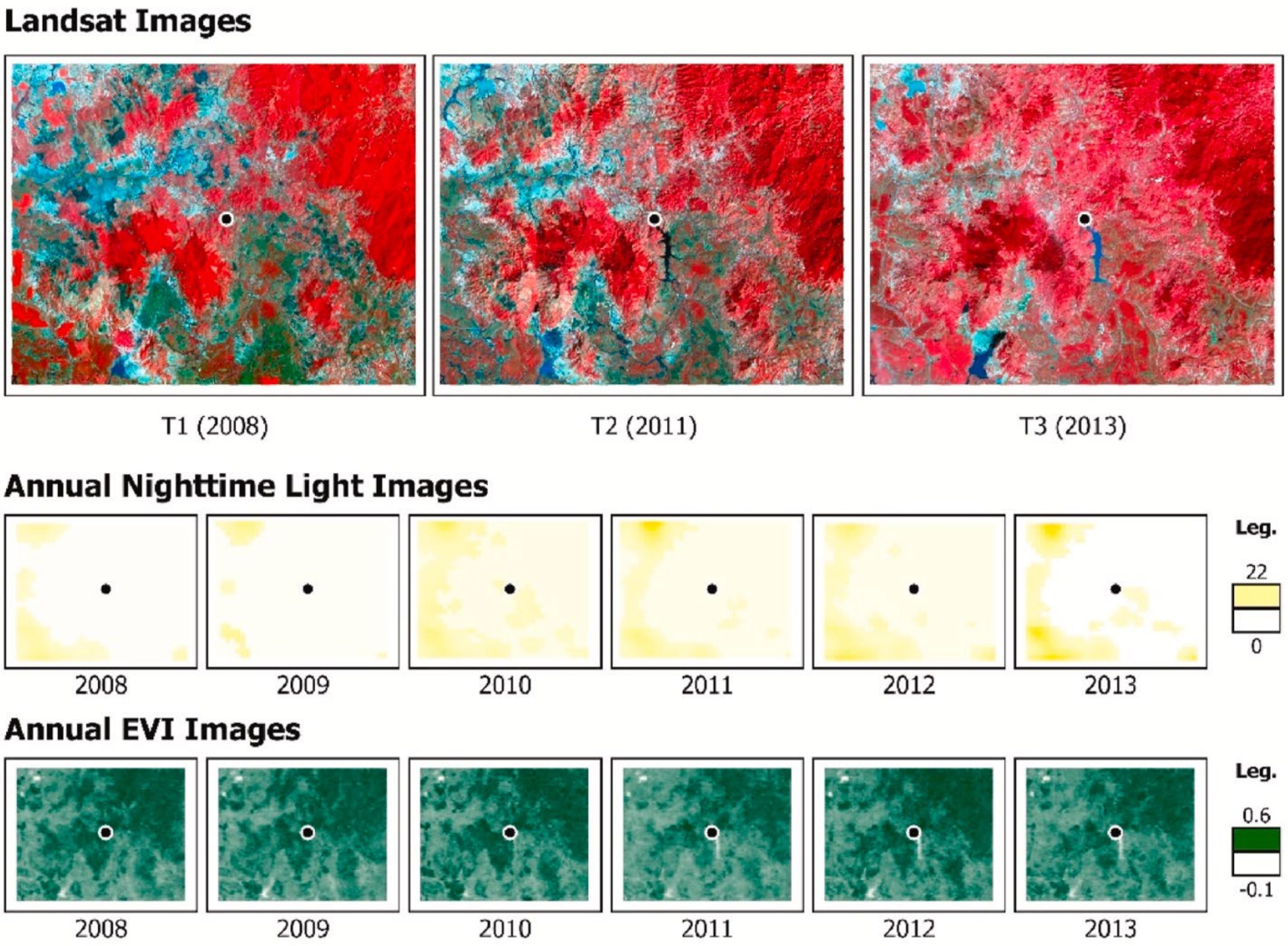
Landsat Images
T1 (2008)
T2 (2011)
T3 (2013)
Annual Nighttime Light Images
2008
2009
2010
2011
2012
2013
Leg.
22
0
Annual EVI Images
2008
2009
2010
2011
2012
2013
Leg.
0.6
-0.1

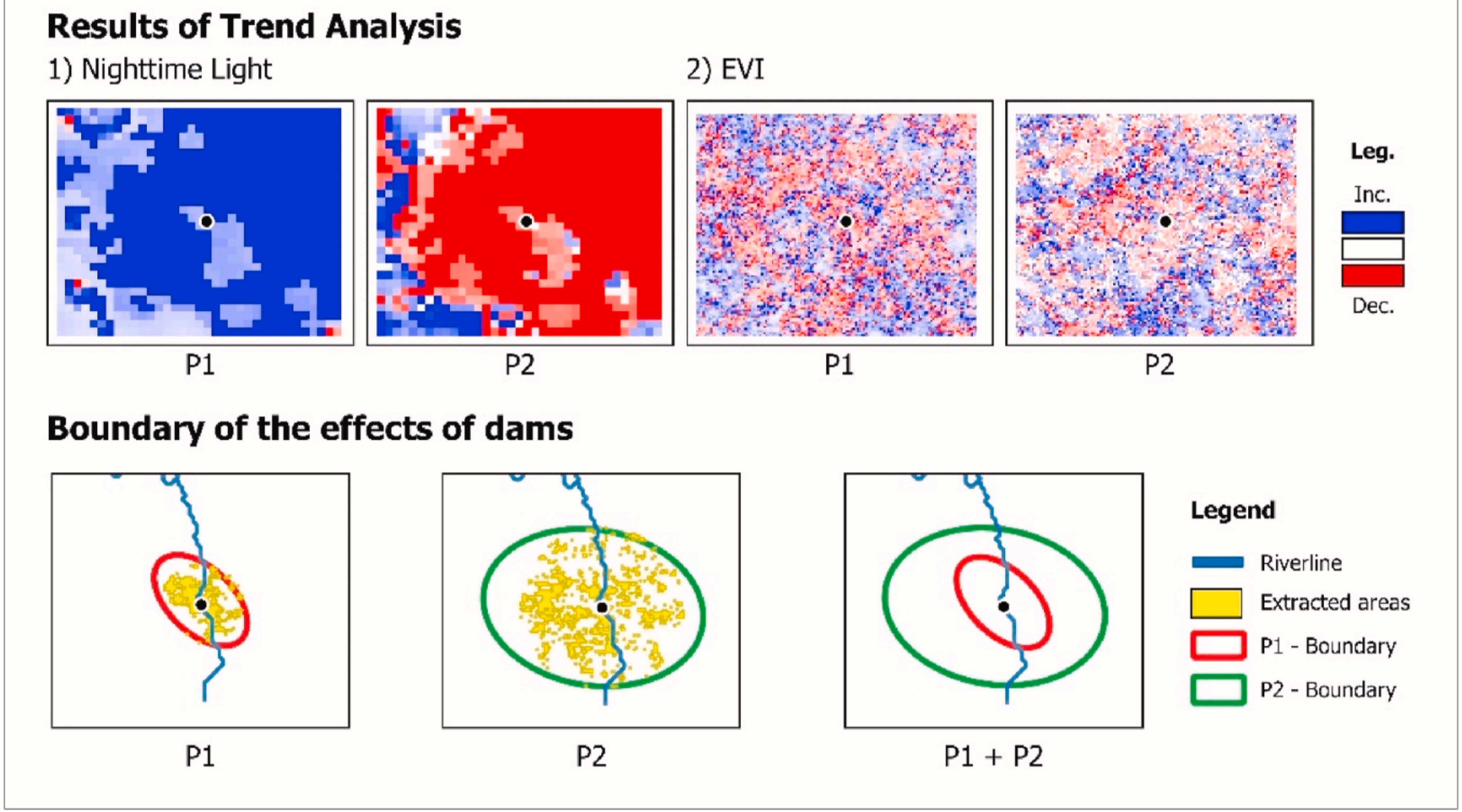

Fig. 5. Delineation of the boundary of the effects of dams: Dak Doa dam (black point). Landsat Images showing the snapshot of T1 (construction starting year - 2008), T2 (commissioned year - 2011), and T3 (stabilized year - 2013) in false color. Annual Nighttime Light Images and EVI Images show the annual snapshot around the dam site. Results of Trend Analysis map show increasing (blue) or decreasing (red) trends of the NLI and EVI. From the slope values of the trend analysis, the dam-influential areas were extracted (yellow areas in bottom row) using the clustering analysis and they were fitted to the ellipse model (red edge – P1 and blue edge – P2). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

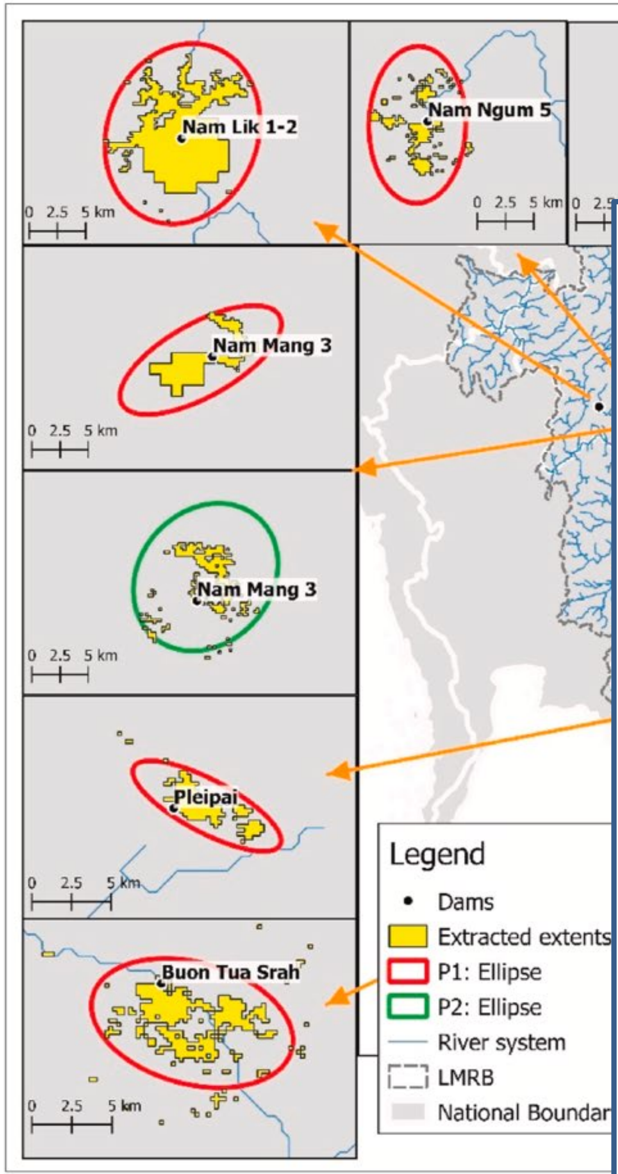

Fig. 6. Spatial extents for the P1 and P2. The filled areas are integ
the integrated extents (see Fig. 4).

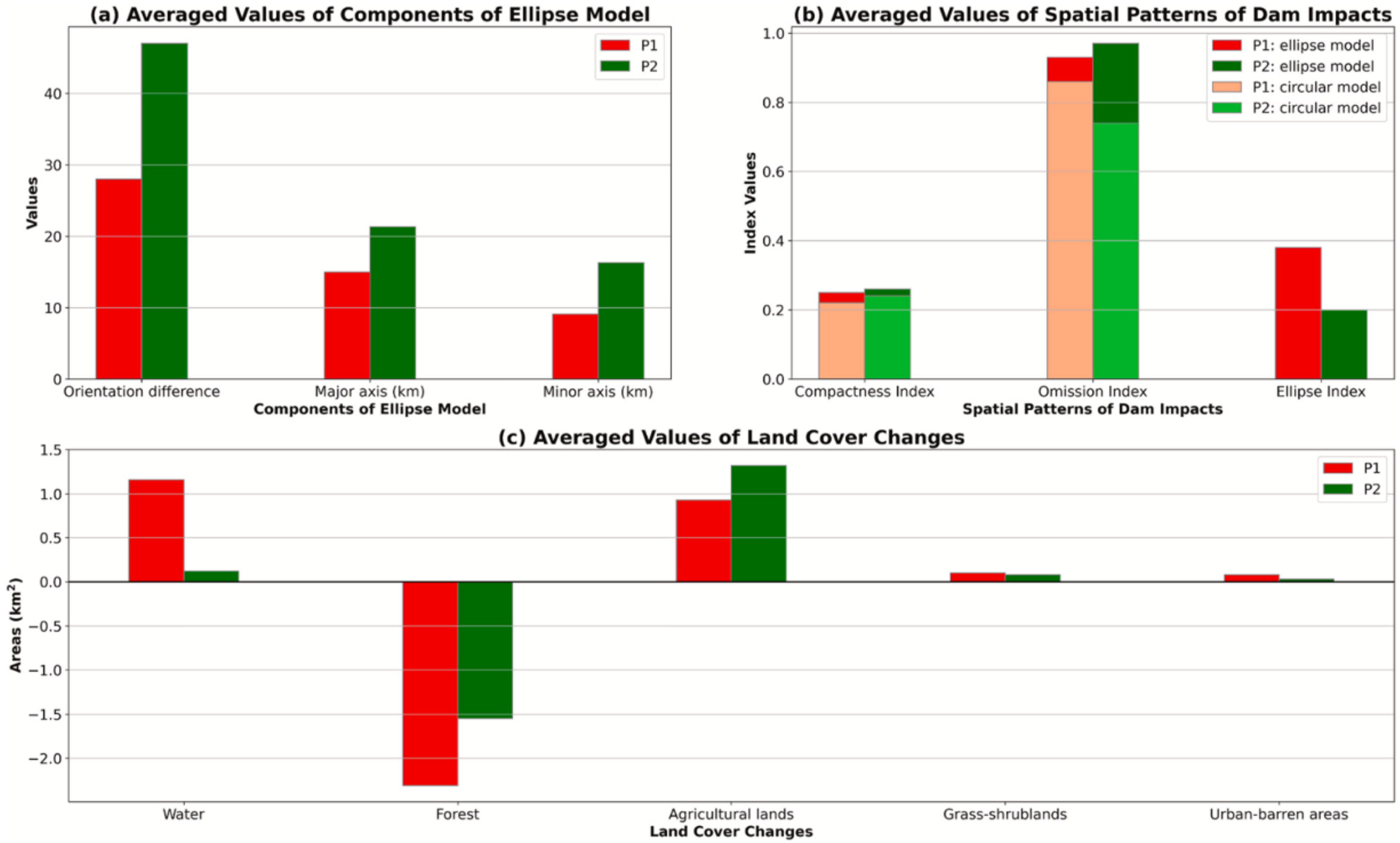

Fig. 7. Comparison of P1 and P2 in components of ellipse model (a), spatial patterns of dam impacts (b), and land cover changes (c). The values were averaged from the dams in P1 and P2, and detail information is in S.1. In (a), the orientation difference (θ_{OD}), the major axis (S_{max}) and the minor axis (S_{min}) of P1 and P2 were compared. In (b), CI and OI of circular model (bright red – P1 and bright green –P2) and those of ellipse model (red – P1 and green – P2) were compared for examining the performance of the ellipse model. Then, CI, OI, and EI of P1 and P2 were compared. In (c), land cover changes of P1 and P2 were compared. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Chapter 8 – The Role of Land in the Water-Energy-Food Nexus

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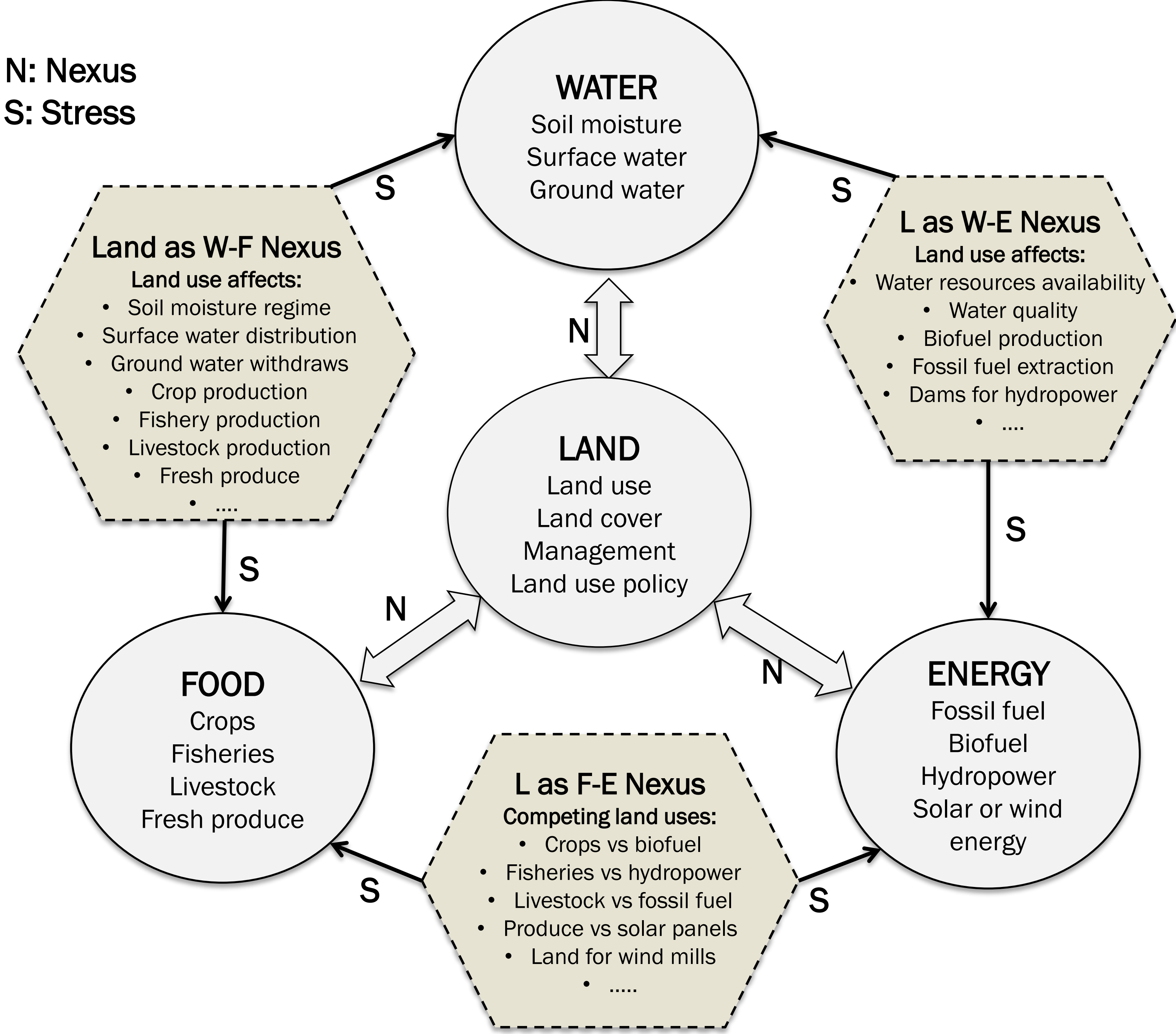


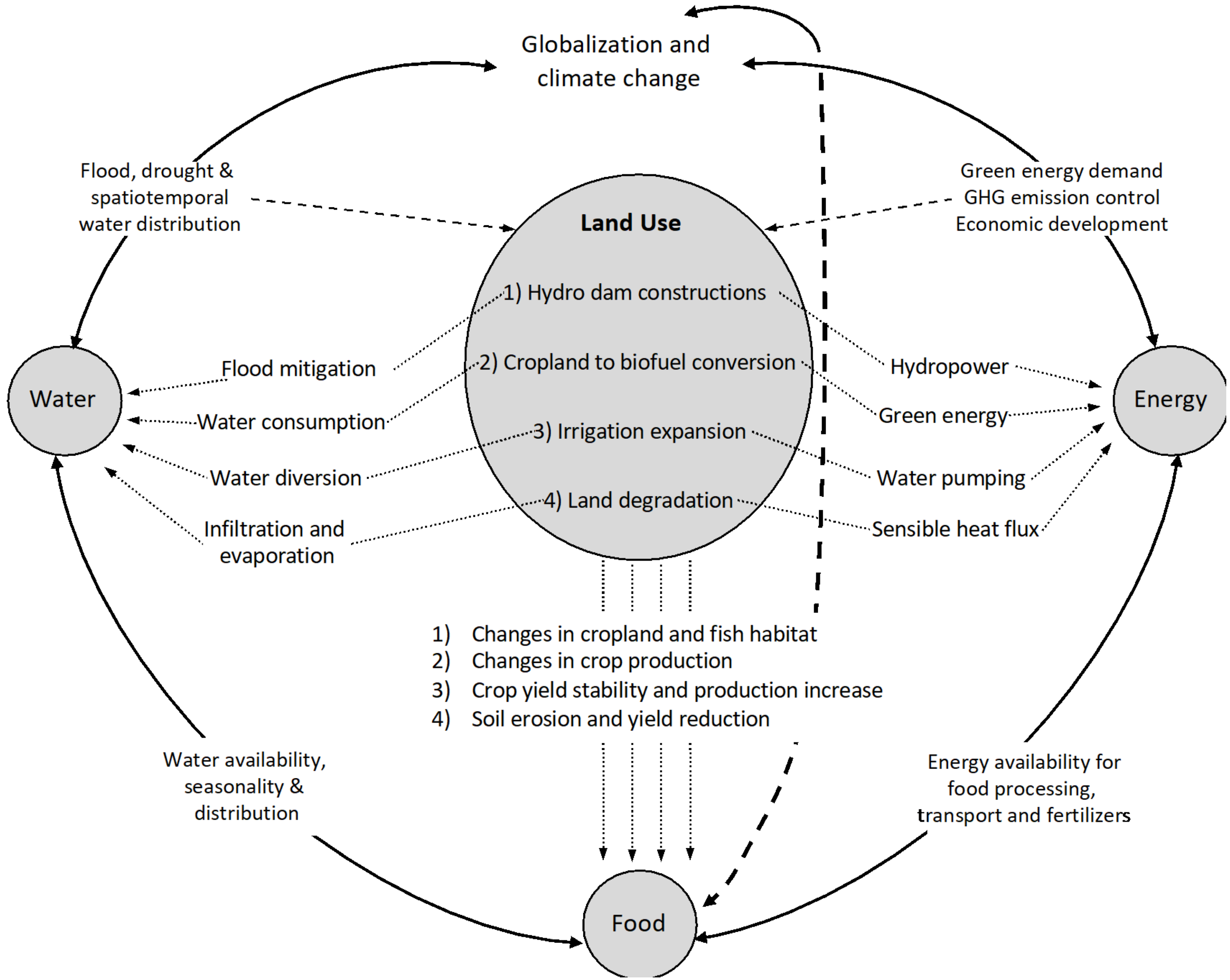


Figure 6. An example land use nexus with water, energy, and food systems in the Mekong River Basin.

Summary Finding

Table 1. Summary of interrelations among water, energy, food, and land systems within the Mekong River Basin.

Land types	Water	Energy	Food
Forests	Water purification, retention, evapotranspiration, erosion protection	Biofuel and woody biomass	Wild vegetables and fruits
Shrublands	Water retention, water quality filtration/purification, erosion protection	Woody biomass and biofuel	Livestock grazing
Grasslands	Water erosion protection and flow regulation	Biomass and biofuel	Livestock grazing
Wetlands	Water resources, water quality, flood buffering		Fisheries, livestock, aquatic vegetables
Croplands	Irrigation, water pollution, infiltration, soil erosion, and freshwater withdraw, evapotranspiration,	Water pumping for irrigation, Biofuel crops, food processing, fertilizer, pesticides	Food crop productions
Aquaculture	Water resources required, water pollution, evaporative loss	Pumping and water circulation, feeding inputs, food processing	Seafood productions
Water bodies	Freshwater storage, supplies and flood buffering	Hydropower, transportation, supplies, water diversion and pumping	Fisheries, livestock consumption, crop irrigation
Snow and ice	Water reservoir, retention, and evaporation	Reflection of solar energy	
Barren	Water erosion, evaporative water loss, flooding	Alternative energy, sensible fluxes	Food stress, wind erosion, loss of soil nutrients
Urban build-up	Freshwater withdraw, water pollution, water stress	Intensive energy consumption	Food consumption
Dams/Reservoirs	Redistribution of water resources, hydrology, irrigation, water storage	Hydropower generation	Crop irrigation, agricultural drought mitigation, and fisheries

Social Survey (Participatory land use planning) co-design, co-production and co-dissemination



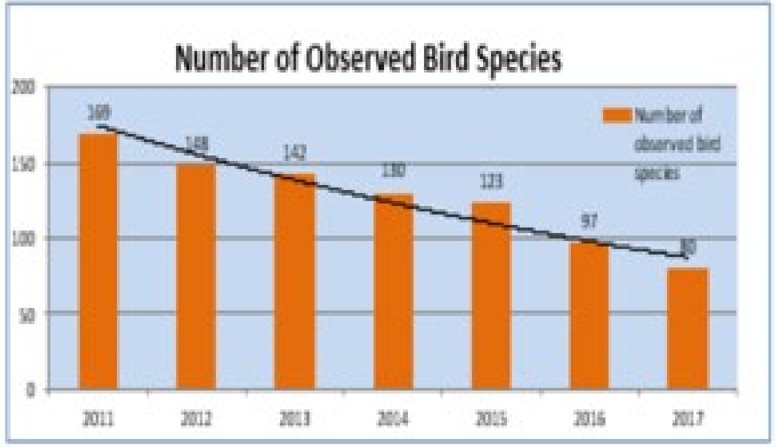





Intralawan et al., 2019

Implications

- ✓More water, energy, chemical used for modern agricultural practices.
- ✓Conflicts/land dispute between user groups
- ✓Trade-off between agriculture products and biodiversity
- ✓The declining of species. The survey confirmed the existence of 138 species consisting of 2 mammals, 117 species of birds, 12 amphibians and 5 reptiles.



Intralawan et al.,

CONCLUSIONS

- **WEF systems in major river basins are highly complex, and there is a need to *collaborate across sector, scale, and borders for national and regional sustainability***
- ***Trade-offs* are critical priority research to balance the long- and short-term needs**
- ***Traditional knowledge* largely ignored**
- **Models have been built and useful for scenario analysis, this policy implications**