Using River Ecosystem Service Framework to identify sweet-spots and hotspots for protection and management in rivers of South East Asia

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Headline

- Land use changes show that **25 % of PAs in the Greater Mekong** are disturbed by human pressures – Moderate to Very Low Degree of Naturalness

- The **River Ecosystem Service Framework** can be used to identify:

    - **Sweet spots** of important ecosystem services

    - **Hot spots** of human pressure

- RESF is being developed as part of a research programme at the University of Edinburgh, UK
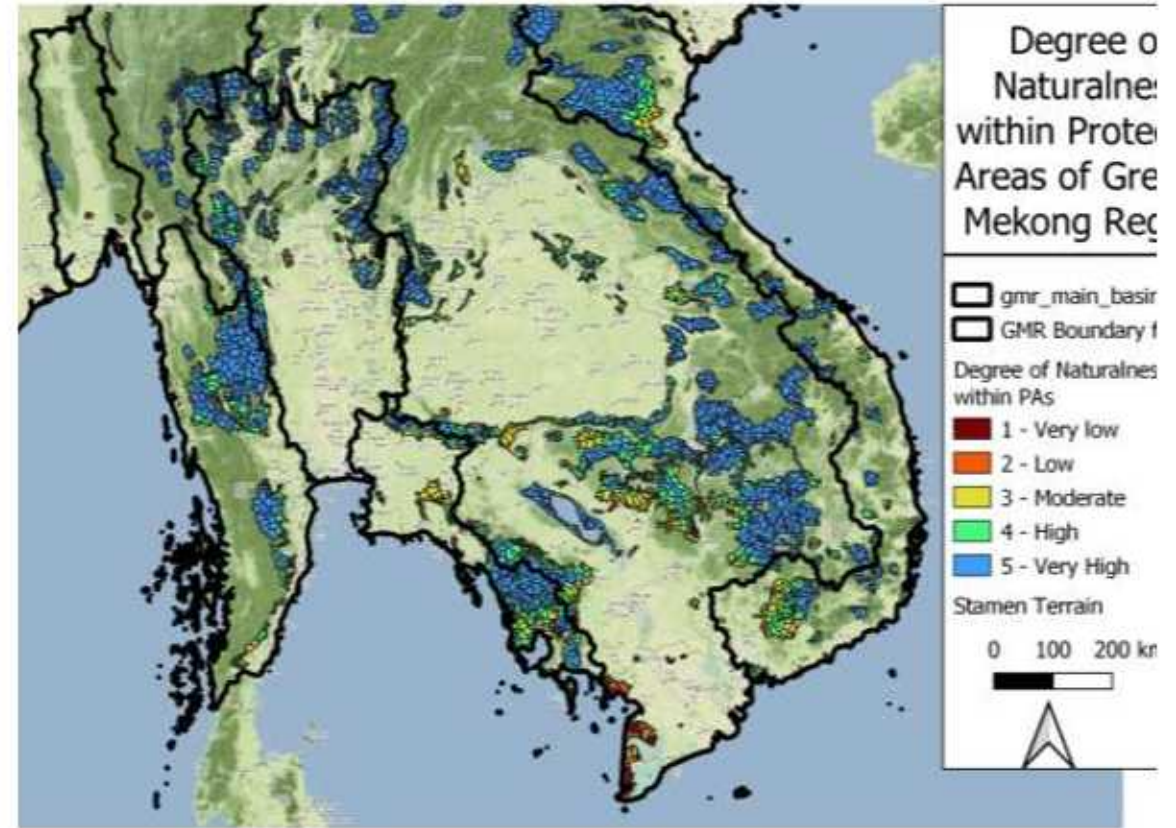
Introducing the RESF for rivers of Greater Mekong Region

- Uses open access geospatial data for river ecology and ecosystem services in GMR

- Uses river reach networks and sub-basins defined by HydroAtlas and river reach classifications e.g. GLoRiC

- Maps and measures indicators of river ecosystem services, and assesses their relative importance by river reach

- Useful for river basin planning, EIAs, monitoring baselines and environmental trends
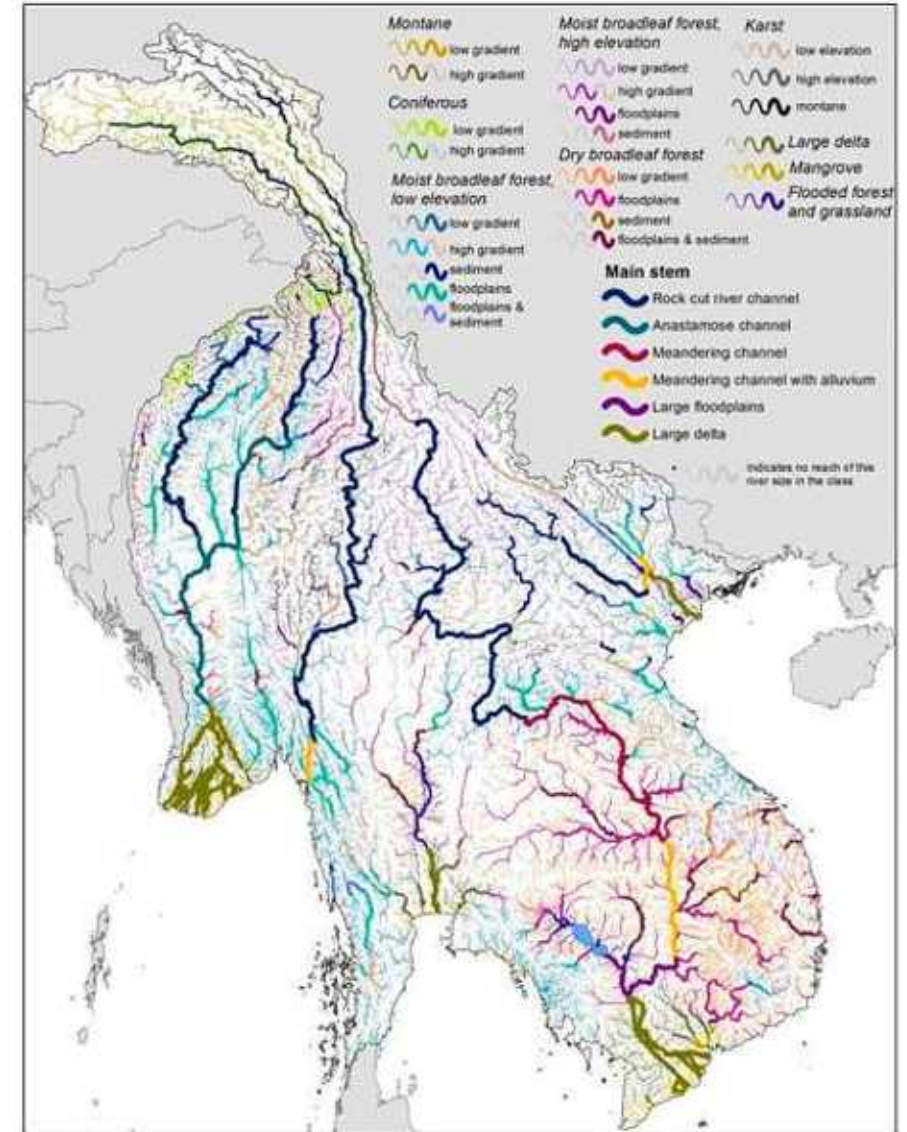
Source: GMR river reach classification, Lehner and Dallaire 2014

Western Tonle Sap river basins to be used as examples – Pursat, Sangker, Dauntri rivers
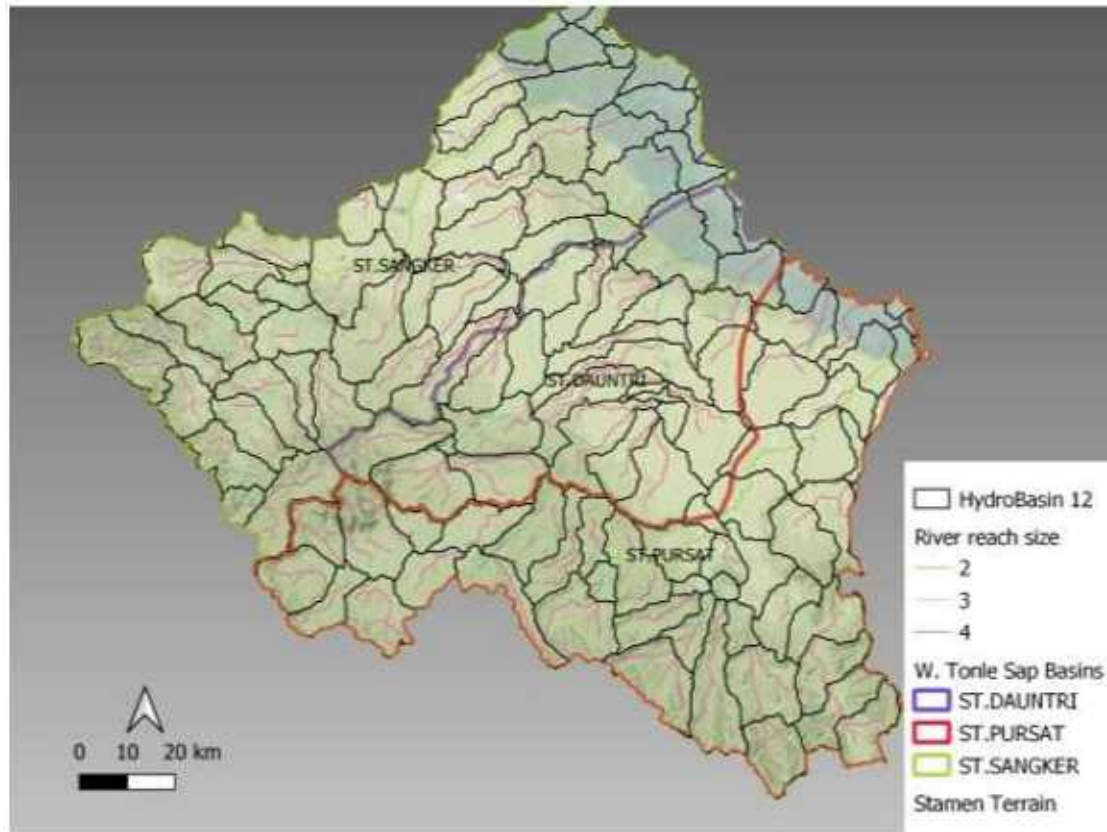
Components of the RESF

- Open access datasets grouped by river basin or sub-basins (HydroBasins) to indicate the relative strength of the parameter

- By river reach using the HydroAtlas networks of rivers classified by size

- Appropriate parameters chosen to indicate river ecosystem services – **Provisioning, Regulating, Supporting and Cultural**

- Relative strength in each hydrobasin assessed and scored on **5 point scale from Very Low to Very High** according to **significance criteria**

- These are mapped to indicate:
  - "**sweet spot**" areas or river reaches, that are ecologically important and
  - "**hotspot**" areas that are at risk or threatened by development pressures

Significance criteria	
Rarity	Productivity
Diversity	Regulating capacity
Connectivity	Integrity

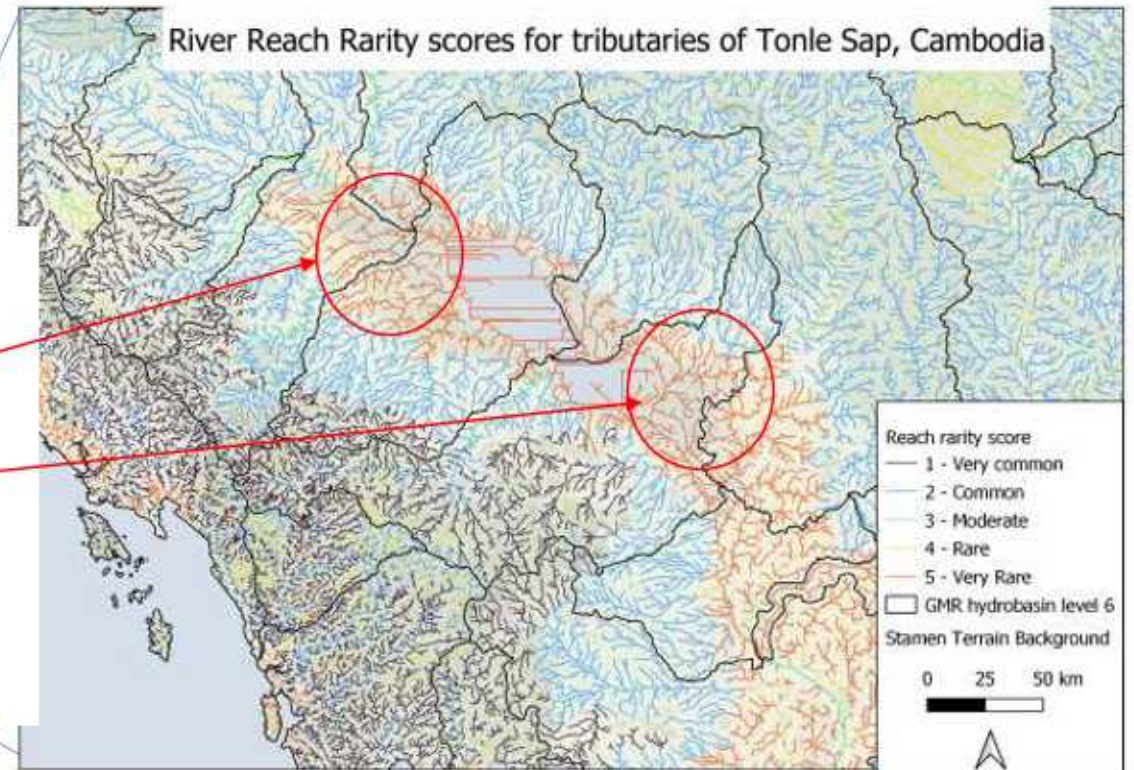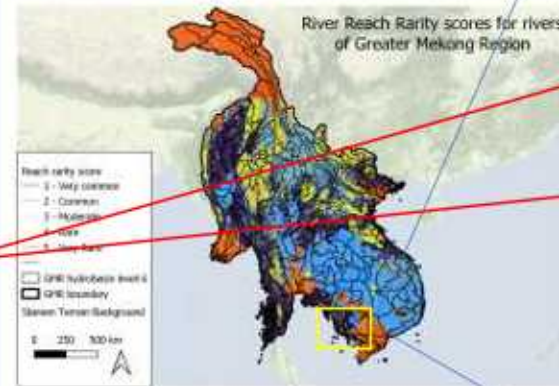# Identifying ecologically important river reaches –

Indicator : River reach rarity

Different reach classes are likely to have different ecologies – rare reach classes have more unique features
Dataset: GMR River reach classification, Lehner and Dallaire (2014)

Reach Rarity	% scale	Rarity score
Very rare	0 - 5	5
Rare	5.01 - 10	4
Medium	10.01 - 15	3
Common	15.01 - 25	2
Very common	>25	1

- **River reach rarity** calculated by taking % of length of each reach size class divided by the total length within the GMR
- Scored according to % scale

For example:

- Highlights the river reaches around the Tonle Sap as being **Very Rare**
- Large, Medium and Small rivers in **Flooded Forest and Grassland with and without Floodplains**

River Reach Rarity scores for tributaries of Tonle Sap, Cambodia

River Reach Rarity scores for rivers of Greater Mekong Region

Identifying ecologically important river reaches within Protected Areas in GMR

Proportion of river reaches in Protected Areas in GMR - River reach protection score

0   250   500 km

Reach protection score
— 1 - Very low protection
— 2 - Low protection
— 3 - Moderate protection
— 4 - High protection
— 5 - Very high protection
☐ GMR hydrobasin level 6
☐ GMR Boundary fixed

- **Indicator**: River reaches within Protected Areas are more important
    a) because the areas have been selected for their natural significance – Cultural and Biodiversity ecosystem service
    b) they have some sort of protection already.

- **Dataset**: Protected Planet data base of protected areas from UNEP/WCMC/IUCN

Proportion of river reaches in Protected Areas around Tonle Sap - River reach protection score

0   25   50 km

Reach protection score
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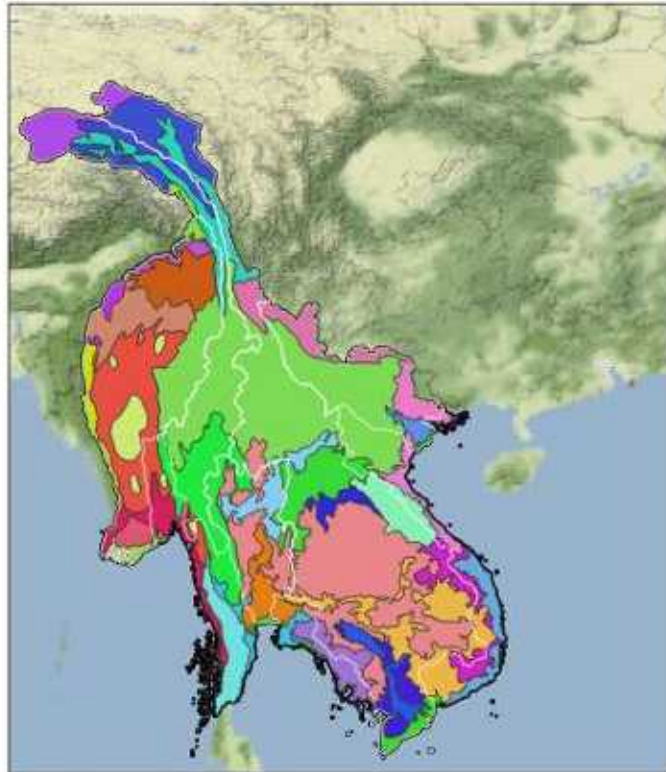☐ GMR hydrobasin level 6
☐ GMR Boundary fixed
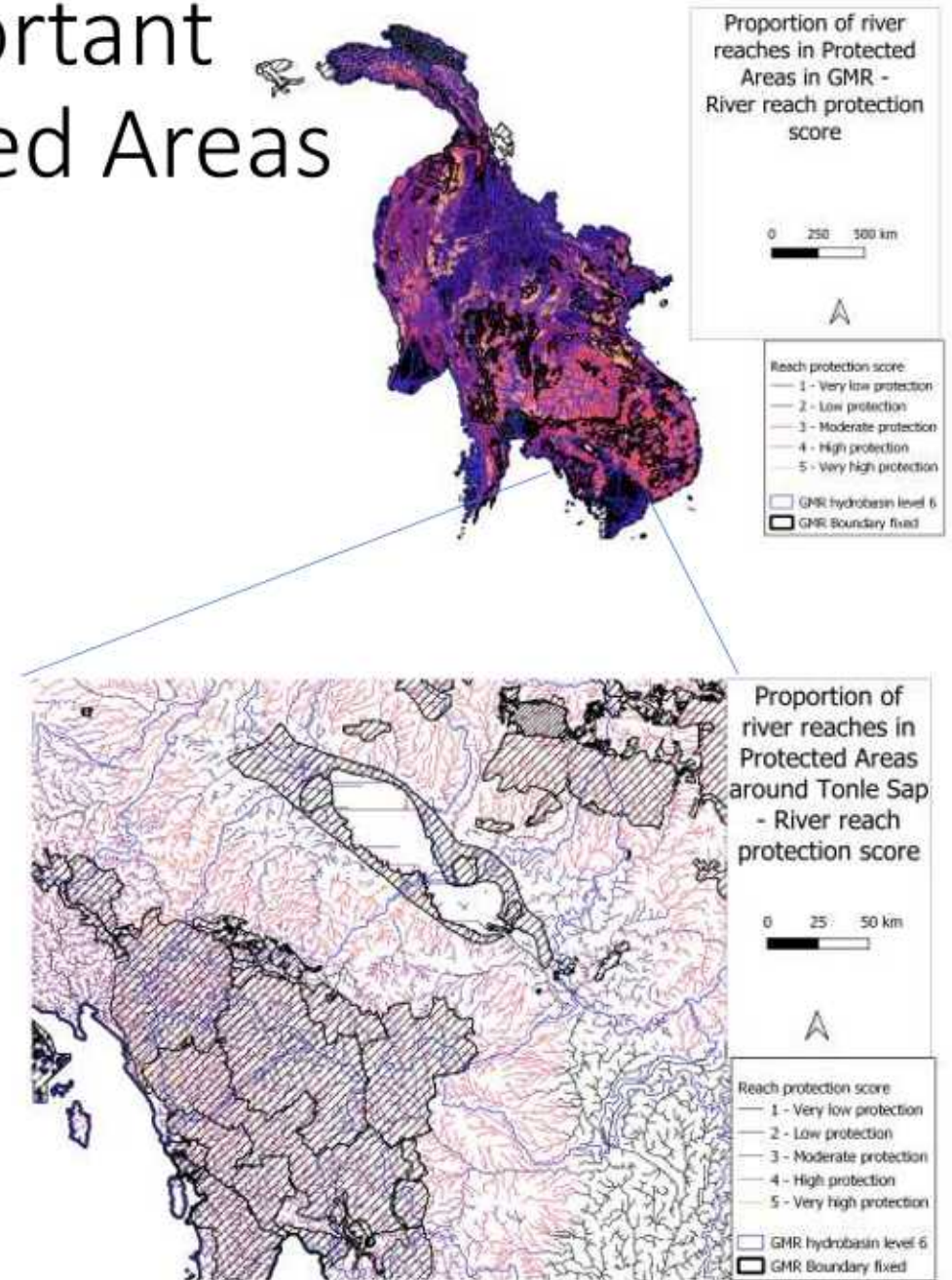
Identifying ecologically important river sub-basins

Indicator: Distribution of **WWF Ecoregions in Greater Mekong** – ecoregions have different ecological features in rivers and sub-basins
Ecoregion Rarity and **Ecoregion Diversity**
Data: WWF Terrestrial Ecoregions of the World

Scoring Ecoregion Rarity by HydroBasin level 12

- **Ecoregion rarity** is a measure of the proportion of each Ecoregion within the overall area of the Greater Mekong

- The **lower** this proportion, the **more rare** the ecoregion and therefore the more likely to have **unique aquatic biodiversity** in each HydroBasin

- Cardamom mountains and Tonle Sap ecoregions are Rare

- Ecoregions to the north of the Tonle sap are more common
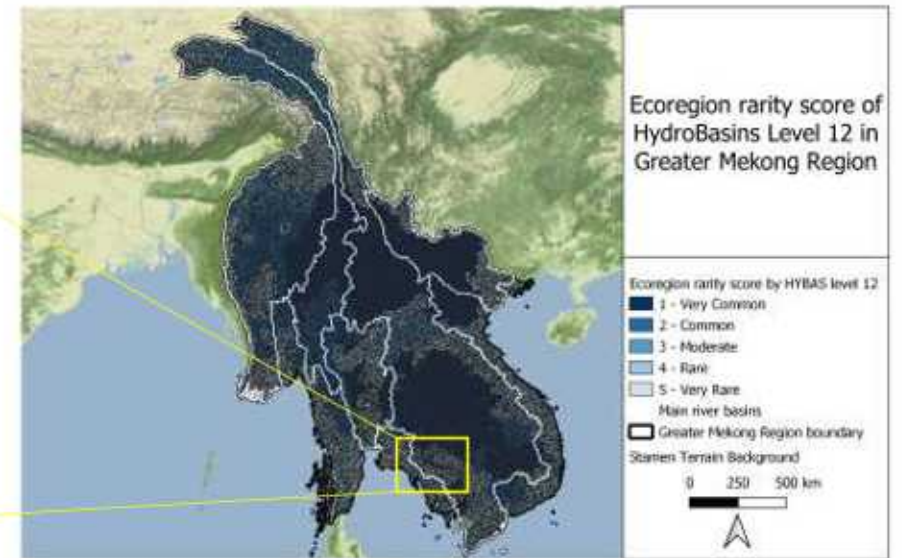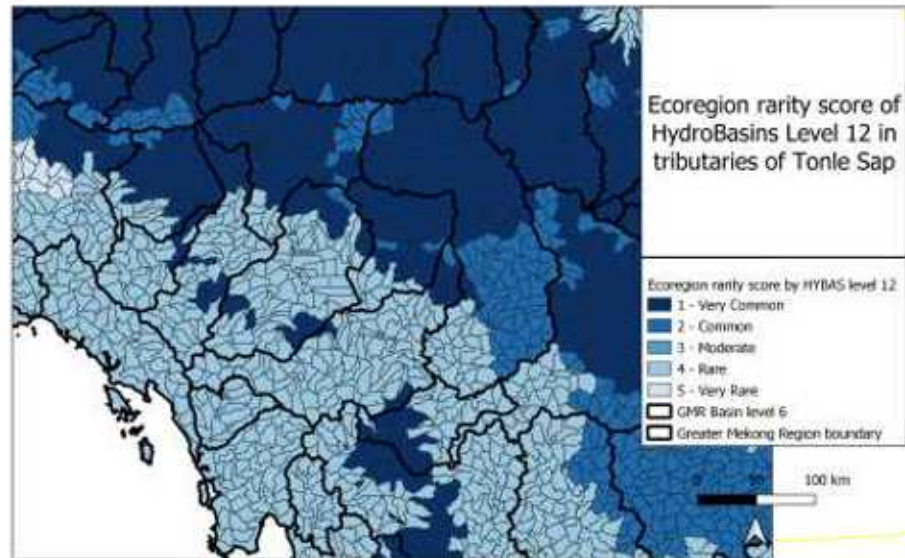
Ecoregion Diversity of tributaries in the Greater Mekong and in Tonle Sap

Diversity of Terrestrial Ecoregions in Hydrobasins Level 6 of the Greater Mekong Region

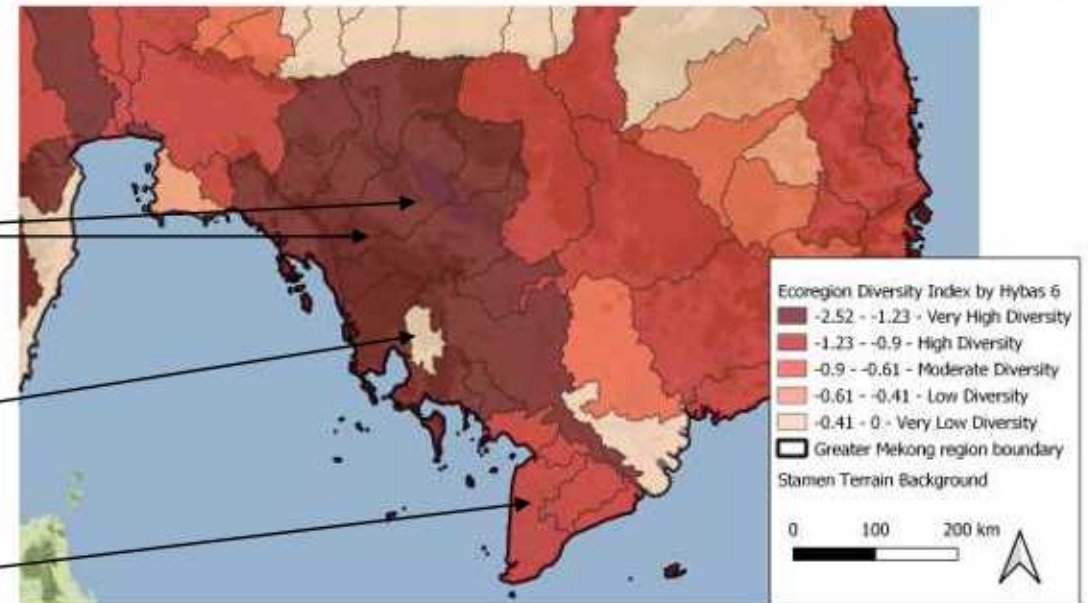- Ecoregion Diversity of Hydrobasins 6 calculated by Shannon Diversity Index of areas of different ecoregions occurring in each hydrobasin

- Ecoregion Diversity Index is a measure of the ecological diversity of the different tributaries –
  - **Low index** - river runs through one ecoregion, and may have a **more unique aquatic biodiversity**, **representative** of the ecoregion
  - **High index** - river runs through multiple ecoregions and is more likely to have **higher aquatic biodiversity**

- Tonle Sap Great Lake and tributaries within Cardamom mountains have **very high** ecoregion diversity

- Small basin has **very low** ecoregion diversity index and may have unique river ecosystem **representative** of the south facing slopes of the Cardamom mountains

- Mekong Delta has **high** ecoregion diversity
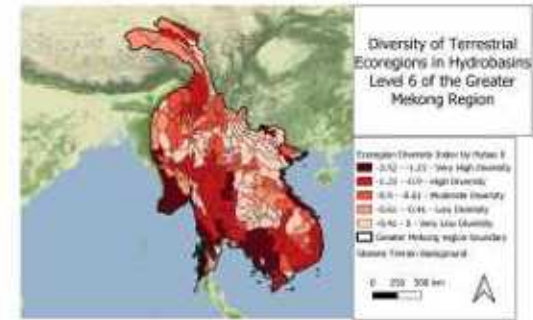
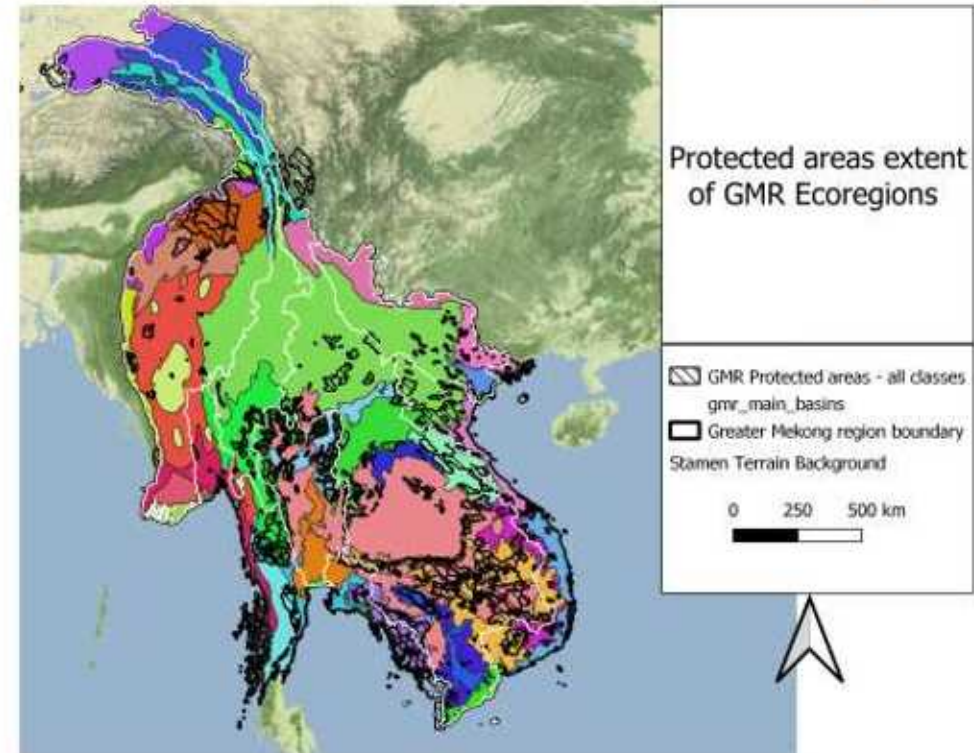

Diversity of Terrestrial Ecoregions in Hydrobasins Level 6 in tributaries of the Tonle Sap and Mekong Delta

Ecoregion Diversity Index by Hybas 6
- -2.52 - -1.23 - Very High Diversity
- -1.23 - -0.9 - High Diversity
- -0.9 - -0.61 - Moderate Diversity
- -0.61 - -0.41 - Low Diversity
- -0.41 - 0 - Very Low Diversity
- Greater Mekong region boundary
Stamen Terrain Background

0   100   200 km

Identifying proportions of Ecoregions lying within Protected Areas

- Protected areas - indicator that basins and river reaches in them are ecologically important
- When combined with ecoregions, indicates proportion of ecoregion under protection
- Use the Protected Planet data base of protected areas from UNEP/WCMC/IUCN
- IUCN Class of PA may indicate different levels of protection/management

Protected Areas in the Greater Mekong Region

GMR Protected areas – IUCN Class
- Ia
- II
- III
- IV
- V
- VI
- Not Applicable
- Not Reported
- gmr_main_basins
- Greater Mekong region boundary
Stamen Terrain Background

0   250   500 km

Protected areas extent of GMR Ecoregions

- GMR Protected areas - all classes
- gmr_main_basins
- Greater Mekong region boundary
Stamen Terrain Background

0   250   500 km

Distribution, rarity and protection of GMR Ecoregions

Scoring on scale of 1 to 5 for rarity and proportion of ecoregion areas lying within PAs

Rarest ecoregions in GMR often have the least coverage of Protected Areas

- Chao Phraya Lowland moist deciduous forests
- Chin Arakan Yoma
- tane rain forests
- Myanmar Coast mangroves
- Northeast India-Myanmar pine forests
- Northern Khorat Plateau moist deciduous forests
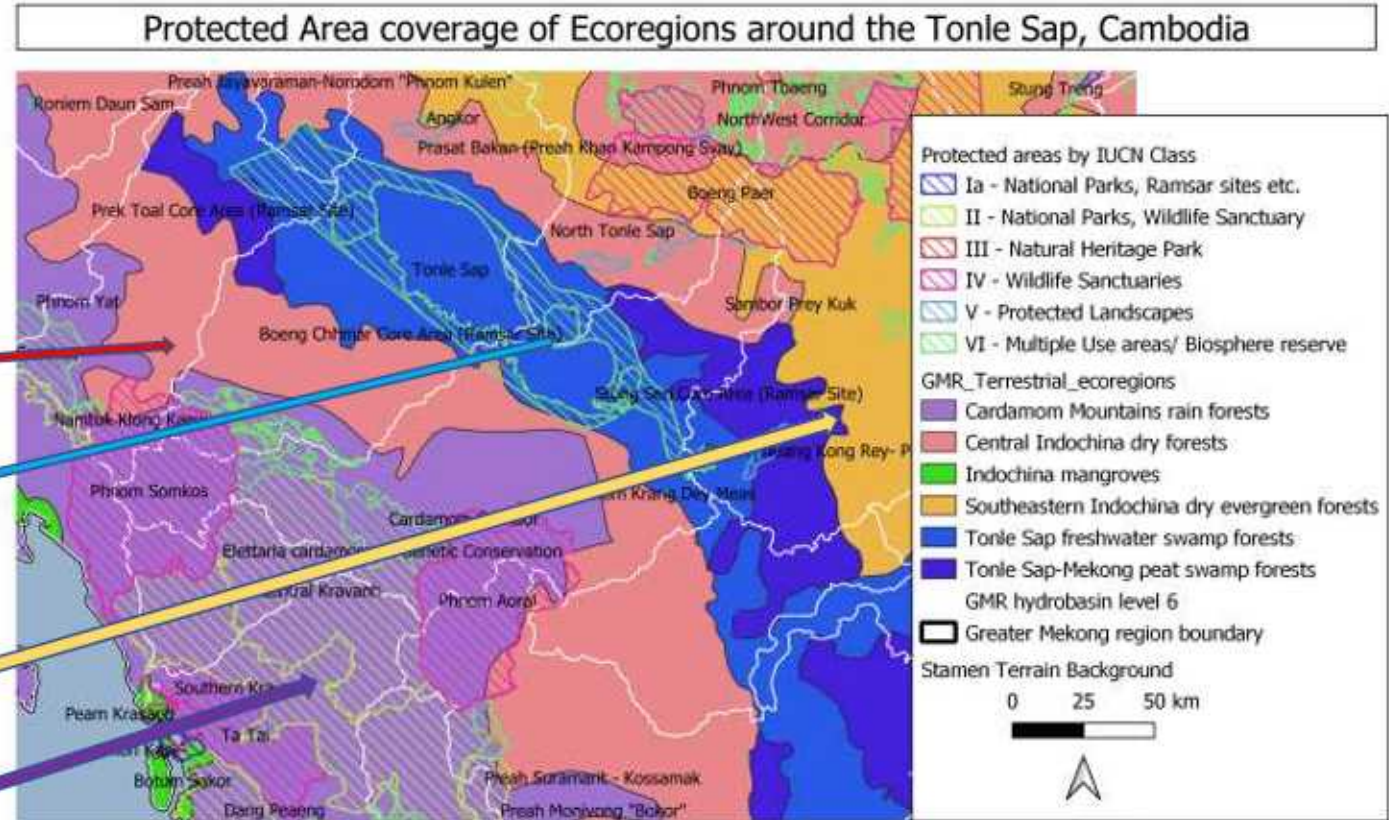- Northern Triangle temperate forests
- Red River freshwater swamp forests

% range	Protected Score	Protection
0 - 20	1	Very low
21 - 40	2	Low
41 - 60	3	Moderate
61 - 80	4	High
81 - 100	5	Very high

Rarity %	Rarity score	Rarity
>10	1	Very Common
5-10	2	Common
1-5	3	Moderate
0.5 - 1	4	Rare
<0.5	5	Very rare

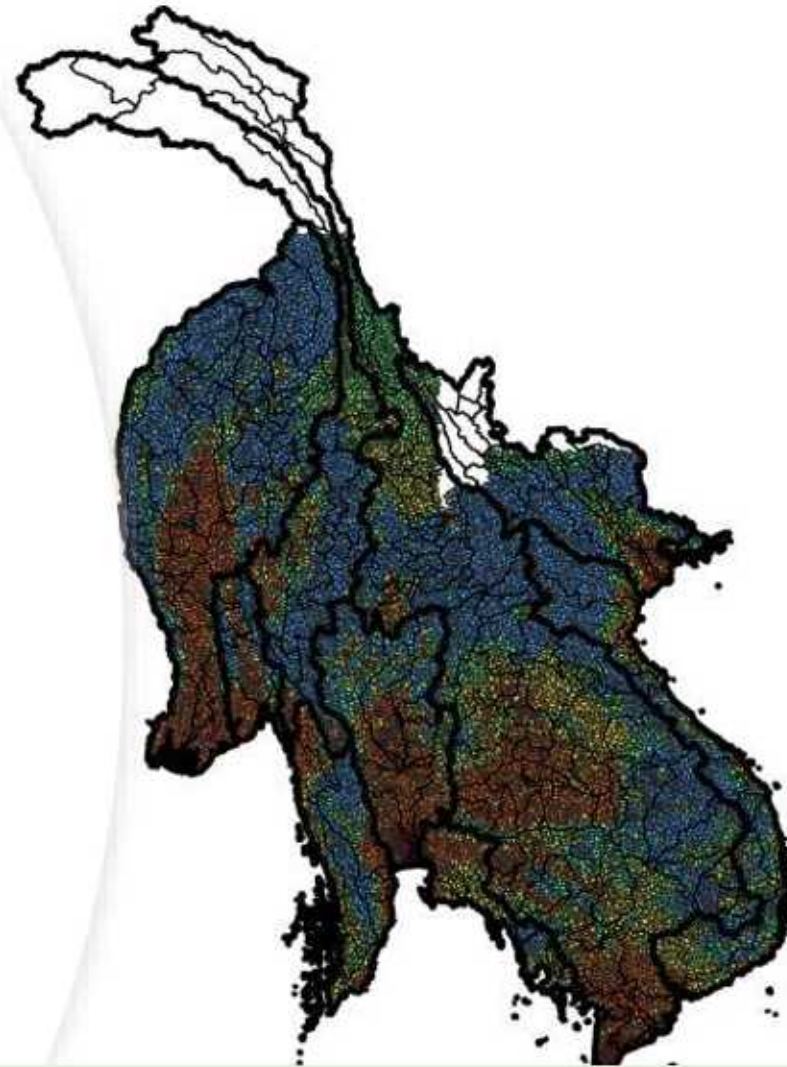| Ecoregion	Total area	Area in GMR	% within GMR	Ecoregion Rarity in GMR	Rarity score	Area in PA	% inside PA	% outside PA	Protected score
	km2	km2	%	%		km2	%	%	1-5
Cardamom mountains rainforest	44,074	44,678	101	2.01	3	24,696	55.27	44.73	3
Central Indochina dry forests	318,937	320,749	101	14.44	1	45,138	14.07	85.93	1
Chao Phraya swamp forests	38,858	38,892	100	1.75	3	68	0.15	99.85	1
Chao Phraya Lowland moist deciduous forests	20,337	20,338	100	0.92	4	2,641	12.99	87.01	1
Chin Arakan Yoma montane forests	29,617	16,613	56	0.75	4	1,179	7.10	92.90	1
Eastern Himalayan alpine shrub and meadows	121,014	9,849	8	0.44	5	4,932	50.07	49.93	3
Eastern Himalayan broadleaf forests	82,916	152	0	0.01	5	51	33.81	66.19	2
Eastern Himalayan sub-alpine conifer forests	27,436	15	0	0.00	5	9	60.80	39.20	4
Hengduan Mountains subalpine conifer forests	99,291	13	0	0.00	5	-	-	100.00	1
Indochina mangroves	26,762	22,655	85	1.02	3	3,401	15.01	84.99	1
Irrawaddy dry forests	34,987	34,987	100	1.57	3	146	0.42	99.58	1
Irrawaddy freshwater swamp forests	15,107	15,106	100	0.68	2	6	0.42	99.58	1
Irrawaddy moist deciduous forests	137,910	137,910	100	6.21	2	3,365	2.44	97.56	1
Kayah-Karen montane rain forests	119,158	125,357	105	5.64	5	43,591	34.77	65.23	2
Luang Prabang montane rain forests	71,585	71,614	100	3.22	3	16,119	22.51	77.49	2
Mizoram-Manipur-Kachin rain forests	135,245	62,169	46	2.80	3	4,411	7.10	92.90	1
Myanmar Coast mangroves	21,238	12,071	57	0.54	4	267	2.21	97.79	1
Myanmar coastal rainforests	66,332	46,811	71	2.11	3	521	1.11	98.89	1
Northeast India-Myanmar pine forests	9,685	8,291	86	0.37	5	-	-	100.00	1
Northeastern Himalayan subalpine conifer forests	46,220	123	0	0.01	5	-	-	100.00	1
Northern Annamites rain forests	47,053	48,992	104	2.21	3	18,391	37.54	62.46	2
Northern Indochina subtropical forests	435,869	436,489	100	19.65	1	31,821	7.29	92.71	1
Northern Khorat Plateau moist deciduous forests	16,794	16,794	100	0.76	4	900	5.36	94.64	1
Northern Thailand-Laos moist deciduous forests	42,010	42,014	100	1.89	3	10,215	24.31	75.69	2
Northern Triangle subtropical forests	53,774	53,774	100	2.42	3	19,110	35.54	64.46	2
Northern Triangle temperate forests	10,709	10,678	100	0.48	5	4,375	40.97	59.03	1
Northern Vietnam lowland rain forests	22,522	22,804	101	1.03	3	4,499	19.73	80.27	1
Nujiang Langcang Gorge alpine conifer and mixed forests	82,699	70,588	85	3.18	3	10,339	14.65	85.35	1
Red River freshwater swamp forests	10,724	10,730	100	0.48	5	199	1.86	98.14	1
Rock and Ice		465	-	0.02	5	-	-	100.00	1
South China-Vietnam subtropical evergreen forests	223,724	25,955	12	1.17	3	2,210	8.51	91.49	1
Southeast Tibet shrublands and meadows	460,542	89,054	19	4.01	3	2	0.00	100.00	1
Southeastern Indochina dry evergreen forests	123,784	130,590	105	5.88	2	49,592	37.98	62.02	2
Southern Annamites montane rain forests	46,314	46,585	101	2.10	3	10,856	23.30	76.70	2
Southern Vietnam lowland dry forests	34,905	34,925	100	1.57	3	2,544	7.29	92.71	1
Tenasserim-South Thailand semi-evergreen rain forests	96,930	45,533	47	2.05	3	9,996	21.95	78.05	2
Tibetan Plateau alpine shrublands and meadows	271,999	42,965	16	1.93	3	1,820	4.23	95.77	1
Tonle Sap freshwater swamp forests	25,926	26,322	102	1.18	3	3,757	14.27	85.73	1
Tonle Sap-Mekong peat swamp forests	29,262	29,752	102	1.34	3	3,608	12.13	87.87	1
Yunnan Plateau subtropical evergreen forests	239,854	48,153	20	2.17	3	72	0.15	99.85	1
Total	3,742,103	2,221,554	59	100.00		334,848	15.07	84.93	

Protected Area coverage of Ecoregions around the Tonle Sap

- Central Indochina dry forests are **very common - very low protection**

- Tonle Sap freshwater swamp forests and peat forests are **moderately rare, with very low protection**

- Southeastern Indochina dry evergreen forests are **common with low protection**

- Cardamom mountain rainforests are **moderately rare and moderately protected**

Protected Area coverage of Ecoregions around the Tonle Sap, Cambodia

Protected areas by IUCN Class
- Ia - National Parks, Ramsar sites etc.
- II - National Parks, Wildlife Sanctuary
- III - Natural Heritage Park
- IV - Wildlife Sanctuaries
- V - Protected Landscapes
- VI - Multiple Use areas/ Biosphere reserve

GMR_Terrestrial_ecoregions
- Cardamom Mountains rain forests
- Central Indochina dry forests
- Indochina mangroves
- Southeastern Indochina dry evergreen forests
- Tonle Sap freshwater swamp forests
- Tonle Sap-Mekong peat swamp forests
- GMR hydrobasin level 6
- Greater Mekong region boundary

Stamen Terrain Background

0   25   50 km

Using landcover data – Degree of Naturalness by sub-basin in GMR

Landcover type	Naturalness Weighting %
Unknown	70
Surface Water	70
Mangroves	100
Flooded Forest	100
Forest	100
Orchard or Plantation Forest	50
Evergreen Broadleaf	100
Mixed Forest	100
Urban and Built Up	10
Cropland	40
Rice	30
Mining	10
Barren	10
Wetlands	100
Grassland	70
Shrubland	70
Aquaculture	10

Greater Mekong Region Naturalness Class by HydroBasin 12

GMR Naturalness Class
- 1 - Very Low Naturalness
- 2 - Low Naturalness
- 3 - Moderate Naturalness
- 4 - High Naturalness
- 5 - Very High Naturalness
- GMR hydrobasin level 6
- gmr_main_basins
- GMR Boundary fixed

0   250   500 km

- **Indicator:** Weighted area of different landcover units within each HydroBasin level 12
- **Naturalness Weighting** % multiplied by area of landcover units in each HydroBasin
- **Dataset:** Servir Mekong Landcover 2019 (Myanmar, Thailand, Cambodia, Laos, Vietnam)

Degree of Naturalness by sub-basin around Tonle Sap

- **Very Low** Degree of Naturalness in Thailand north-west of Tonle Sap

- Populated and cultivated Land area around Tonle Sap shows bands of **low and very low degree of naturalness**

- Cardamom mountains show high and **very high degrees of naturalness**

- Follows patterns of Protected area coverage of ecoregions

Naturalness class by HydroBasin in Tributaries the Tonle Sap

GMR Naturalness Class
- 1 - Very Low Natural
- 2 - Low Naturalness
- 3 - Moderate Natura
- 4 - High Naturalness
- 5 - Very High Natura
- GMR hydrobasin leve
- gmr_main_basins
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0   250
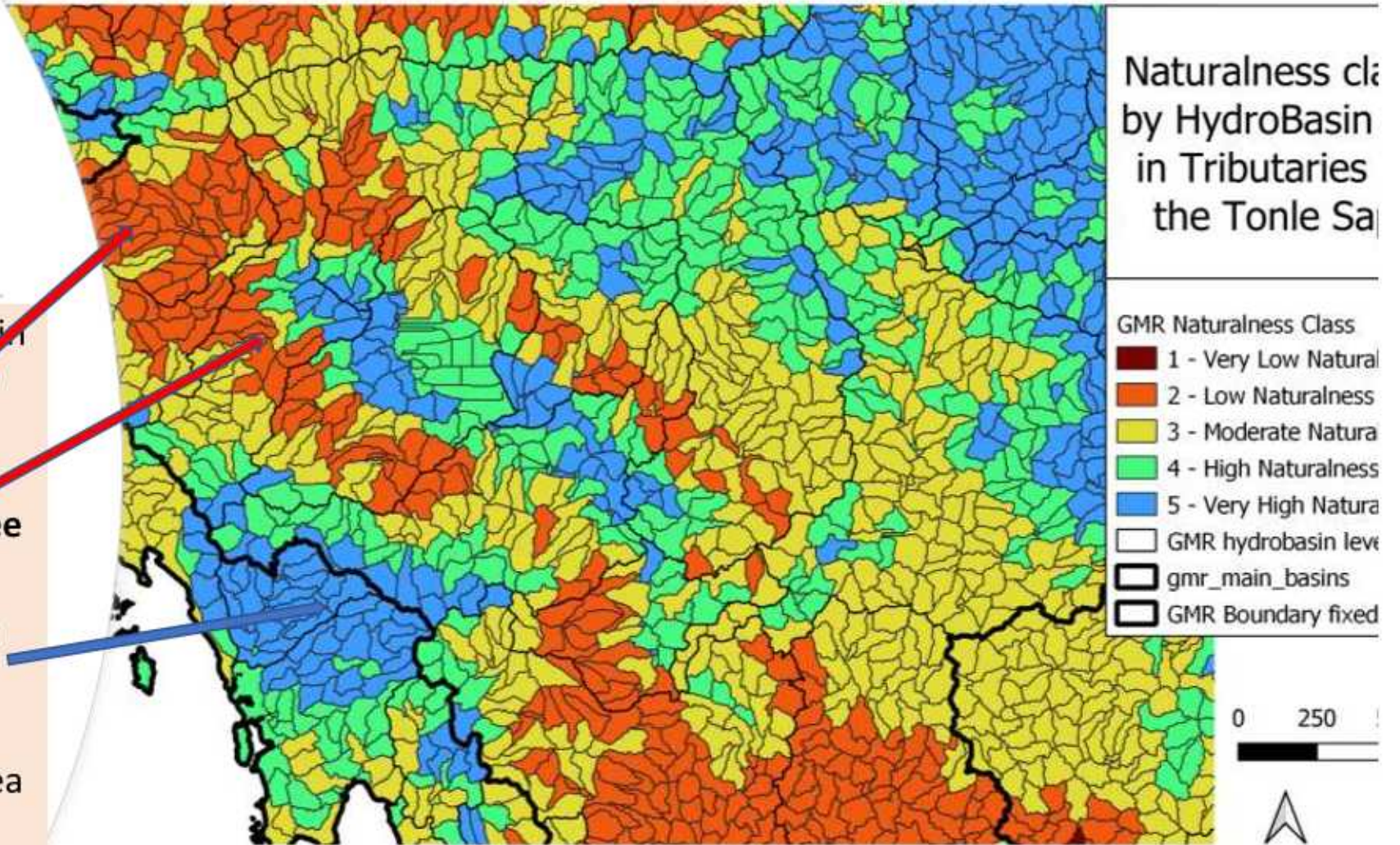
# Degree of Naturalness within Protected Areas

- Sub-basins within PAs encroached or damaged by change of landuse or deforestation

- Hotspots of low degree of naturalness within sweet spots of PAs

Degree of Naturalness within Protected Areas around the Tonle Sap
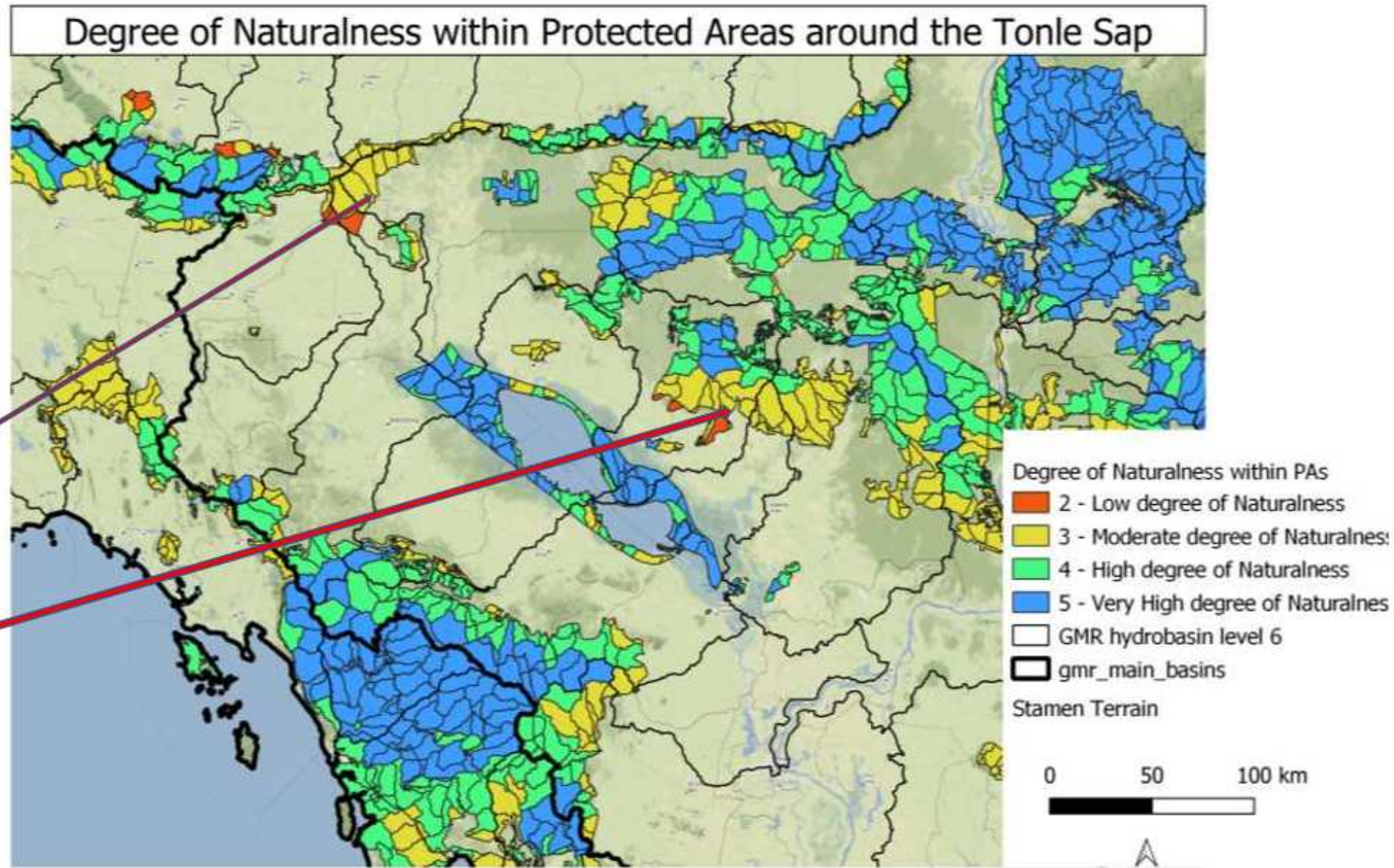
Human Pressure Index

Index developed from composite of indicators, analysed by HydroBasin 12:

- **Connectivity** – locations of hydropower, irrigation dams and weirs

- **Linear infrastructure** – roads, canals, transmission lines

- **Urban infrastructure**

- **Agriculture intensity**

- **Population density**
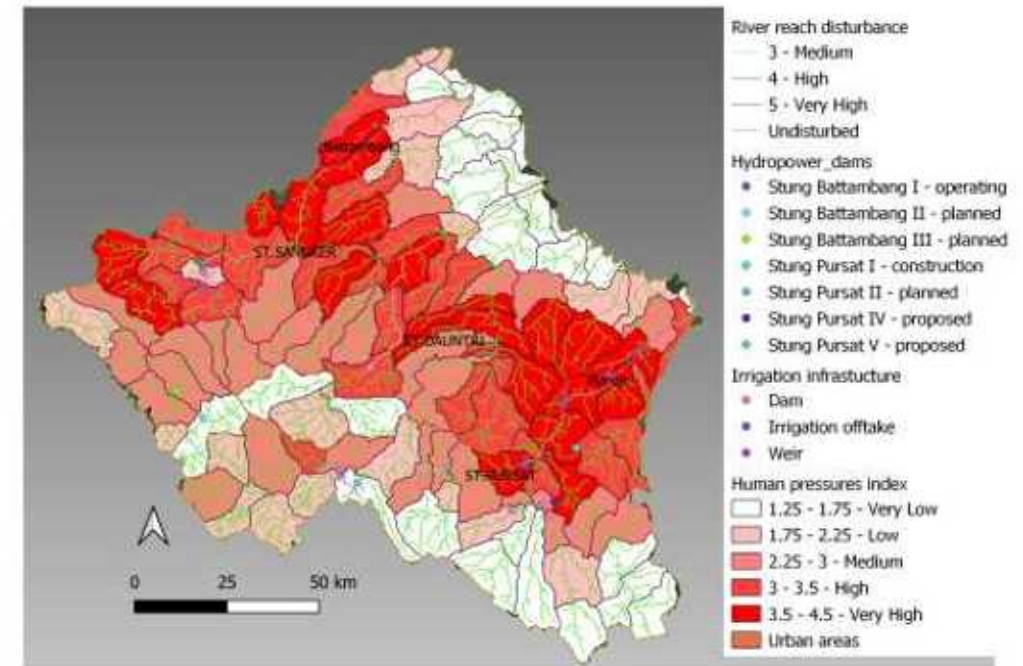
Western Tonle Sap basins
- Urban areas of Battambang and Pursat show up as very high pressure
- Central belt of lowland paddy agriculture is also high pressure
- Some PAs e.g. Samlaut and Phnom Somkos and Central Cardamoms also show increasing disturbance

Human Pressure Index on river network of Western Tonle Sap river basins
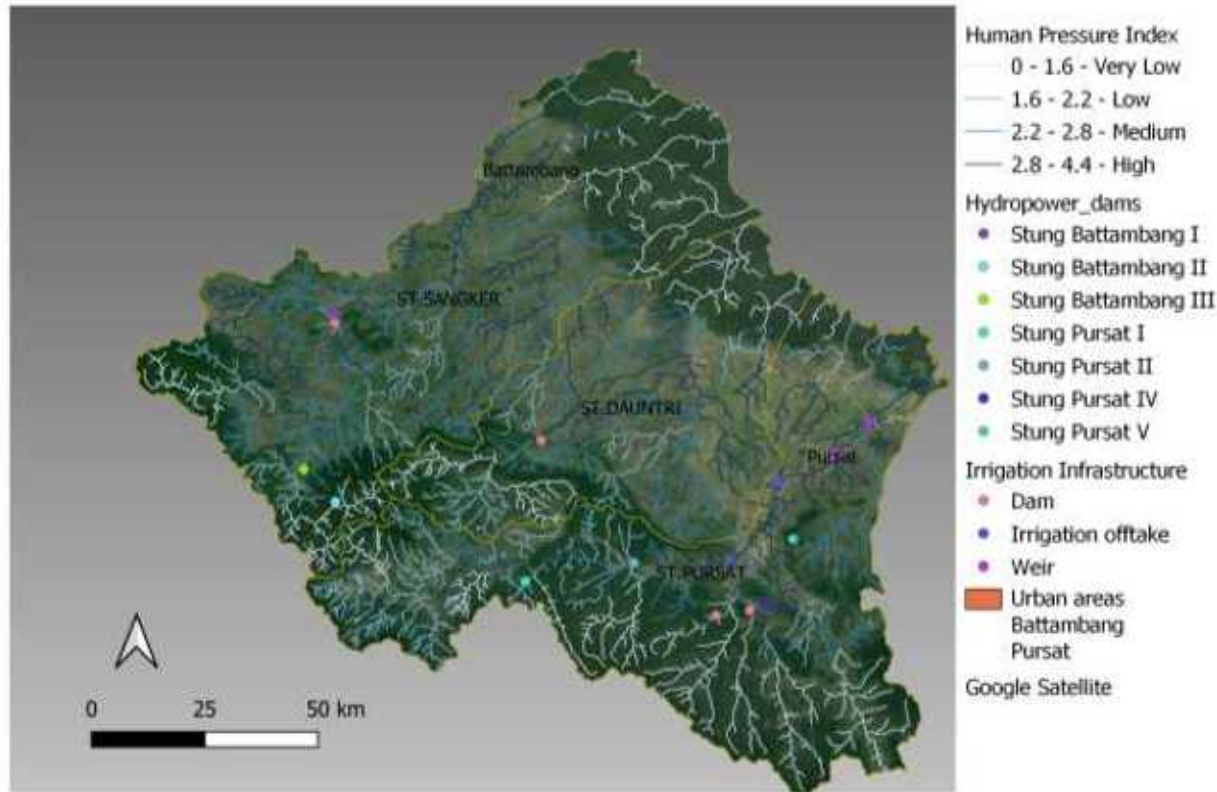
Identifying hotspots in river network

Threats and pressures to river ecosystems includes terrestrial pressures plus
- Hydropower
- Irrigation weirs
- Urban pollution

Conclusions

- The RESF provides an approach for identifying:
  - **Sweet-spots** of ecosystem service importance for rivers and river basins and
  - **Hotspots** of human pressure on rivers and river basins

- Can highlight the sweet-spots under the most pressure

- Uses open access global or regional datasets

- Express these as five-point scale on maps or in geo-referenced tables of different hydrobasins or river reaches

- Used in **impact assessment process** showing both baselines or projected impacts e.g. land use change or infrastructure for specific areas within the Greater Mekong
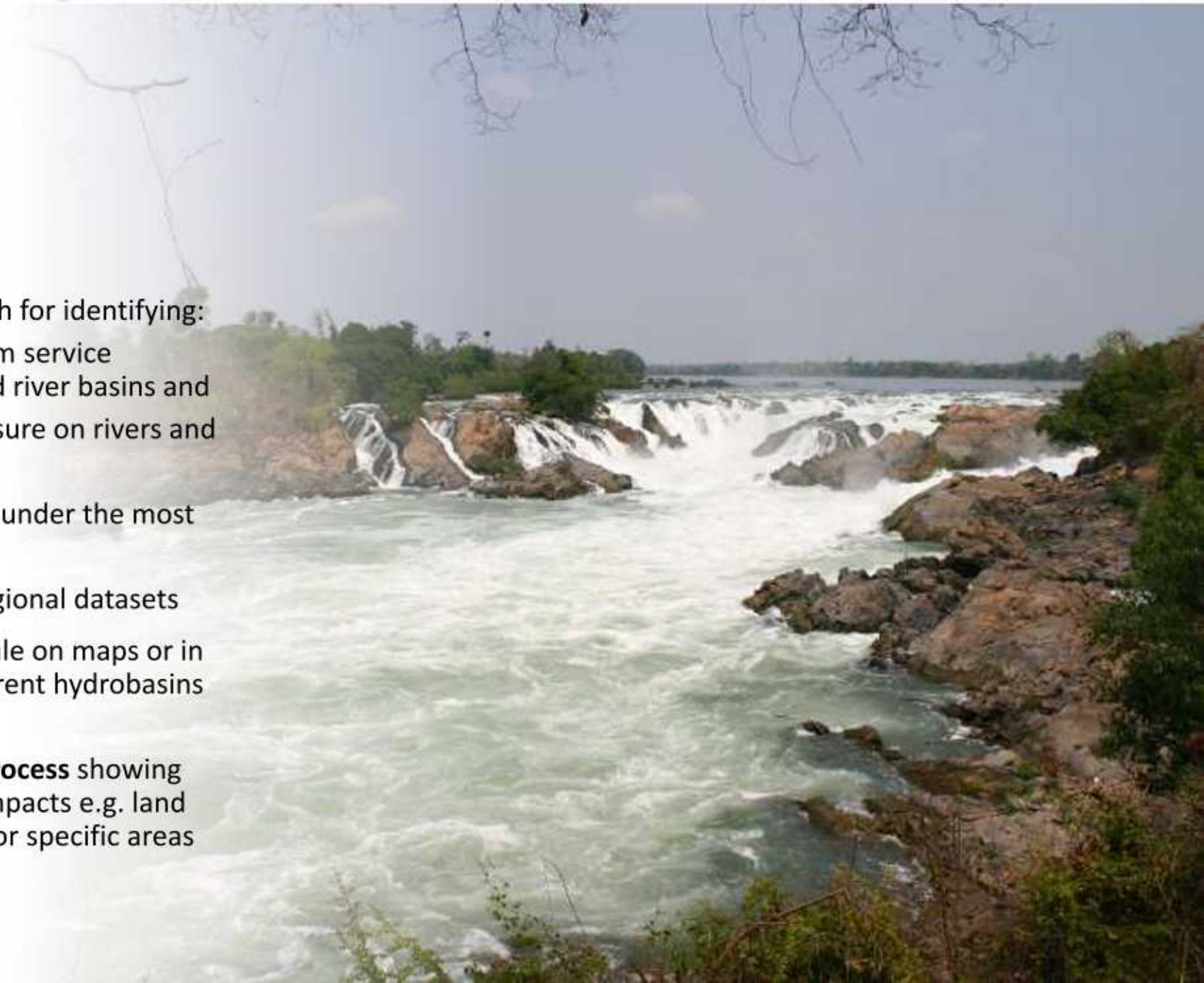
Thank You

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