Cloud-based System for SDGs Monitoring and Assessment in the HKH

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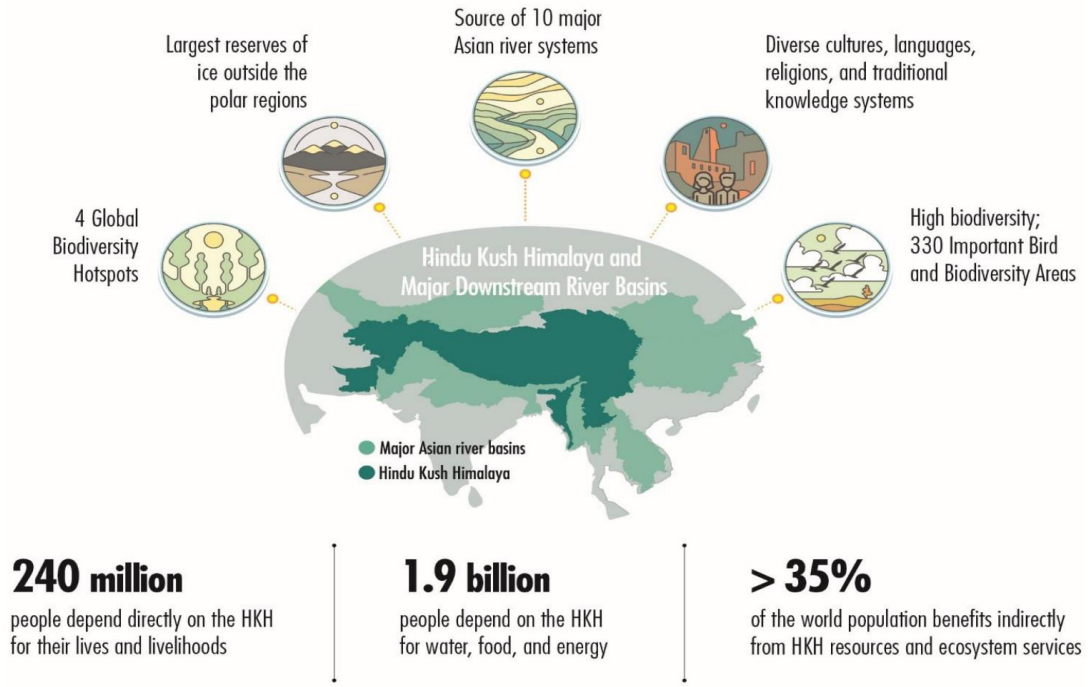
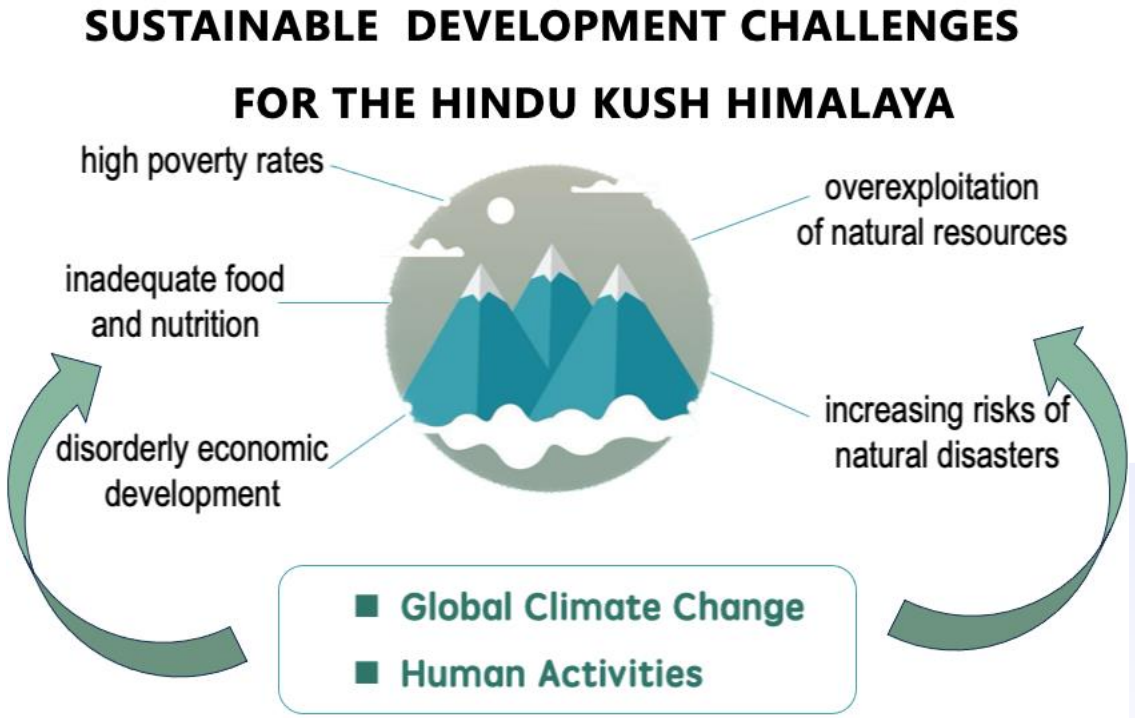
Hindu Kush Himalaya

One of the world's largest mountain systems, source of 10 major Asian river systems and one of the most biodiverse regions globally

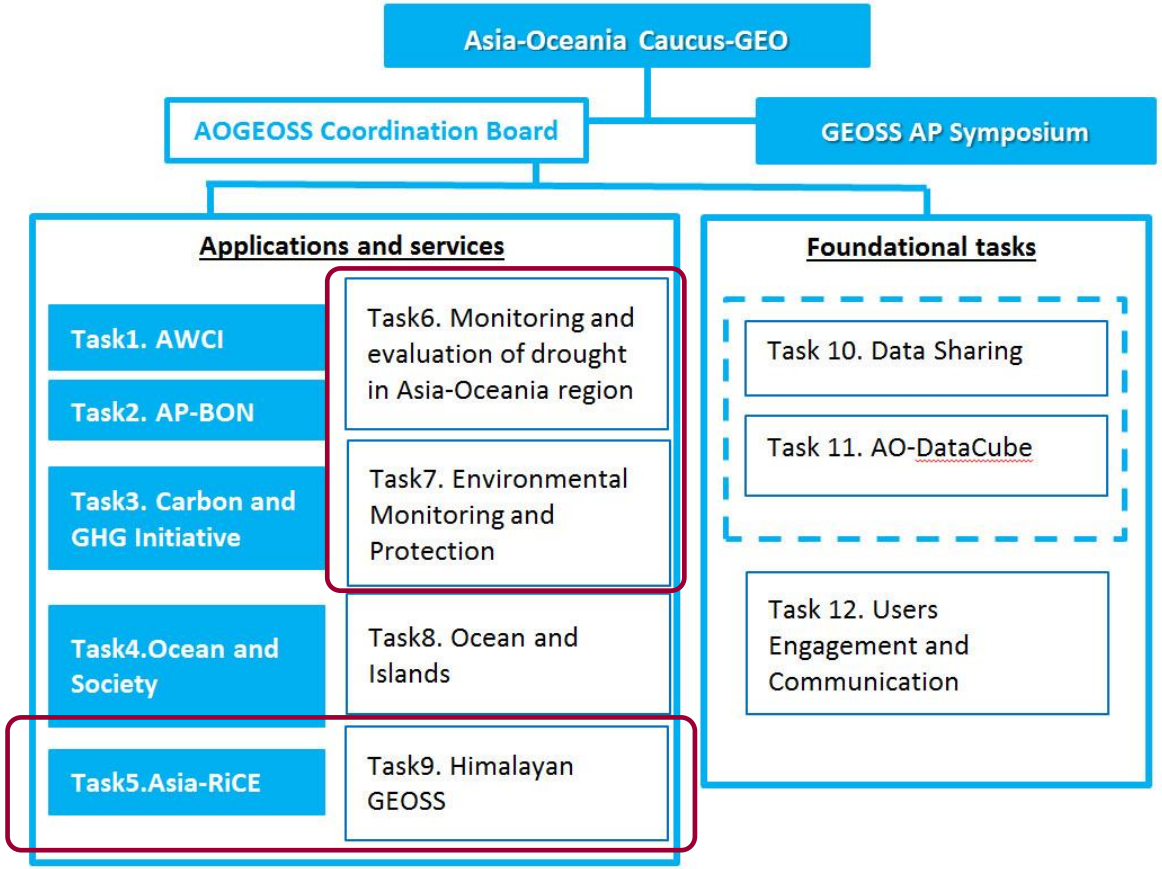


Dhrupad Choudhury, The Hindu Kush Himalaya Assessment – ICIMOD



Motivation

In response to the six urgent actions for the HKH as well as AOGEO's tasks on sustainable agriculture, water resources, and ecological environment



Resonating call for a mountain alliance for the Hindu Kush Himalaya – ICIMOD, 2018

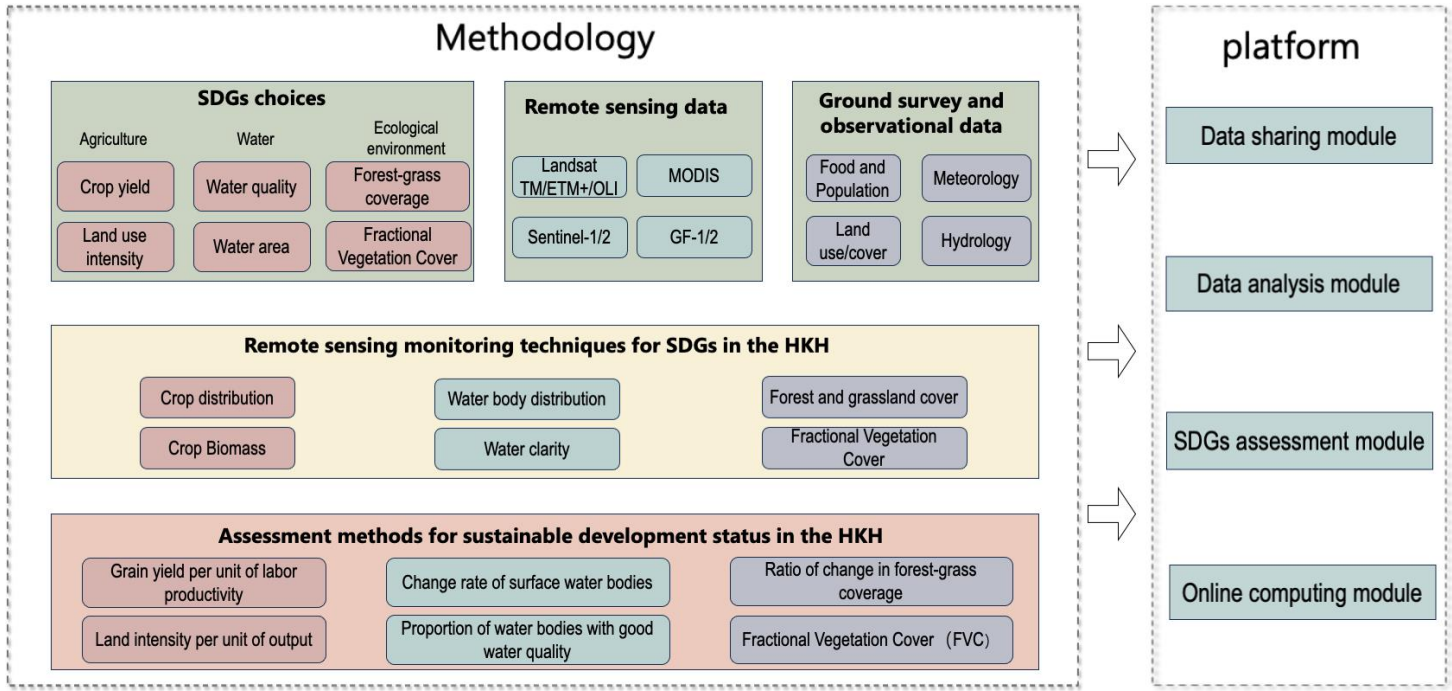
Motivation

The Ministry of Science and Technology of China launched the International Cooperation Special Project under the National Key Research and Development Program：

“Remote Sensing Monitoring and Sustainable Development Assessment in the HKH”

Project Objectives

- Develop remote sensing monitoring technology and provide data products for SDGs in the HKH
- Present the result of sustainable development assessment of the HKH;
- **Build a cloud-based HKH SDGs monitoring and assessment system**



Objectives of the System

- Create a data catalog for the key element datasets for SDGs assessment.
- Provide map visualization and download functions for the all datasets in the system.
- Provide multiple web-based online analysis functions for these datasets.
- Present sustainable development assessment results in the HKH for the year 2000, 2010, 2020.
- Build high accuracy AI model for efficiently and accurately extracting water, forest and grass.
- Implement a cloud-based pipeline for the on-demand extraction of water, forest and grass from the EO data.

Data Sharing

- Catalogue
- Query
- Web Map layer
- Download

Online Analysis

- Statistics chart
- Spatio-temporal change map
- Result download

Assessment for SDGs

- 6 assessment indicators
- Assessment for the HKH
- Assessment for every country in the HKH

AI and cloud-based Computing

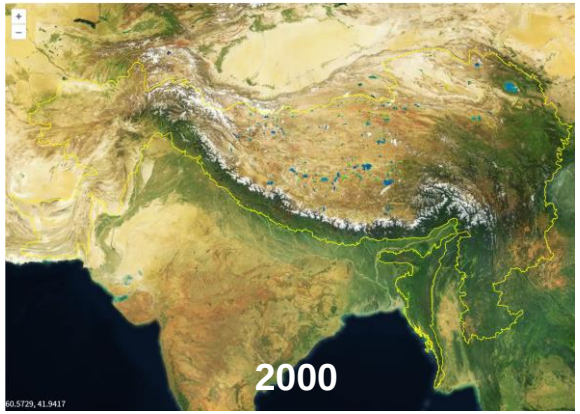
- Freely select dates and regions
- Near real-time extraction of land cover data

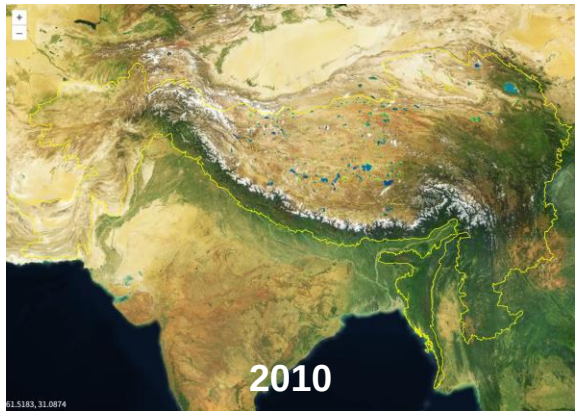
Key Element Datasets for SDGs

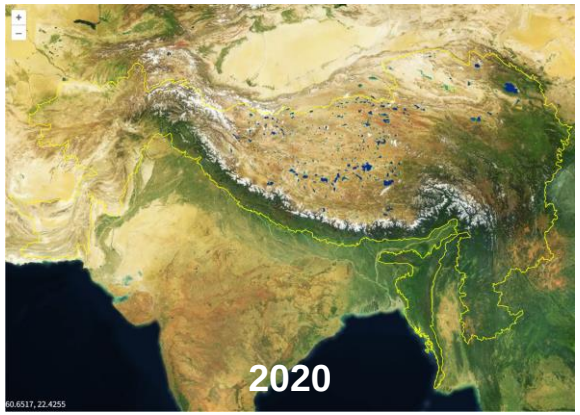
Category	Dataset Name	Online Status
Water	Water Body Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)	Ready
	Water Clarity dataset in the HKH for the year 2000, 2010, 2020 (30m)	Ready
	Water Body Distribution dataset in the HKH for the year 2015 ~ 2023 (10m)	Ready (the year 2021)
Agriculture	Crop Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)	Not ready
	Agricultural Biomass dataset in the HKH for the year 2000, 2010, 2020 (30m)	Not ready
Forest & Grass	Fractional Vegetation Cover (FVC) dataset in the HKH for the year 2000, 2010, 2020 (30m)	Not ready
	Forest and Grassland Cover dataset in the HKH for the year 2000, 2010, 2020 (30m)	Not ready

Key Element Datasets for SDGs

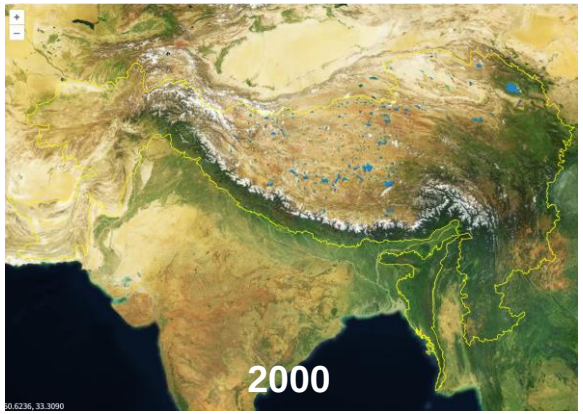
Water

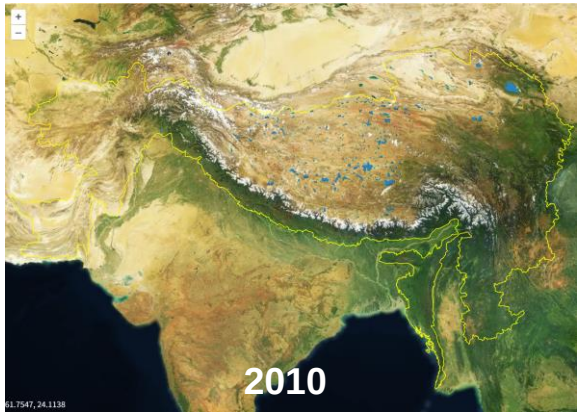


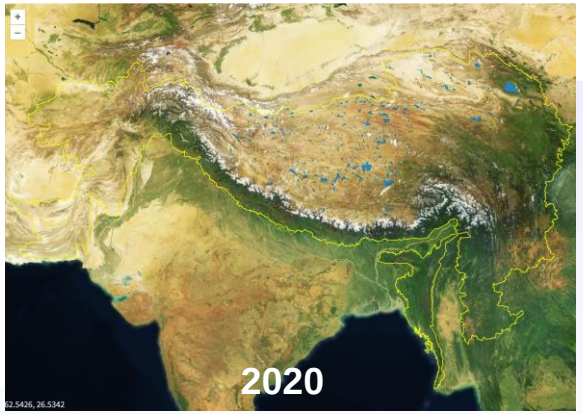




Water Clarity dataset in the HKH (30m) – *EO Source: Landsat*



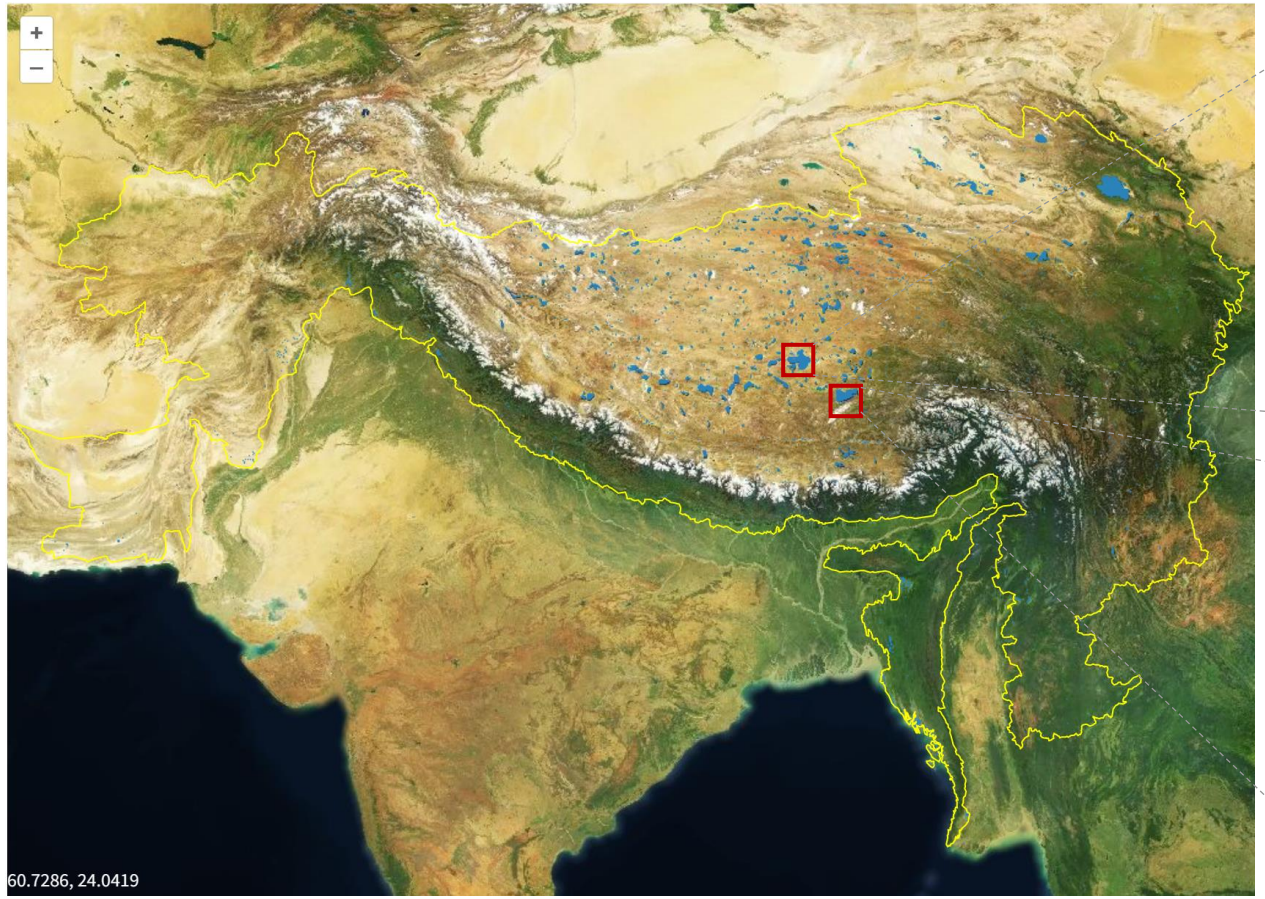


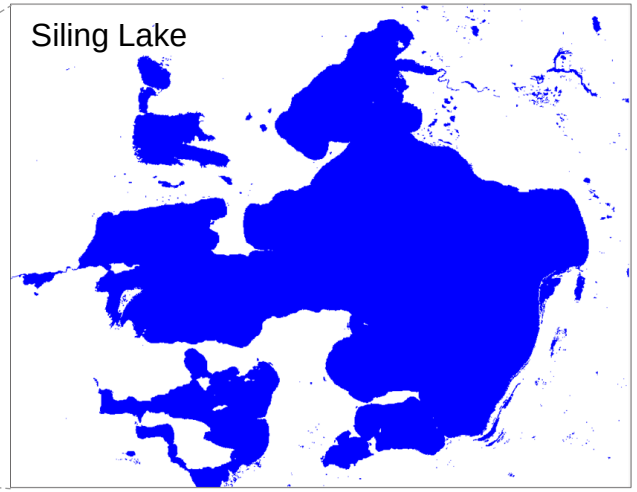


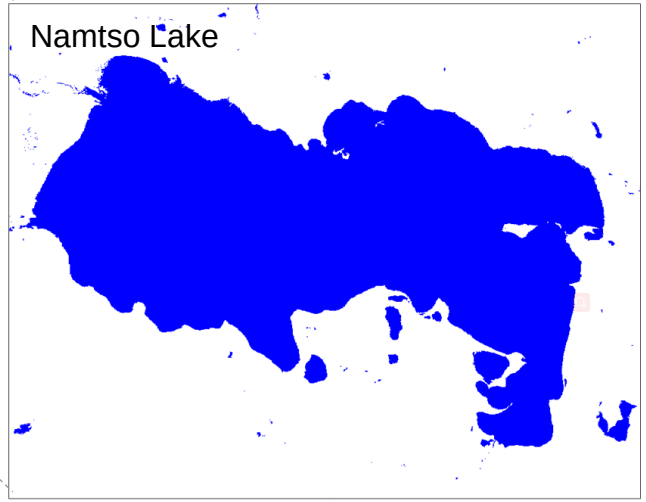
Water Body Distribution dataset in the HKH (30m) – *EO Source: Landsat*

Key Element Datasets for SDGs

Water



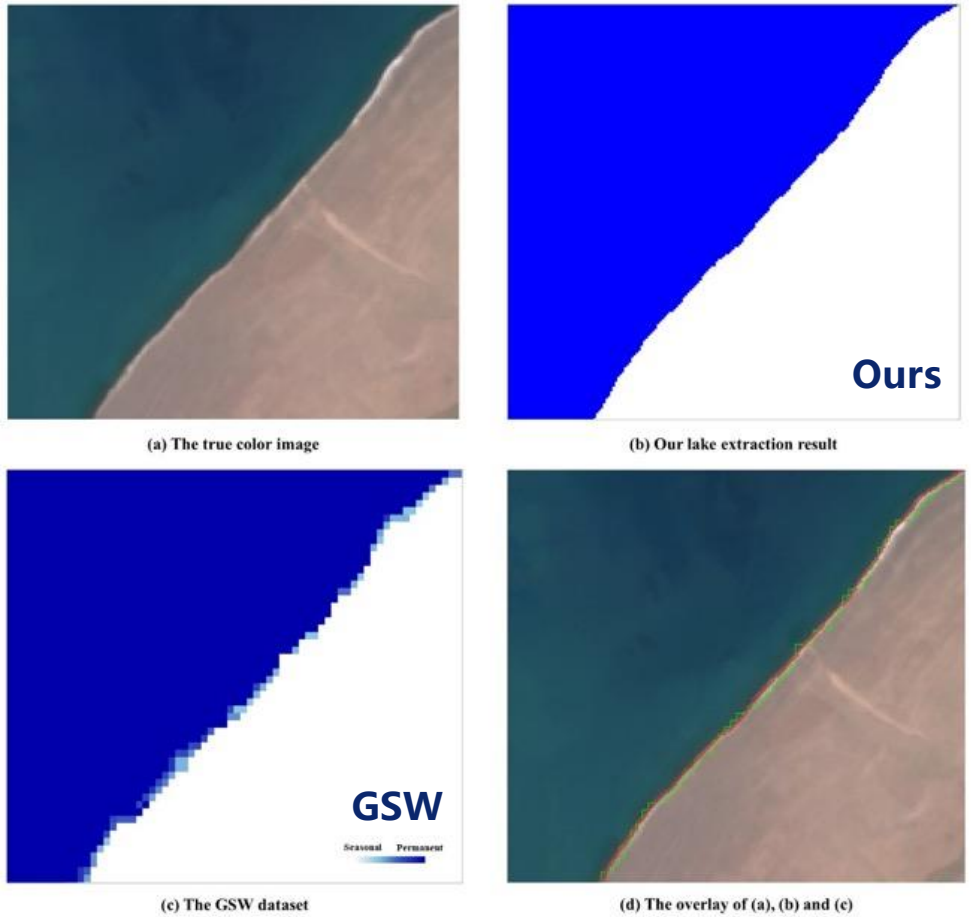




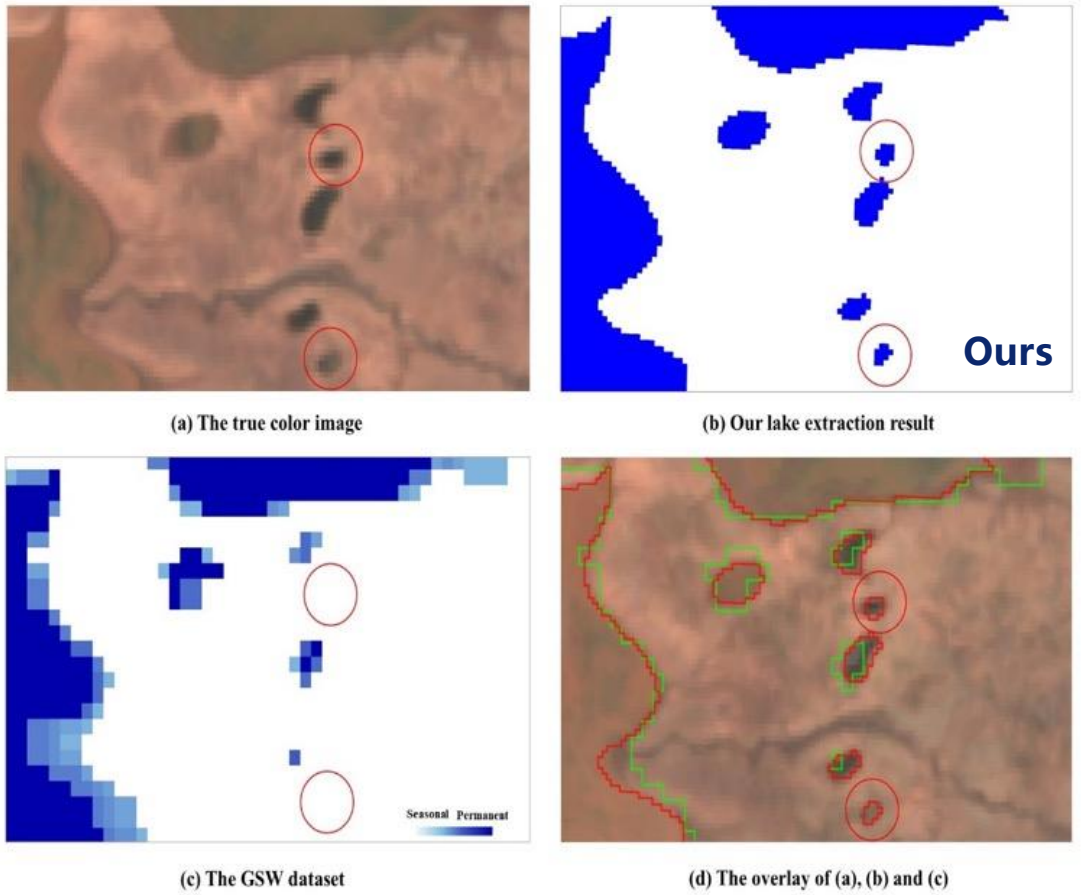
Water Body Distribution dataset in the HKH for the year 2021 (10m)
– *EO Source: Sentinel-2*

Key Element Datasets for SDGs

Water



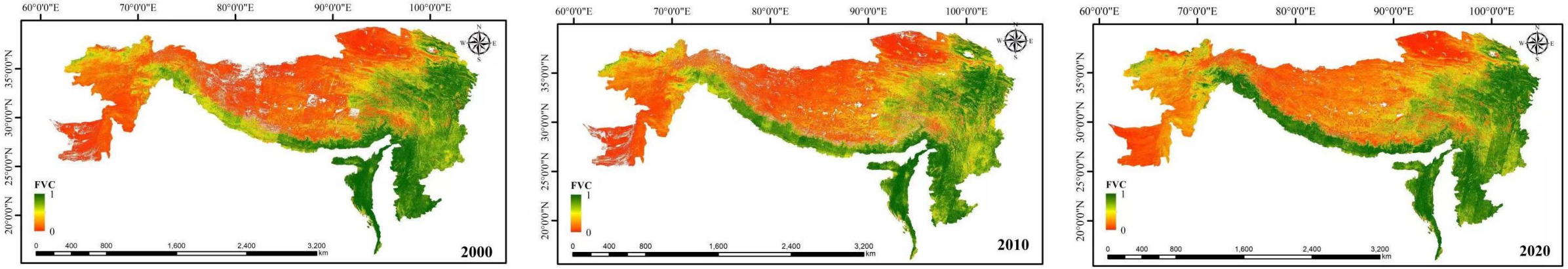
Boundary comparison with JCR Global Surface Water (GSW) data



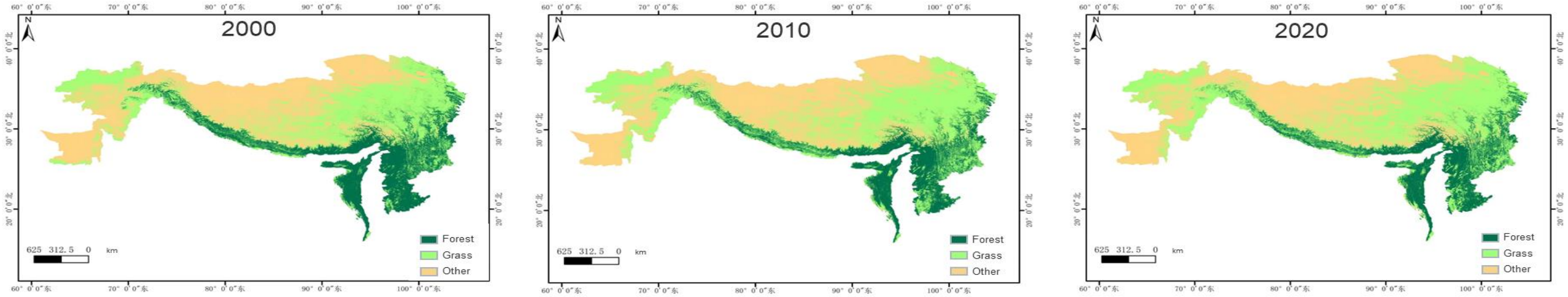
Missing small lakes comparison with JCR GSW data

Key Element Datasets for SDGs

Forest & Grass



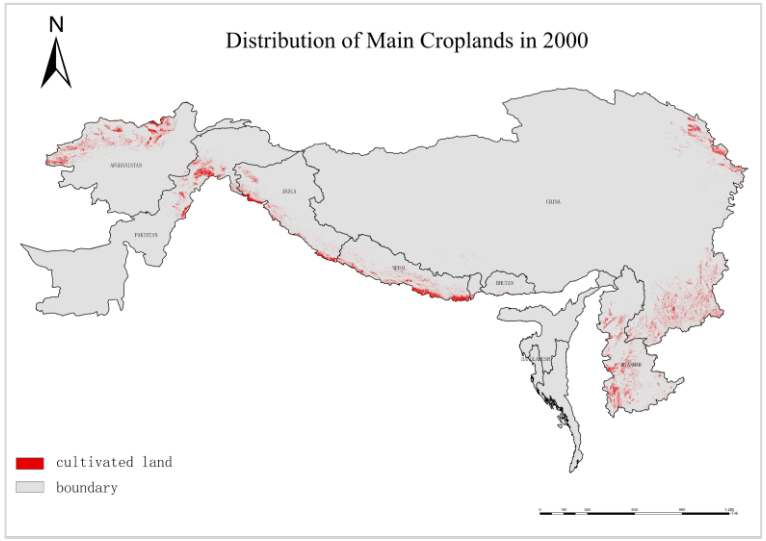
Fractional Vegetation Cover (FVC) dataset in the HKH (30m)

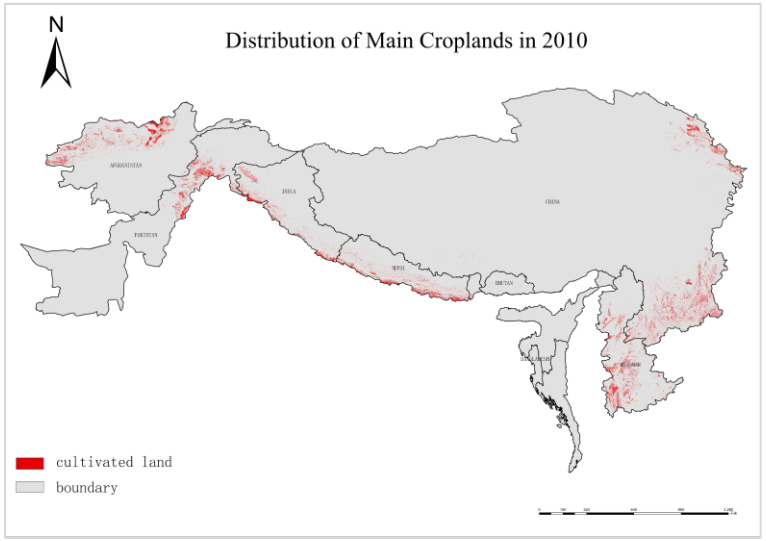


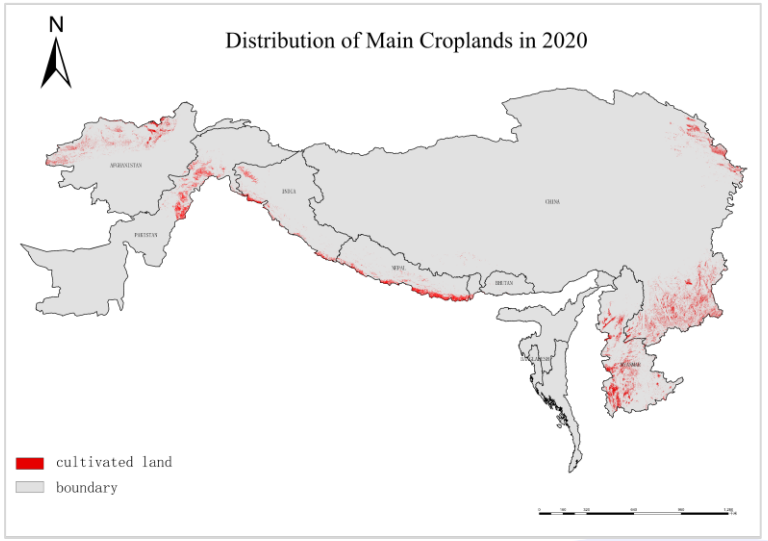
Forest and Grassland Cover dataset in the HKH (30m)

Key Element Datasets for SDGs

Sustainable Agriculture







Cropland Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)

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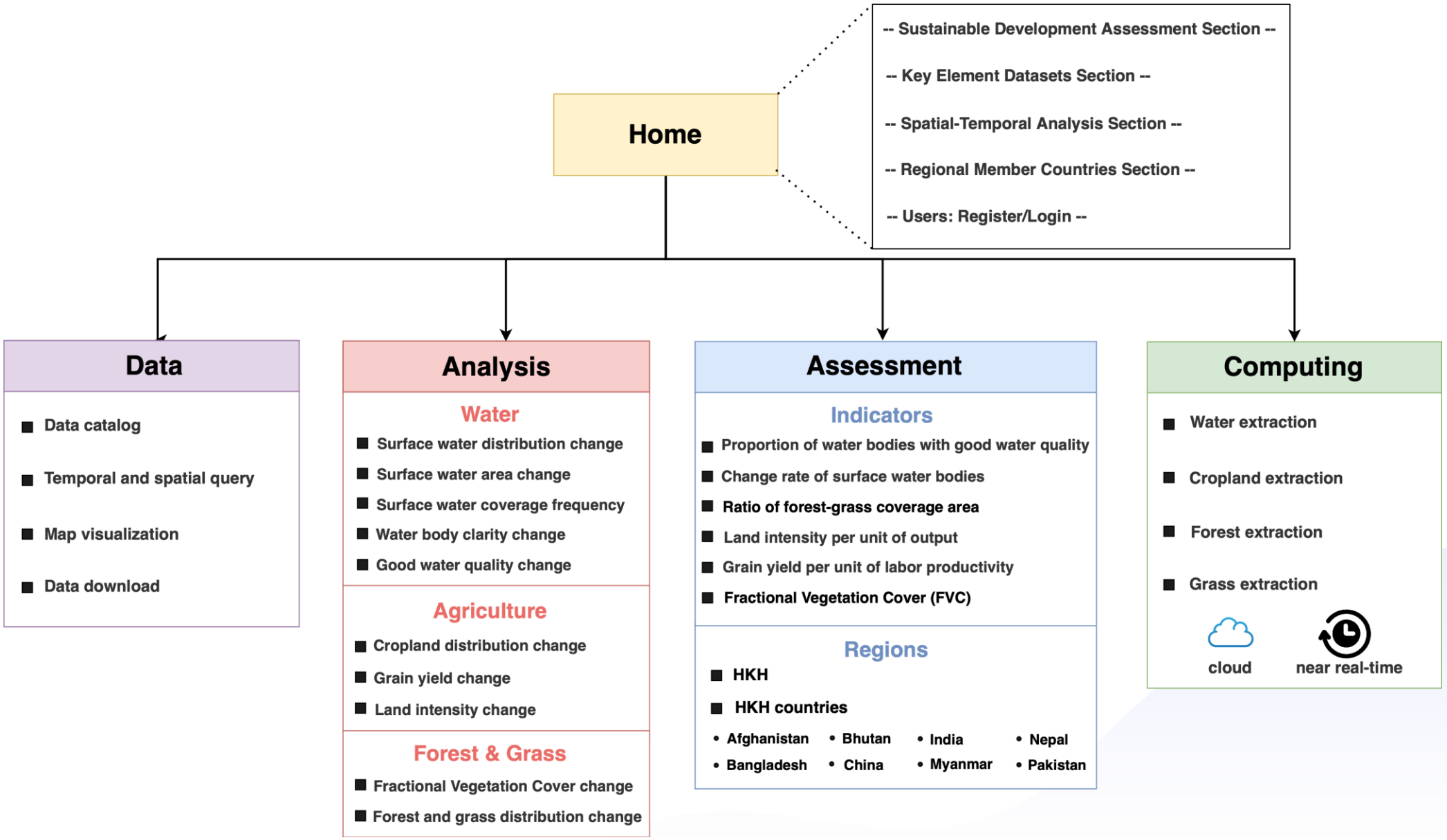
Framework


Home
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-- Spatial-Temporal Analysis Section --
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-- Users: Register/Login --
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Proportion of water bodies with good water quality
Change rate of surface water bodies
Ratio of forest-grass coverage area
Land intensity per unit of output
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Fractional Vegetation Cover (FVC)
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HKH
HKH countries
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Cropland extraction
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cloud
near real-time

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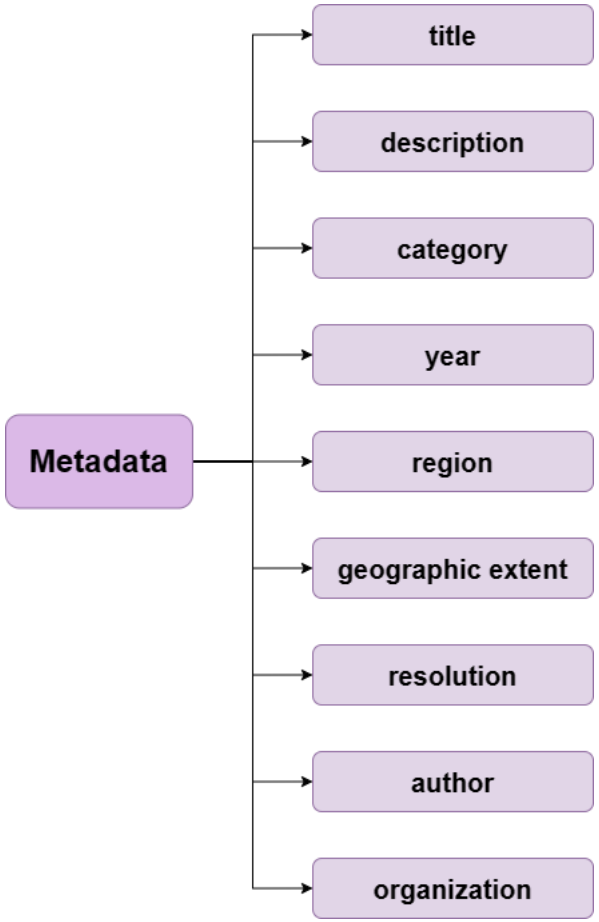
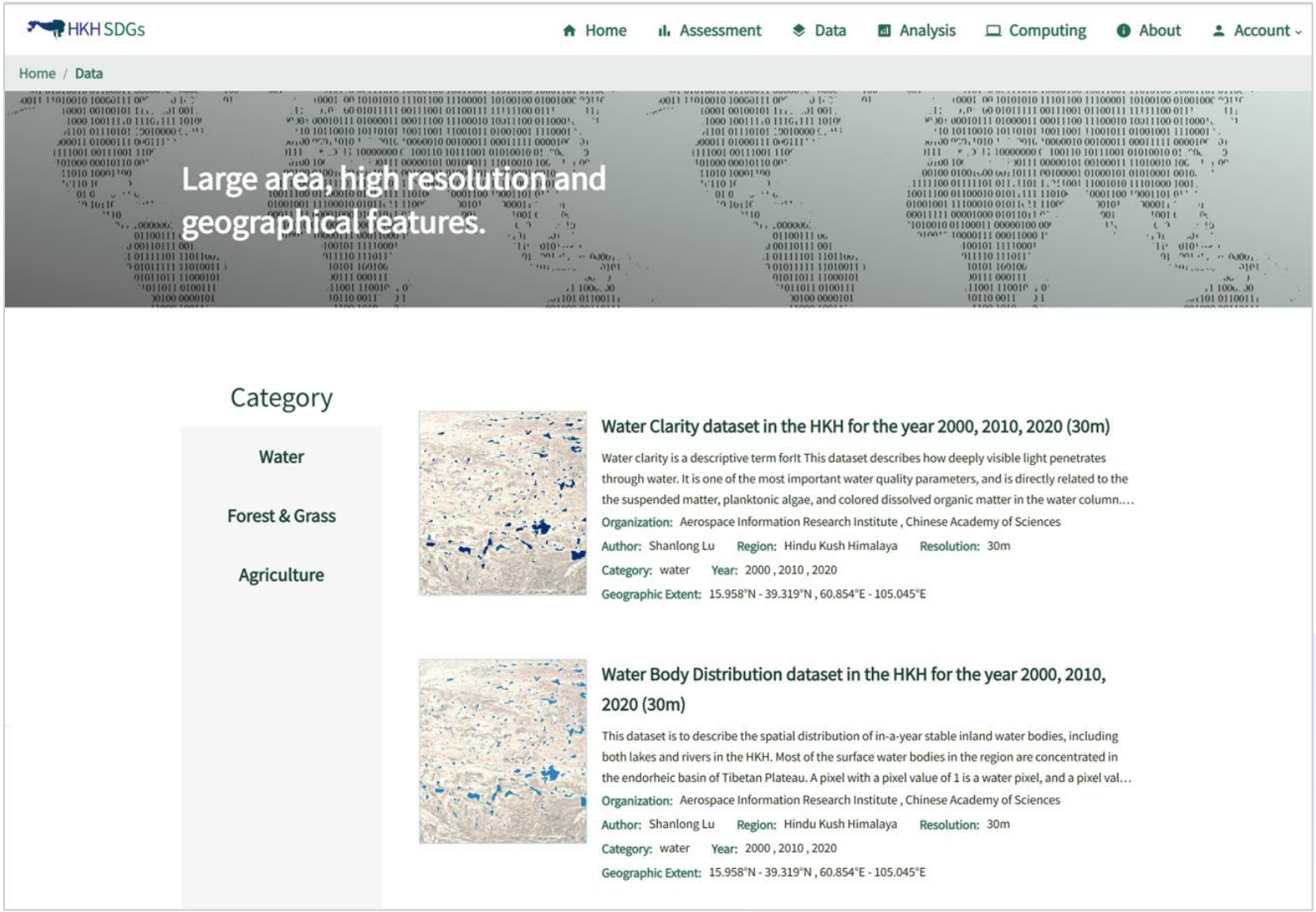
Data Module

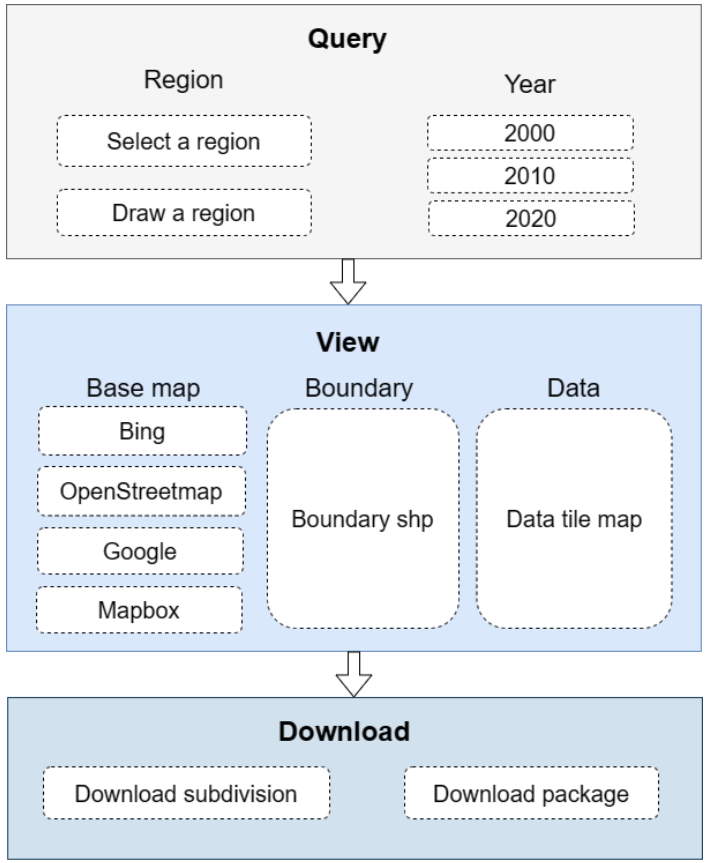
Data Catalog

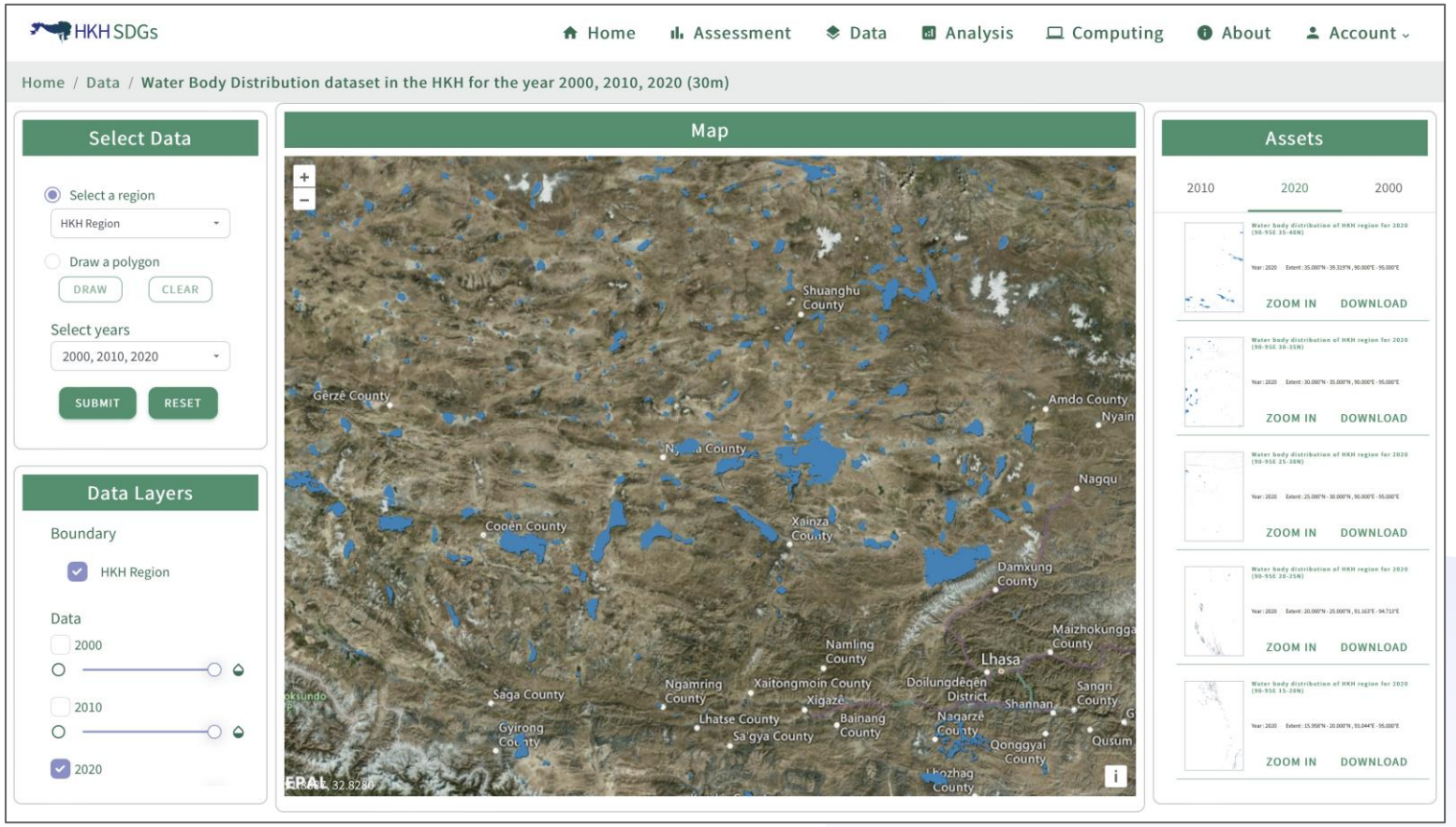




Data Module

Data Query, View and Download

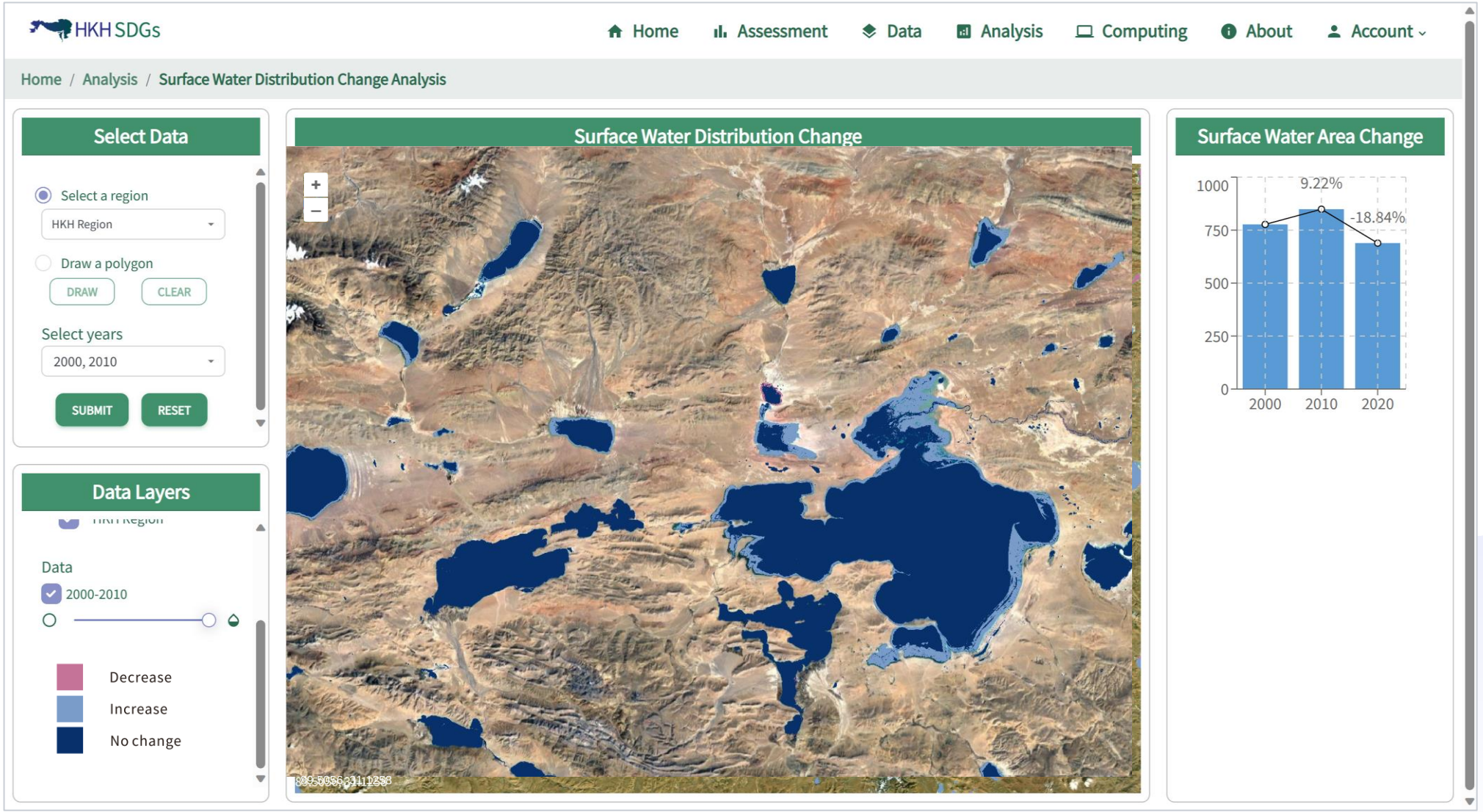




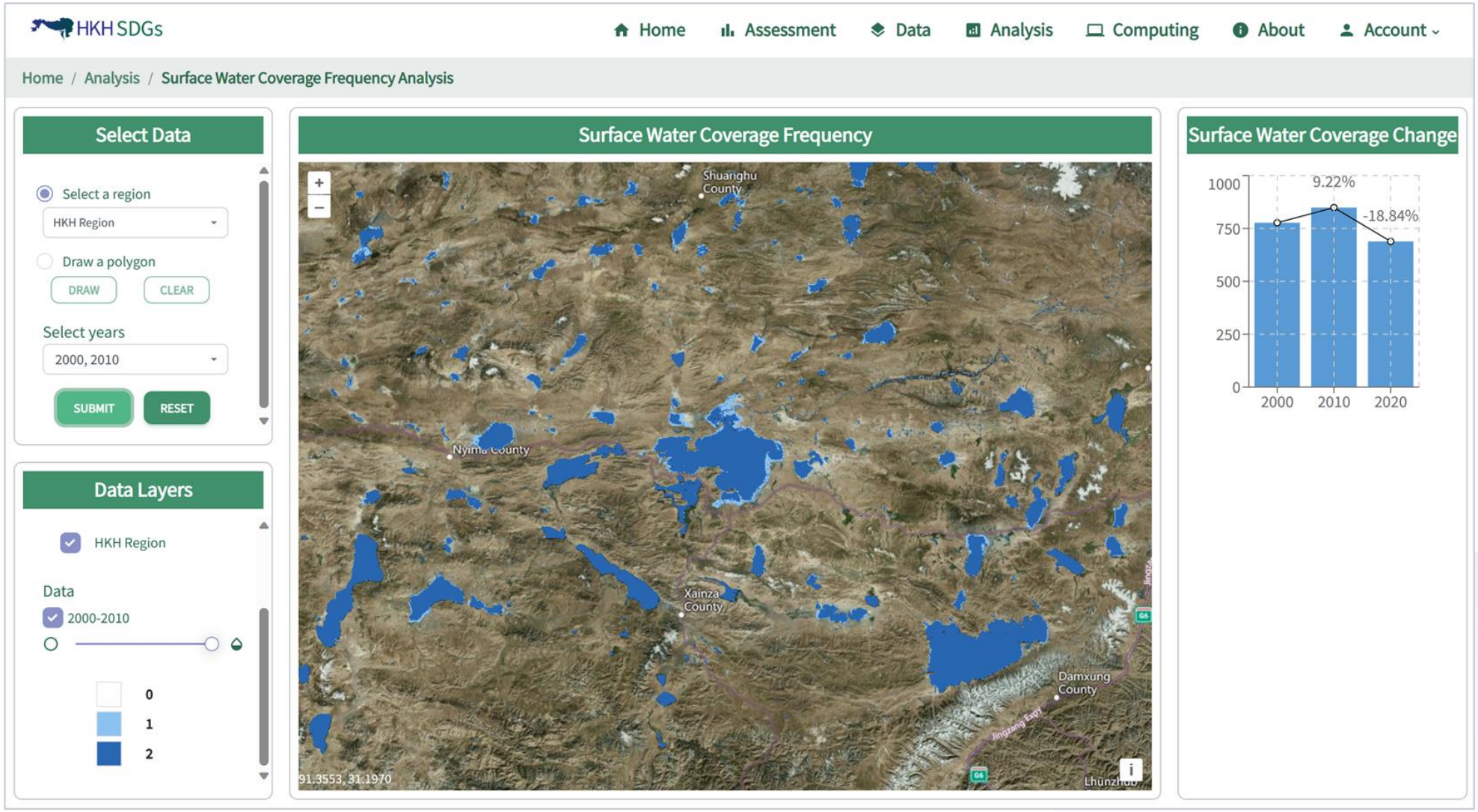
Analysis Module

Water	Agriculture	Forest & Grass
■ Surface Water Distribution Change	■ Cropland Distribution Change	■ Fractional Vegetation Cover Change
■ Surface Water Area Change	■ Grain Yield Change	■ Forest and Grass Distribution Change
■ Surface Water Coverage Frequency	■ Land Intensity Change	■ …
■ Water Body Clarity Change	■ …	■ …
■ Good Water Quality Change	■ …	■ …
	Developing	**Developing**

Analysis Module



Analysis Module



Assessment Module

Water Assessment

■ Change rate of surface water bodies (for SDG 6.6.1)

This indicator is to reflect the change rate of surface water body area detected between the target year and the base year.

$$Change\ rate\ of\ surface\ water\ bodies = \frac{Area_{target\ year} - Area_{base\ year}}{Area_{base\ year}}$$

■ Proportion of water bodies with good water quality (for SDG 6.3.2)

It reflects the proportion of water bodies that are not harmful to ecosystem function and human health (with water clarity > 0.5 m).

$$Proportion\ of\ water\ bodies\ with\ good\ water\ quality = \frac{Area_{water\ clarity \geq 0.5m}}{Area_{region}}$$

Assessment Module

Ecological Assessment

■ Ratio of forest-grass coverage area

It reflects the proportion of forest land and grassland coverage to the regional coverage area, providing information on forest and grassland distribution.

$$Ratio\ of\ forest-grass\ coverage\ area = \frac{Area_{forest\ /\ Grass}}{Area_{region}}$$

■ Fractional Vegetation Cover （FVC)

It is the average of Fractional Vegetation Cover calculated in multiple years (such as 2000, 2010 and 2020), providing information on forest and grassland greenness in the region.

$$Fractional\ Vegetation\ Cover\ \ (FVC) = \frac{\sum_{k=0}^{n} FVC_k}{n}$$

n: number of pixels

Assessment Module

Assessment for Sustainable Agriculture

■ Grain yield per unit of labor productivity

This indicator is measured in kilograms per person. The standard for the labor force population is the population between the ages of 15-64 in the area.

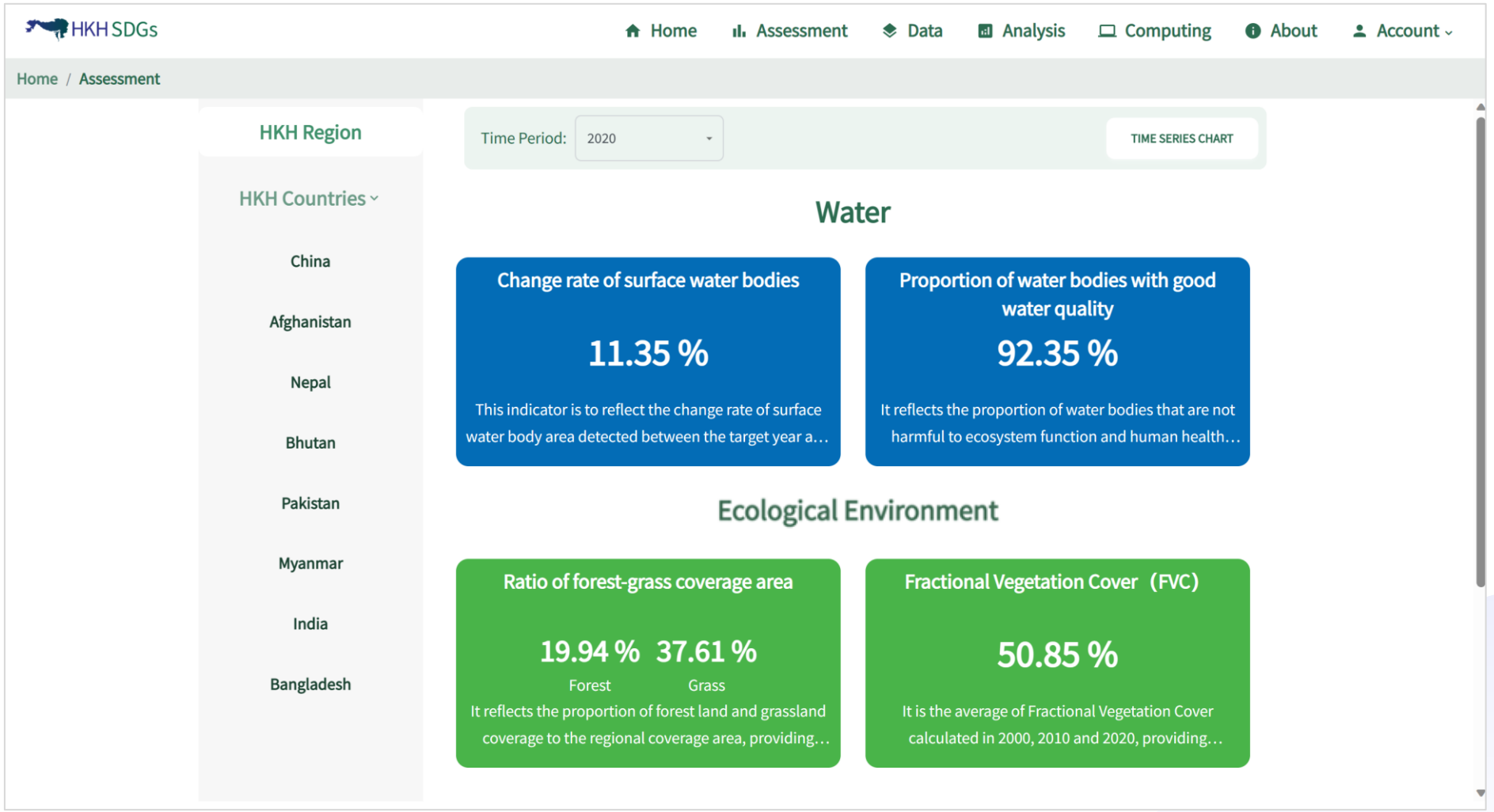
$$Grain\ yield\ per\ unit\ of\ labor\ productivity = \frac{Grain\ yield}{Number\ of\ labor\ force\ population}$$

■ Land intensity per unit of output

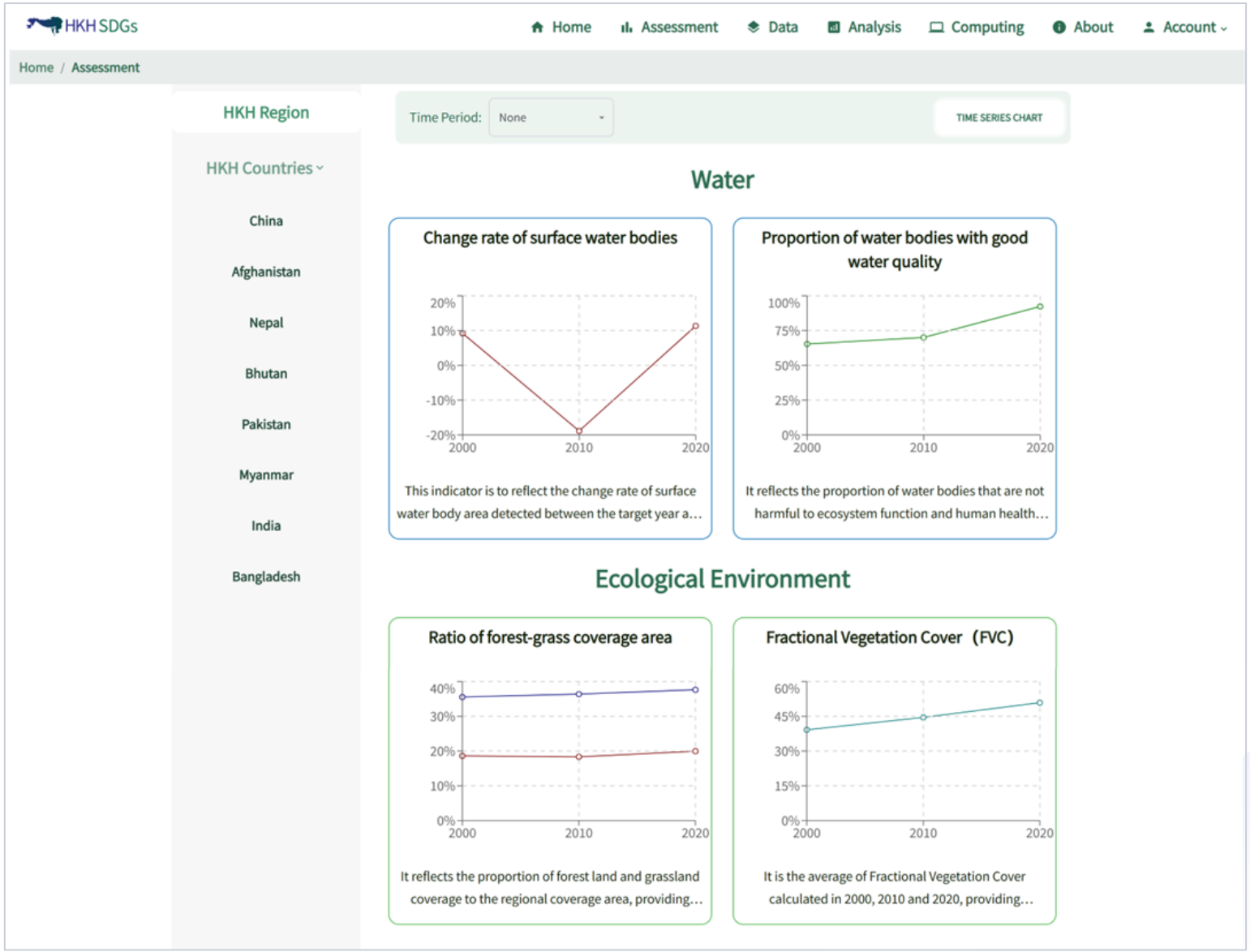
This indicator is used to reflect how much land area required to produce one ton of grain, and it is measured in hectares per ton.

$$Land\ intensity\ per\ unit\ of\ output = \frac{Area_{land}}{Grain\ yield}$$

Assessment Module

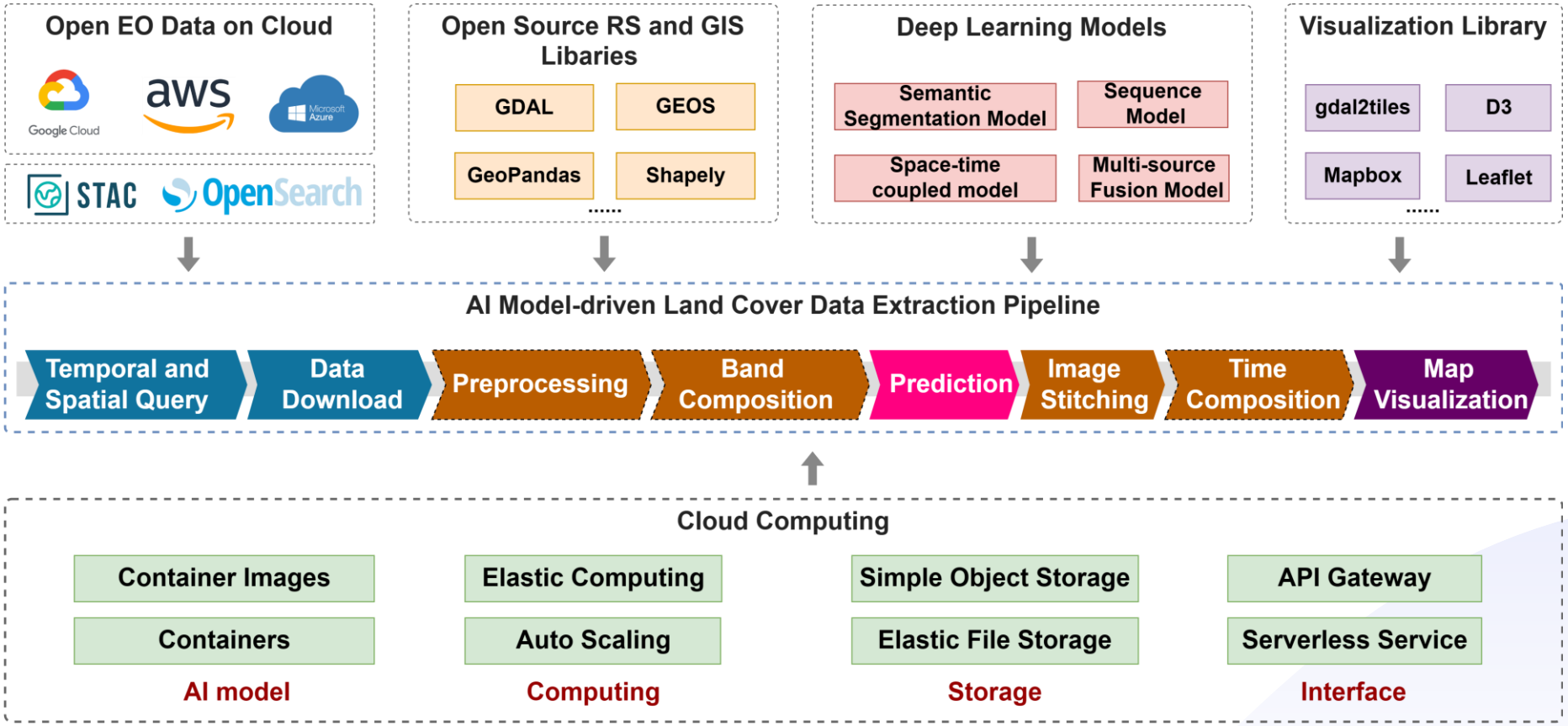


Assessment Module



Computing Module

Technical Framework of Near Real-time Land Cover Data Extraction

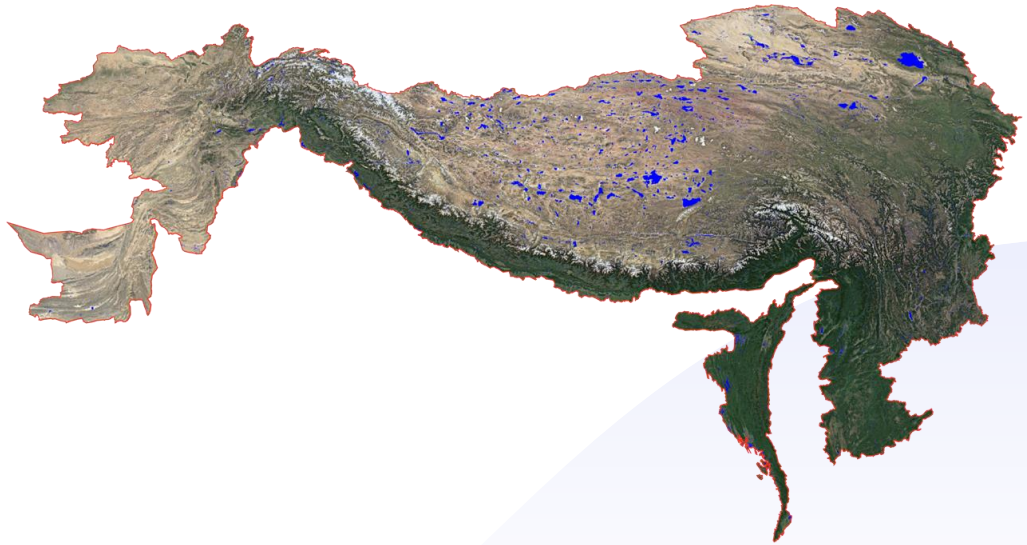


Computing Module

Practice on Near Real-time Surface Water Body Extraction in the HKH

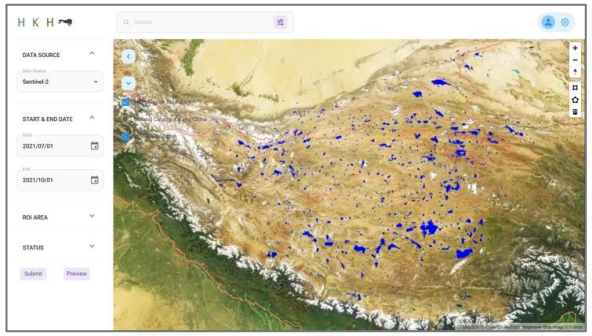
- **Microsoft Planetary Computer (Free)**
  - GPU：1 NVIDIA T4 16GB
  - vCPU: 4 cores
  - Memory：28 GB
  - Disk storage：15 GB
- **Region：HKH**
- **EO Data: 7661 Sentinel-2 images**
  - Time period: July to Oct 2021
  - Cloud cover: <= 20%
- **Total Elapsed Time：192 hours (8 days)**

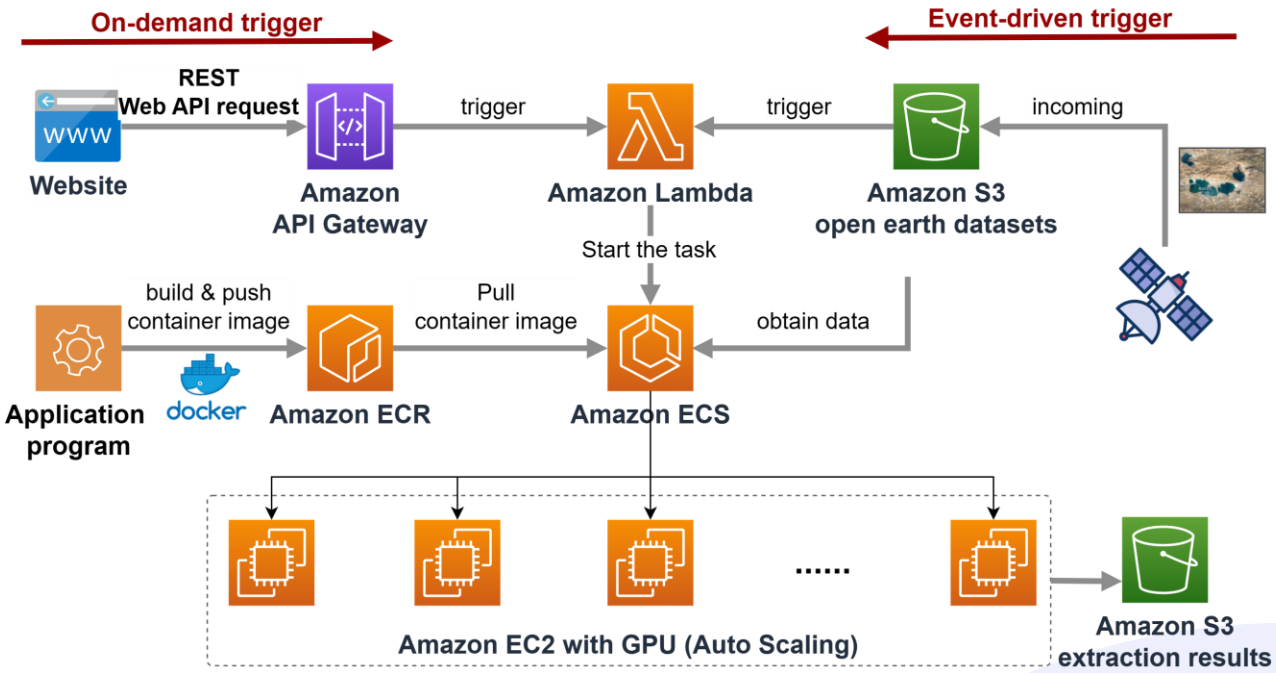
- **Elapsed time for a single image：**
  - Elapsed time：**1 min and 30 secs**
  - Download and preparing data for AI model：about 10 secs
  - Prediction time: about 1 min and 20 secs



Computing Module

Near Real-time Surface Water Body Extraction in the HKH





- **Starting time of Serverless Service**
  - Cold-start: approx. 3 ~ 4 mins
  - Hot-start: second
- **Test results on Amazon Cloud:**

Spot Instance type	GPU type	GPU Mem	vCPUs	Mem	Instance number	Elapsed Time	Approx. Cost
g5.xlarge	NVIDIA A10	24 GB	4	16 GB	48	1.5 hour	$50
g4dn.xlarge	NVIDIA T4	16 GB	4	16 GB	48	4 hours	$60

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Future Work

- **Data production for SDGs monitoring, including:**
  - 10-m water body distribution dataset in the HKH for the year 2015 ~ 2023
  - 30-m Agricultural Biomass dataset in the HKH for the year 2000, 2010, 2020
- **Make all the key element datasets available in the system，and add more analysis functions, including:**
  - cropland, forest, grass distribution and area change
  - vegetation cover change, cropland biomass change
- **Achieve near real-time extraction for water, cropland, forest, grassland from Sentinel-2 imagery by using AI model and cloud computing infrastructure.**
- **The entire system will be completed by the end of 2023 and the system will go live in February 2024.**

Thank you