

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

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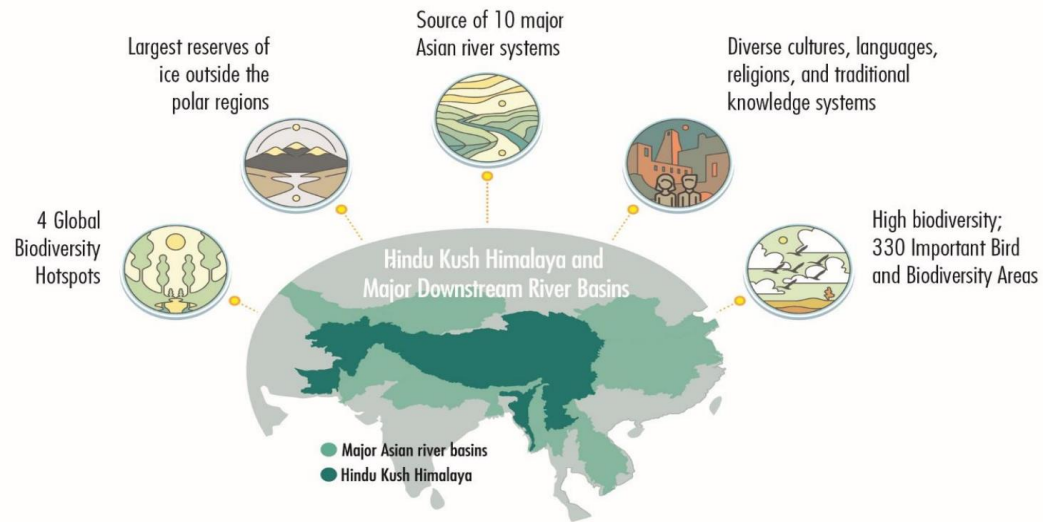
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# Hindu Kush Himalaya

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



**240 million**

people depend directly on the HKH for their lives and livelihoods

**1.9 billion**

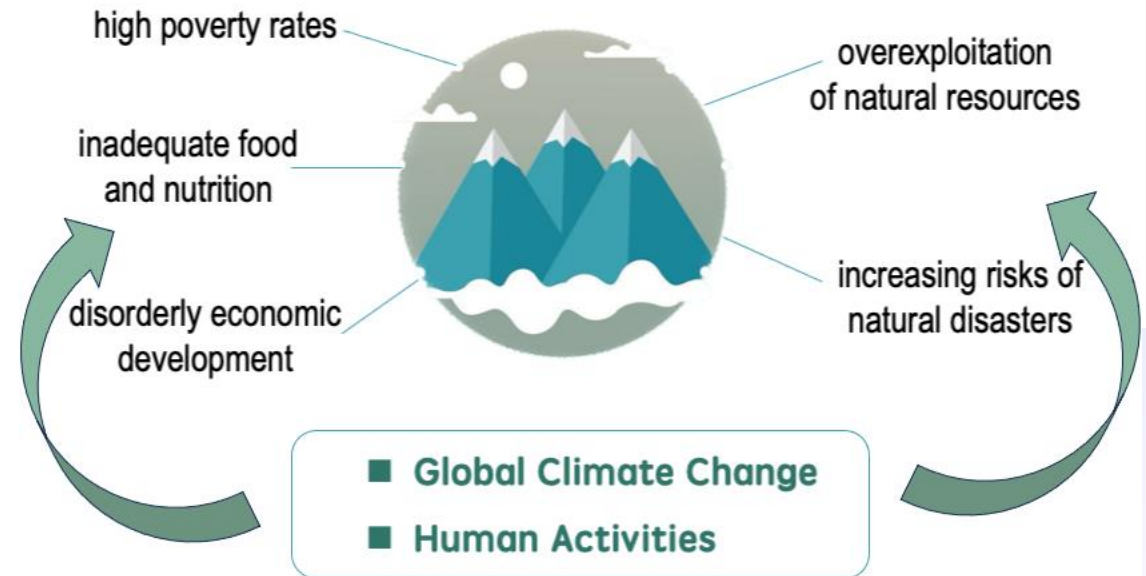
people depend on the HKH for water, food, and energy

**> 35%**

of the world population benefits indirectly from HKH resources and ecosystem services

Dhrupad Choudhury, The Hindu Kush Himalaya Assessment – ICIMOD

## SUSTAINABLE DEVELOPMENT CHALLENGES FOR THE HINDU KUSH HIMALAYA



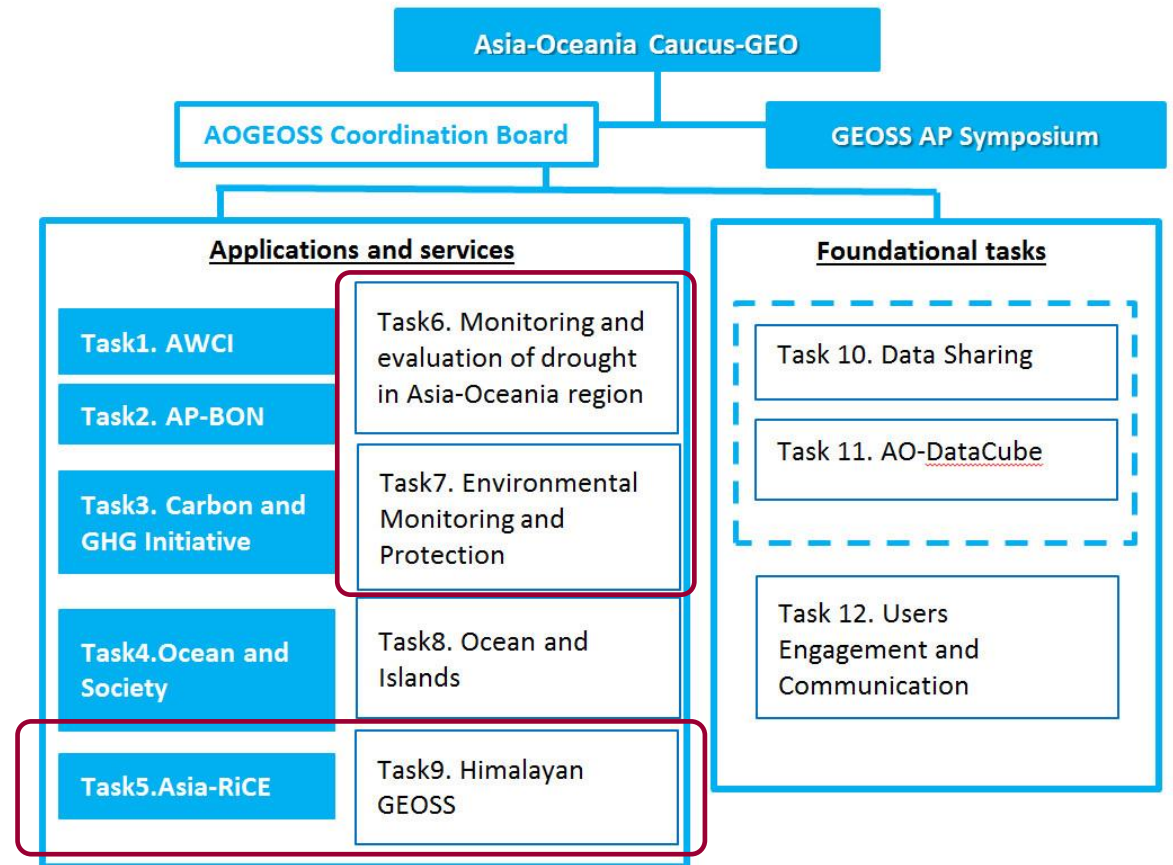
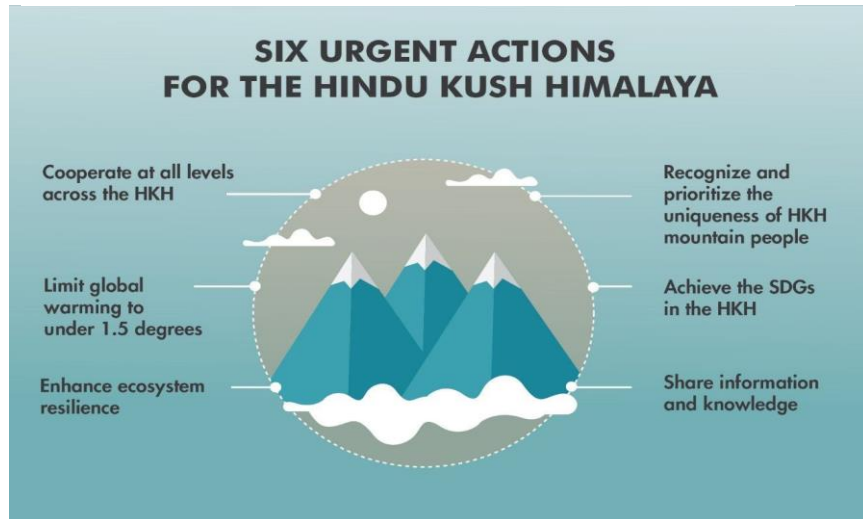
# Motivation

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



ICIMOD

## Ministerial Declaration on the HKH Call to Action



# Motivation

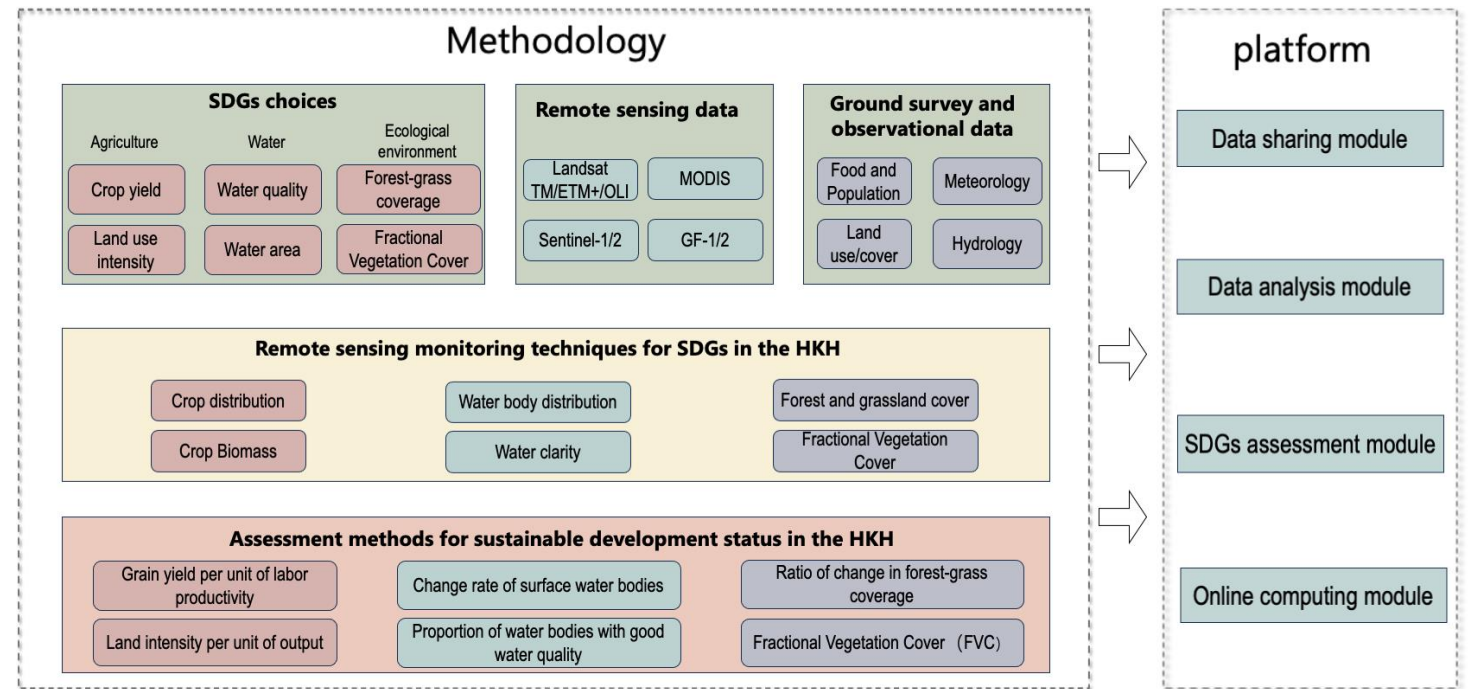


The Ministry of Science and Technology of China launched the International Cooperation Special Project under the National Key Research and Development Program:

## “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

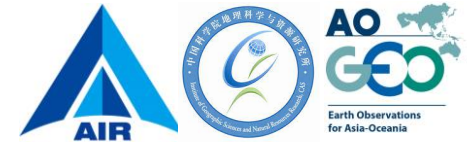
- 6 assessment indicators
- Assessment for the HKH
- Assessment for every country in the HKH

## AI and cloud-based Computing

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



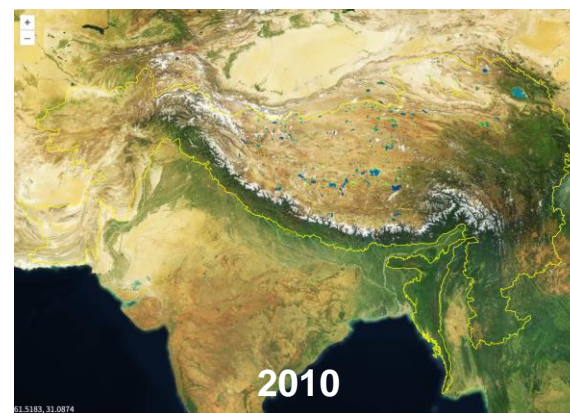
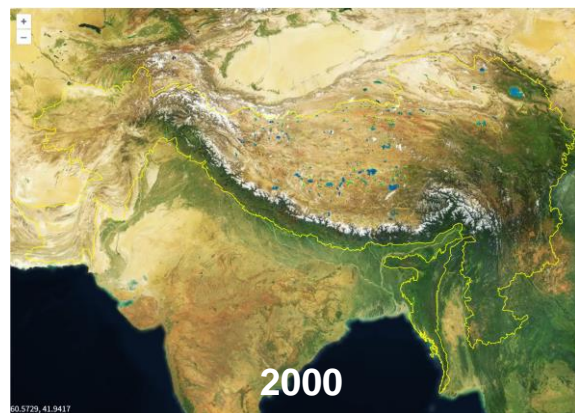
# Key Element Datasets for SDGs



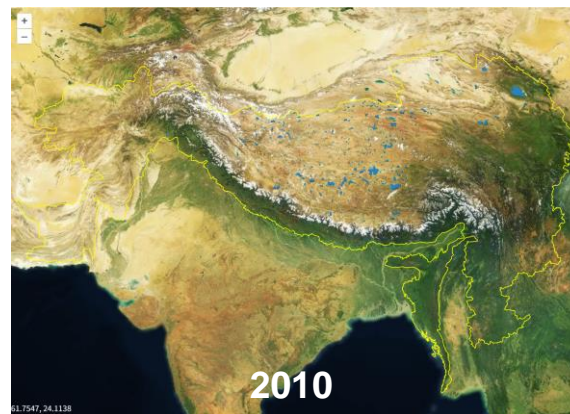
Category	Dataset Name	Online Status
Water	Water Body Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)	Ready
	Water Clarity dataset in the HKH for the year 2000, 2010, 2020 (30m)	Ready
	Water Body Distribution dataset in the HKH for the year 2015 ~ 2023 (10m)	Ready (the year 2021)
Agriculture	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*

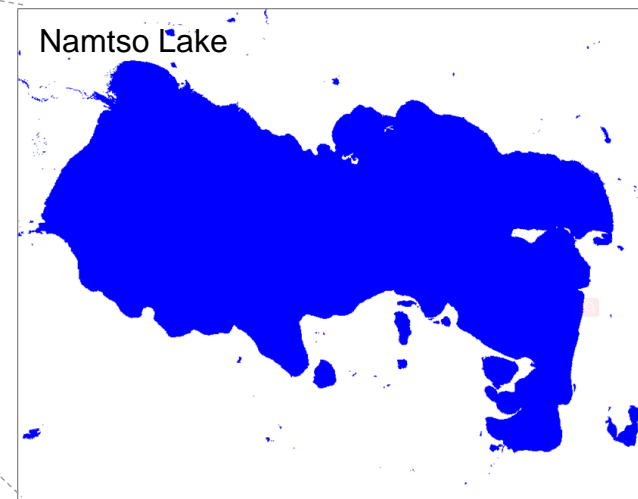


Water Body Distribution dataset in the HKH (30m) – *EO Source: Landsat*



# Key Element Datasets for SDGs

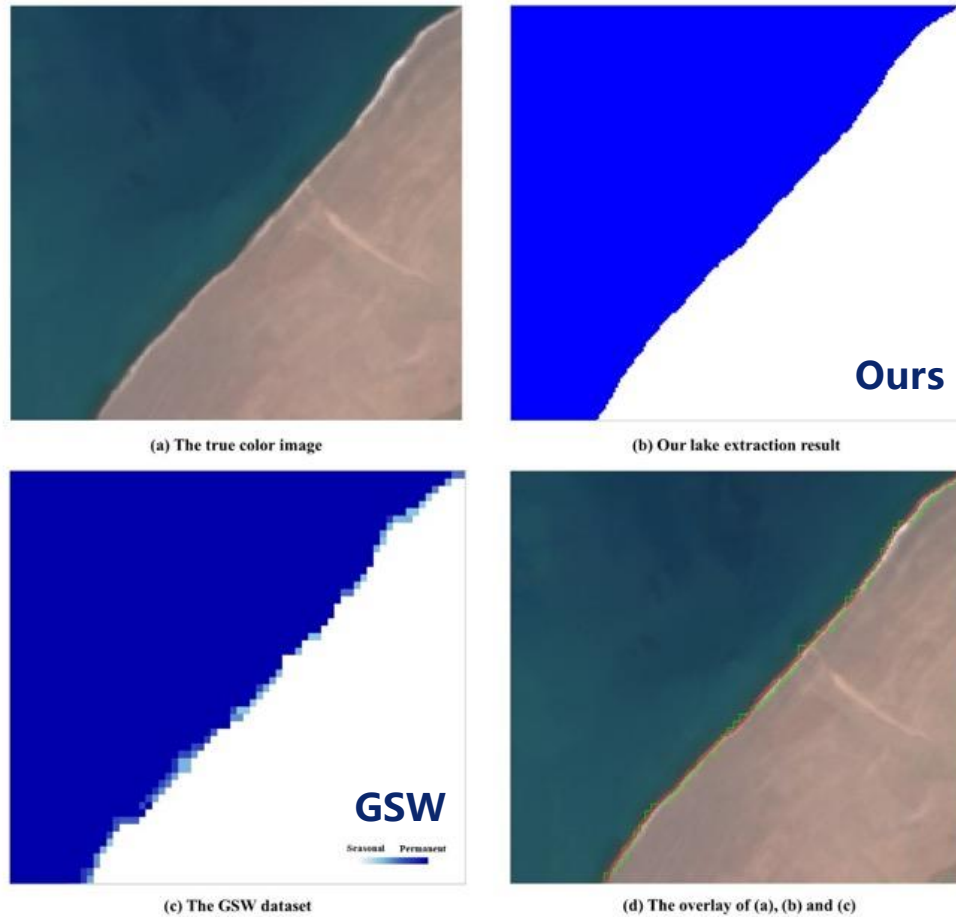
## Water



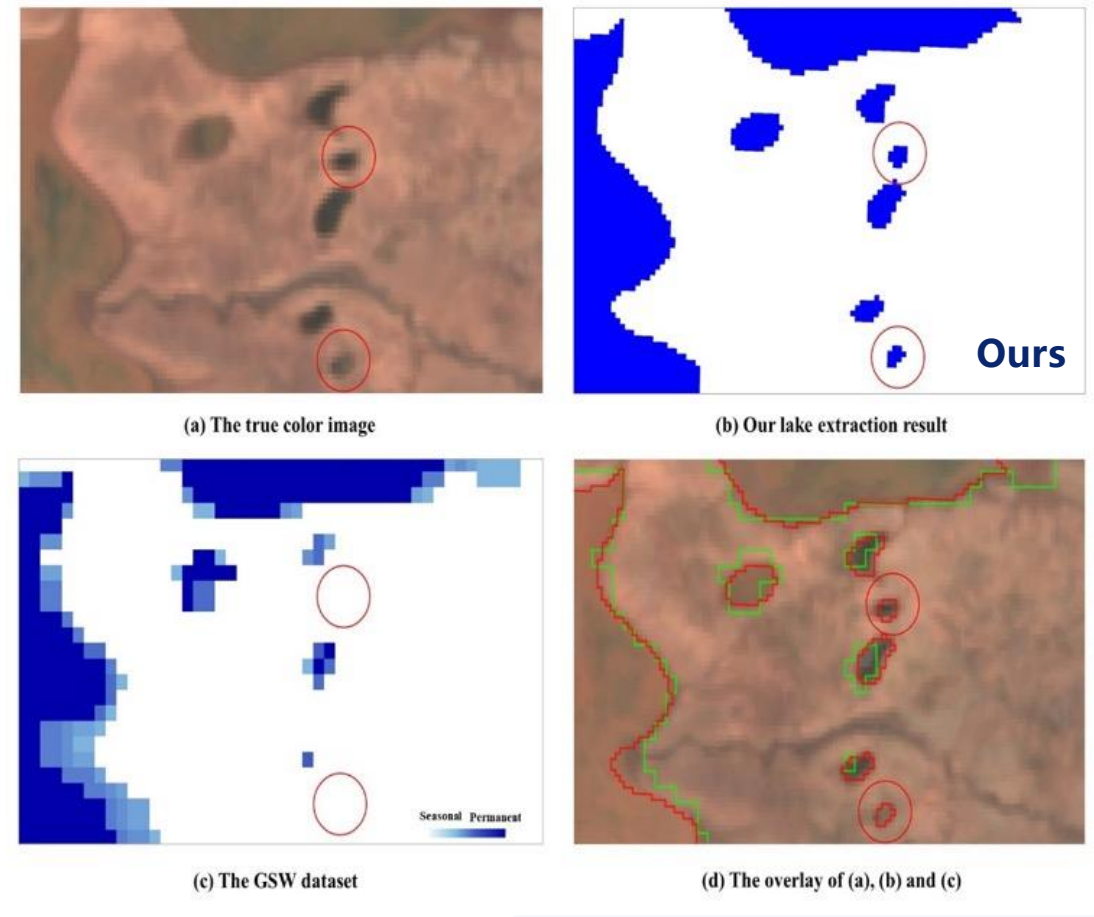
Water Body Distribution dataset in the HKH for the year 2021 (10m)  
– EO Source: Sentinel-2

# Key Element Datasets for SDGs

## Water



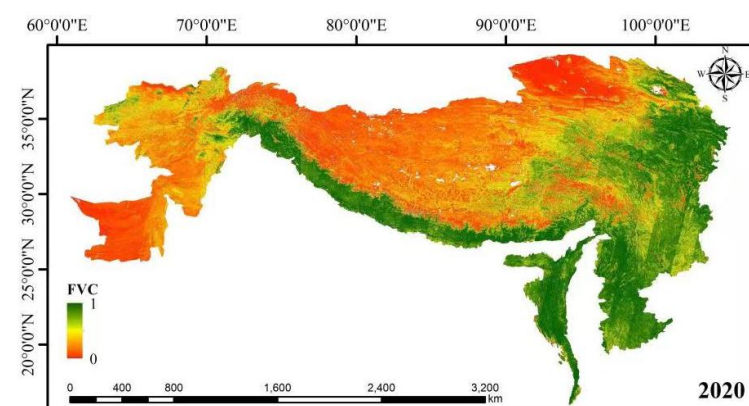
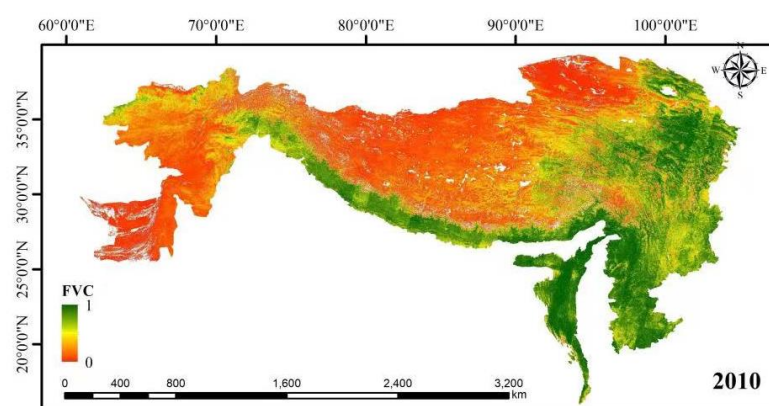
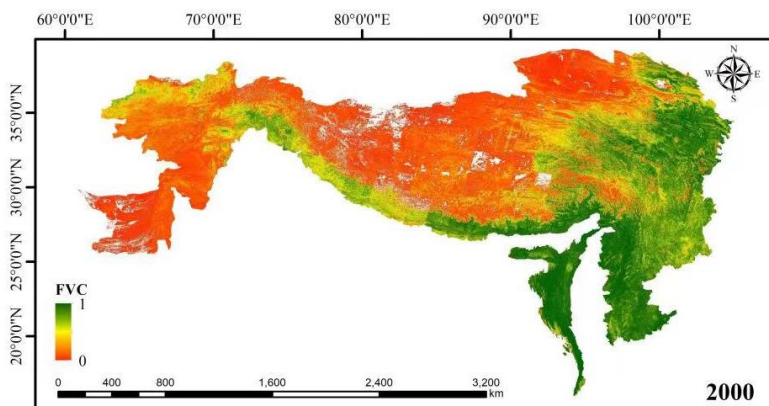
Boundary comparison with JCR Global Surface Water (GSW) data



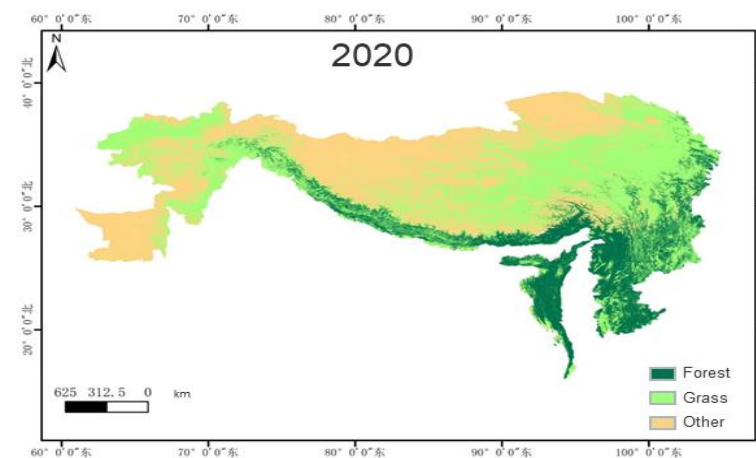
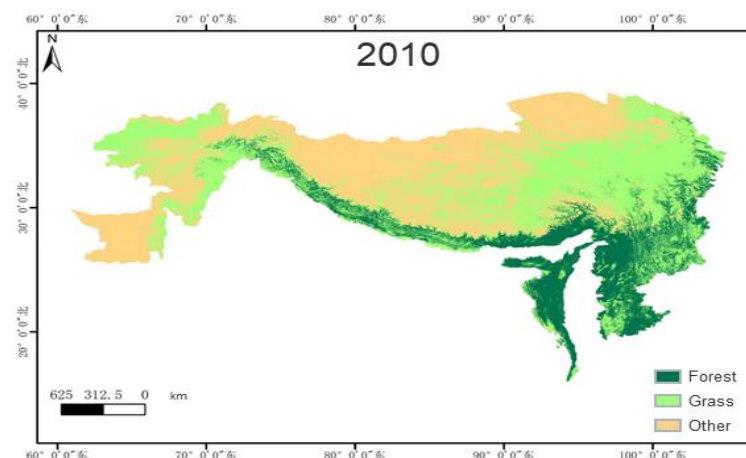
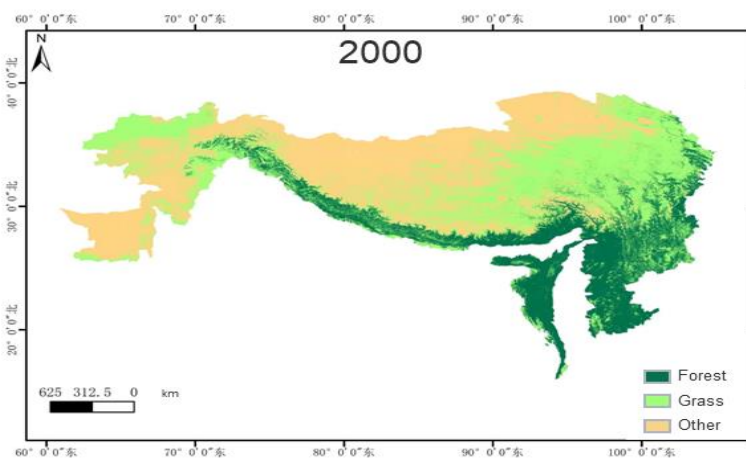
Missing small lakes comparison with JCR GSW data

# Key Element Datasets for SDGs

## Forest & Grass



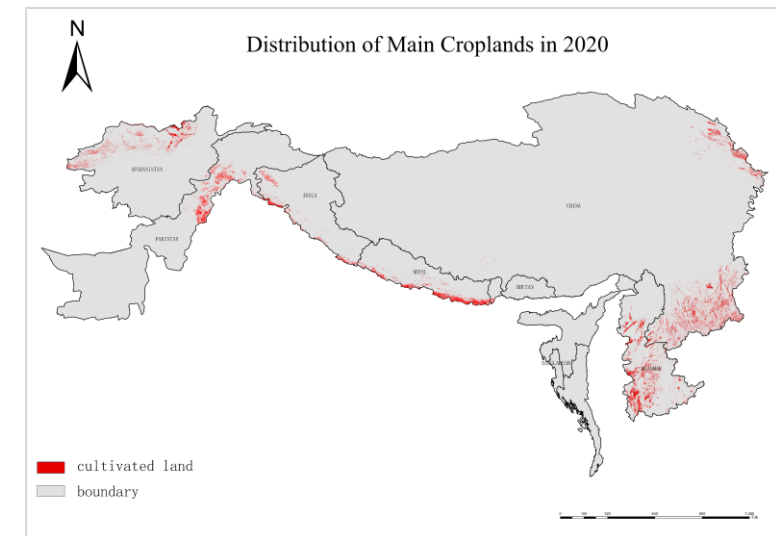
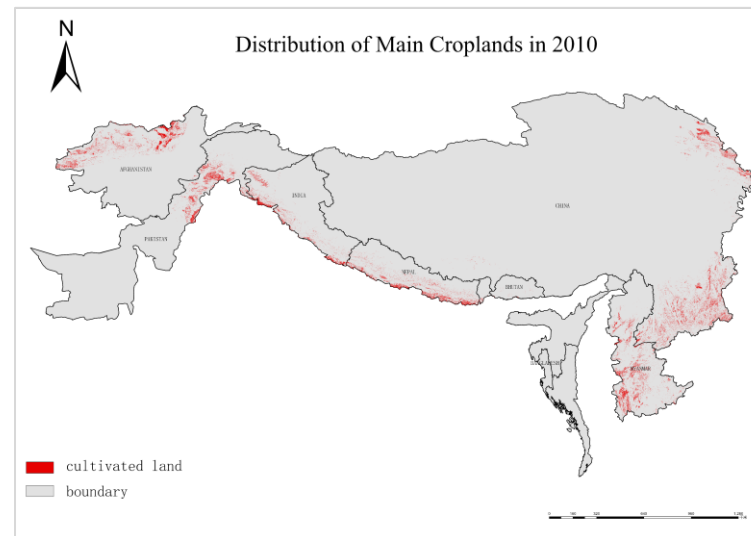
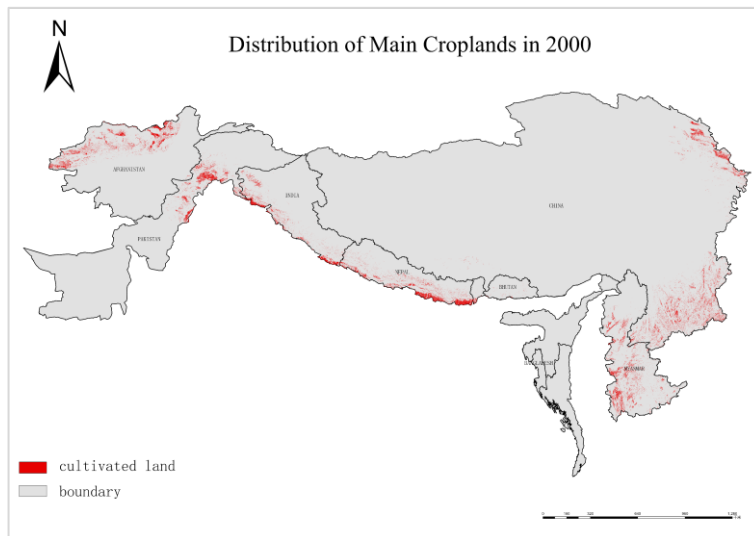
Fractional Vegetation Cover (FVC) dataset in the HKH (30m)



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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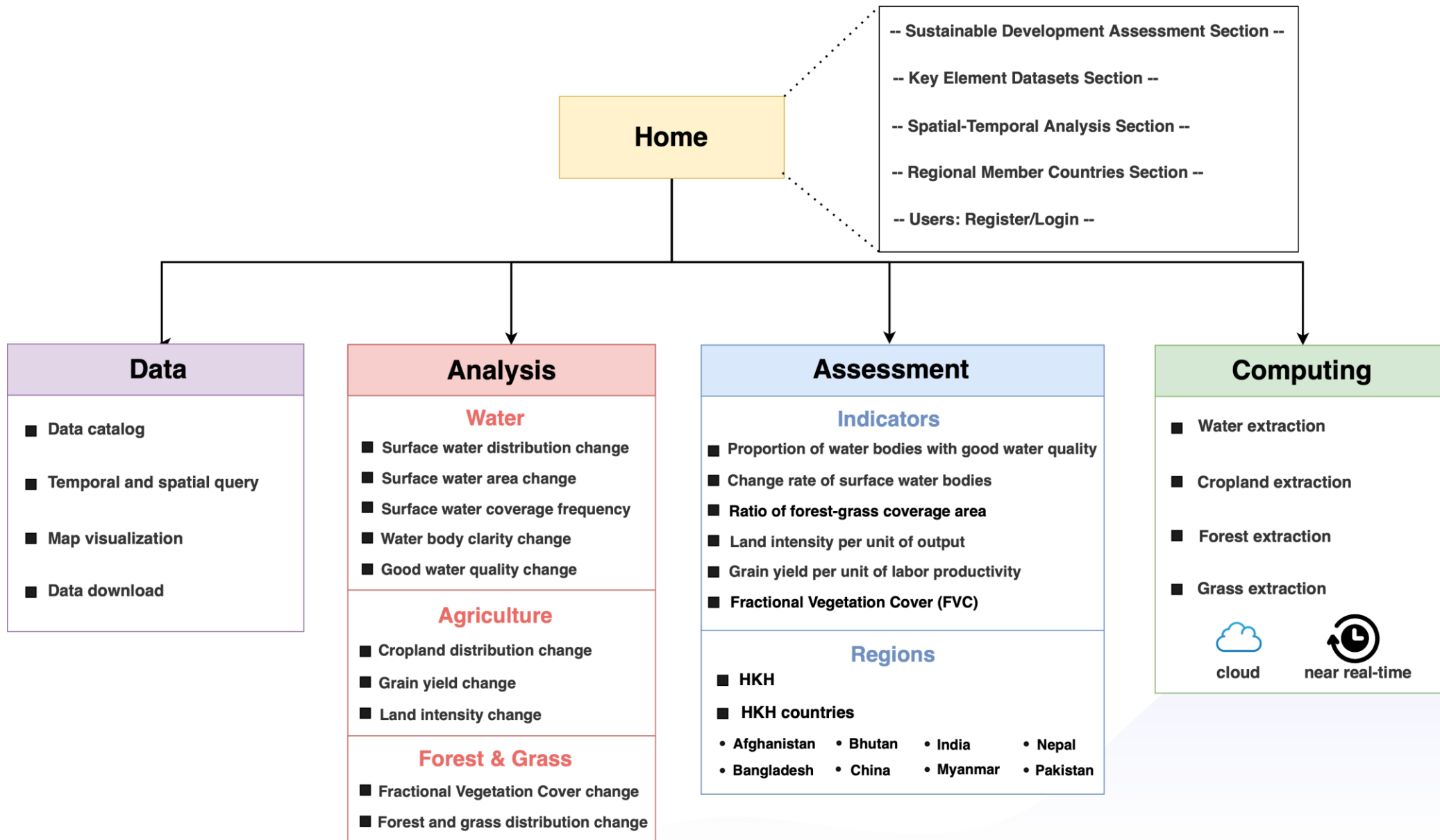
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# Framework



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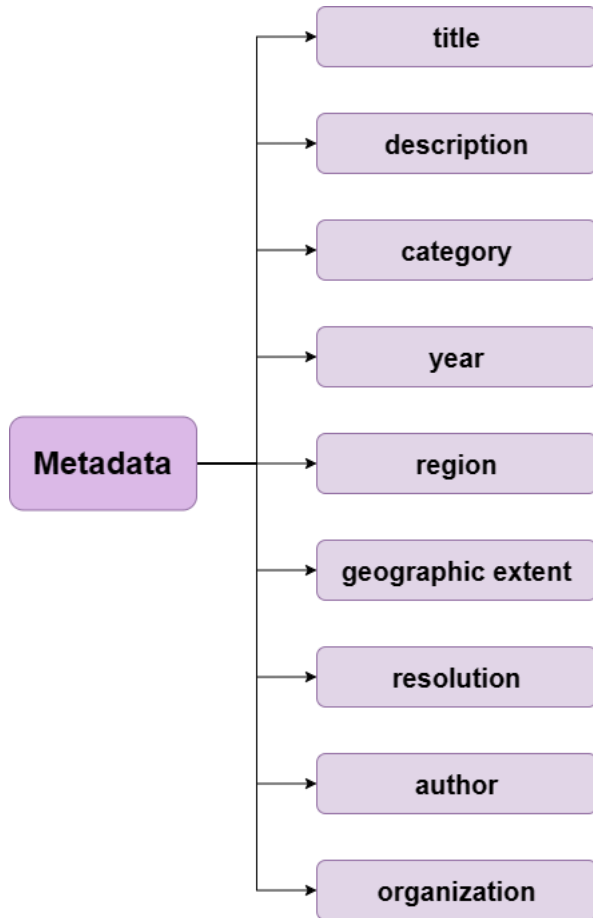
**Modules**

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# Data Module

## Data Catalog



Home / Data

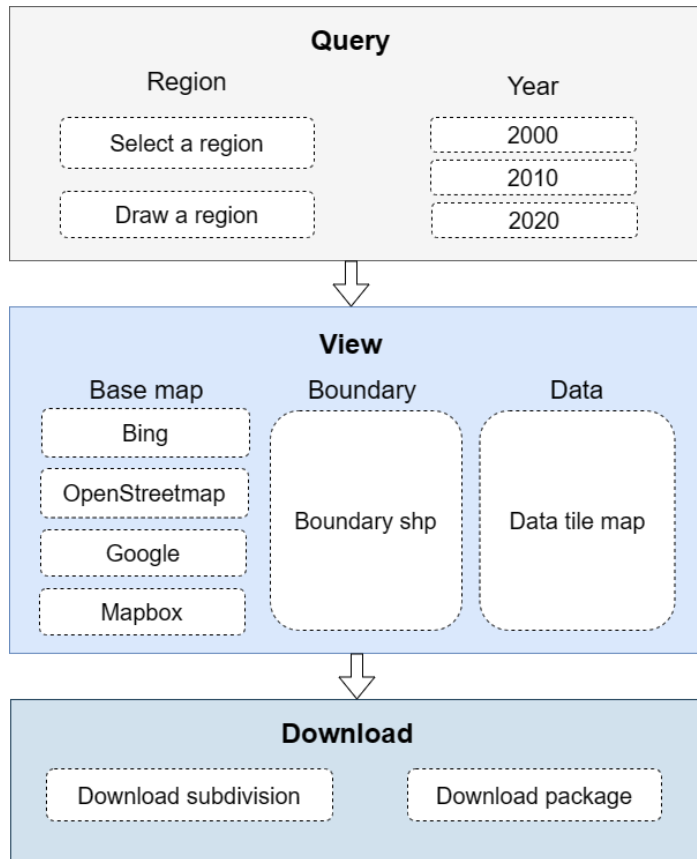
Large area, high resolution and geographical features.

Category	Thumbnail	Title	Description	Organization	Author	Region	Resolution	Category	Year	Geographic Extent
Water		Water Clarity dataset in the HKH for the year 2000, 2010, 2020 (30m)	Water clarity is a descriptive term for it This dataset describes how deeply visible light penetrates through water. It is one of the most important water quality parameters, and is directly related to the the suspended matter, planktonic algae, and colored dissolved organic matter in the water column...	Aerospace Information Research Institute , Chinese Academy of Sciences	Shanlong Lu	Hindu Kush Himalaya	30m	water	2000, 2010, 2020	15.958°N - 39.319°N , 60.854°E - 105.045°E
Water		Water Body Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)	This dataset is to describe the spatial distribution of in-a-year stable inland water bodies, including both lakes and rivers in the HKH. Most of the surface water bodies in the region are concentrated in the endorheic basin of Tibetan Plateau. A pixel with a pixel value of 1 is a water pixel, and a pixel val...	Aerospace Information Research Institute , Chinese Academy of Sciences	Shanlong Lu	Hindu Kush Himalaya	30m	water	2000, 2010, 2020	15.958°N - 39.319°N , 60.854°E - 105.045°E



# Data Module

## Data Query, View and Download



The screenshot displays the HKHSDGs web application interface. At the top, there is a navigation bar with links for Home, Assessment, Data, Analysis, Computing, About, and Account. The main content area is titled "Home / Data / Water Body Distribution dataset in the HKH for the year 2000, 2010, 2020 (30m)".

The interface is divided into three main sections:

- Select Data:** This section allows users to choose a region (currently "HKH Region" is selected) or draw a polygon. It also includes a "Select years" dropdown menu with options for 2000, 2010, and 2020. There are "DRAW", "CLEAR", "SUBMIT", and "RESET" buttons.
- Map:** The central map shows the water body distribution in the HKH region for the selected years. The map is overlaid on a satellite-style base map. Various counties and districts are labeled, including Shuanghu County, Gerze County, Nyain County, Coqen County, Xainza County, Damxung County, Lhasa, and others. The map includes zoom in (+) and zoom out (-) controls.
- Assets:** This section displays a list of data assets for the years 2010 and 2020. Each asset entry includes a thumbnail map, the year, the extent (e.g., "Extent: 35.0007N, 93.327N, 90.000E, 95.000E"), and "ZOOM IN" and "DOWNLOAD" buttons.

At the bottom left, there is a "Data Layers" panel with checkboxes for "Boundary" (checked) and "Data" (unchecked). Under "Data", there are sliders for the years 2000, 2010, and 2020, with 2020 currently selected.

# Analysis Module



Water
■ Surface Water Distribution Change
■ Surface Water Area Change
■ Surface Water Coverage Frequency
■ Water Body Clarity Change
■ Good Water Quality Change

Agriculture
■ Cropland Distribution Change
■ Grain Yield Change
■ Land Intensity Change
■ ...
■ ...

Developing

Forest & Grass
■ Fractional Vegetation Cover Change
■ Forest and Grass Distribution Change
■ ...
■ ...
■ ...

Developing

# Analysis Module

HKH SDGs

Home / Analysis / Surface Water Distribution Change Analysis

Home | Assessment | Data | Analysis | Computing | About | Account

### Select Data


Select a region  
HKH Region

Draw a polygon  
DRAW CLEAR

Select years  
2000, 2010

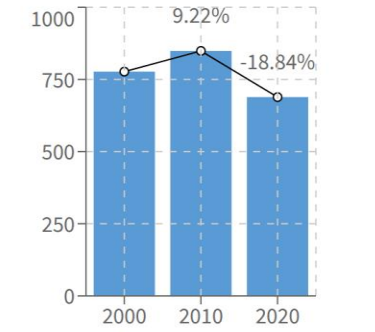
SUBMIT RESET

### Surface Water Distribution Change



890500563111236

### Surface Water Area Change



Year	Change (%)
2000	0
2010	9.22%
2020	-18.84%

# Analysis Module

HKH SDGs

Home / Analysis / Surface Water Coverage Frequency Analysis

Home | Assessment | Data | Analysis | Computing | About | Account

### Select Data


Select a region  
HKH Region

Draw a polygon  
DRAW CLEAR

Select years  
2000, 2010

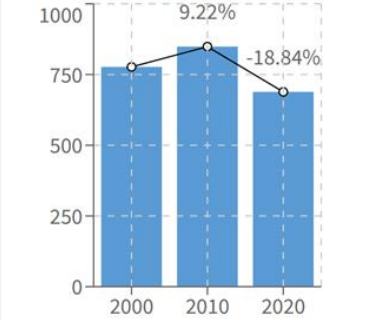
SUBMIT RESET

### Surface Water Coverage Frequency



91.3553, 31.1970

### Surface Water Coverage Change



Year	Change (%)
2000	780
2010	880 (9.22% increase)
2020	650 (-18.84% decrease)

# 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.

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

### ■ 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).

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

# 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.

$$\text{Ratio of forest – grass coverage area} = \frac{\text{Area}_{\text{forest / Grass}}}{\text{Area}_{\text{region}}}$$

### ■ 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.

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

$n$ : 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.

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

### ■ 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.

$$\textit{Land intensity per unit of output} = \frac{\textit{Area}_{\textit{land}}}{\textit{Grain yield}}$$

# Assessment Module



HKH SDGs

Home / Assessment

Home | Assessment | Data | Analysis | Computing | About | Account

HKH Region

Time Period: 2020

TIME SERIES CHART

HKH Countries

- China
- Afghanistan
- Nepal
- Bhutan
- Pakistan
- Myanmar
- India
- Bangladesh

### Water

**Change rate of surface water bodies**

**11.35 %**

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

**Proportion of water bodies with good water quality**

**92.35 %**

It reflects the proportion of water bodies that are not harmful to ecosystem function and human health...

### Ecological Environment

**Ratio of forest-grass coverage area**

**19.94 % 37.61 %**

Forest Grass

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

**Fractional Vegetation Cover (FVC)**

**50.85 %**

It is the average of Fractional Vegetation Cover calculated in 2000, 2010 and 2020, providing...



# Assessment Module

HKH SDGs

Home Assessment Data Analysis Computing About Account

Home / Assessment

HKH Region

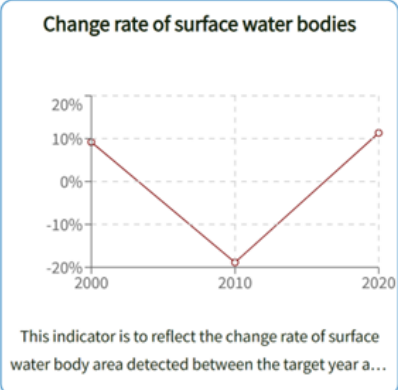
Time Period: None TIME SERIES CHART

HKH Countries

- China
- Afghanistan
- Nepal
- Bhutan
- Pakistan
- Myanmar
- India
- Bangladesh

### Water

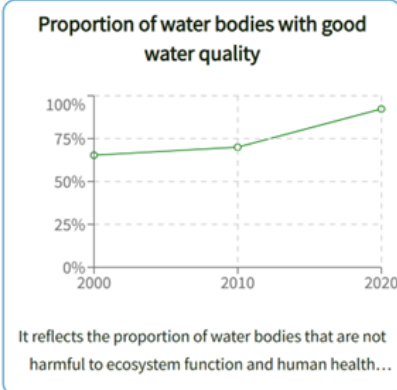
#### Change rate of surface water bodies



Year	Change rate (%)
2000	10%
2010	-20%
2020	10%

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

#### Proportion of water bodies with good water quality

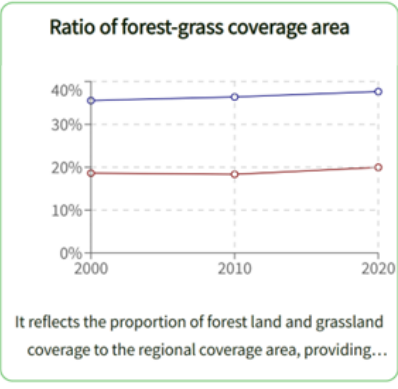


Year	Proportion (%)
2000	65%
2010	70%
2020	100%

It reflects the proportion of water bodies that are not harmful to ecosystem function and human health...

### Ecological Environment

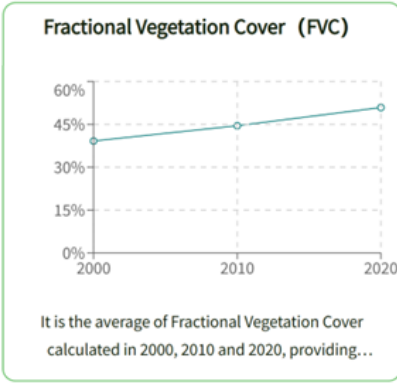
#### Ratio of forest-grass coverage area



Year	Forest Coverage (%)	Grassland Coverage (%)
2000	35%	18%
2010	38%	18%
2020	40%	20%

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

#### Fractional Vegetation Cover (FVC)

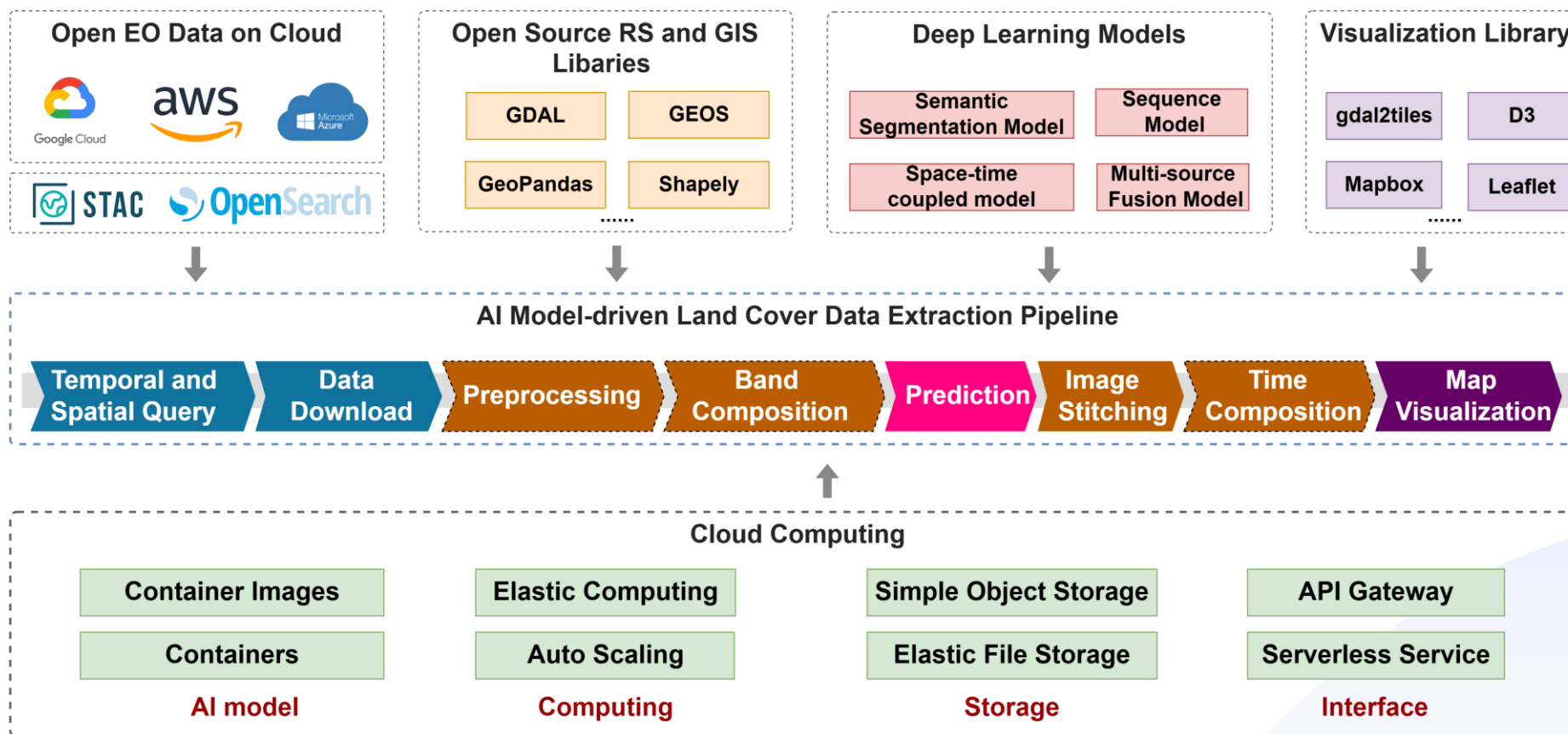


Year	FVC (%)
2000	40%
2010	45%
2020	55%

It is the average of Fractional Vegetation Cover calculated in 2000, 2010 and 2020, providing...

# 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

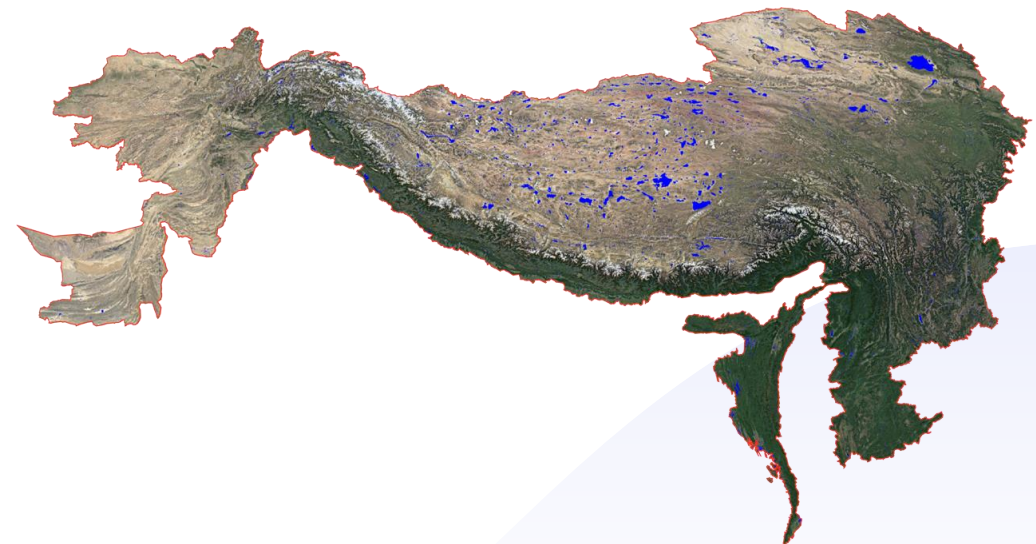
### ■ EO Data: 7661 Sentinel-2 images

- Time period: July to Oct 2021
- Cloud cover:  $\leq 20\%$

### □ Total Elapsed Time: **192 hours (8 days)**

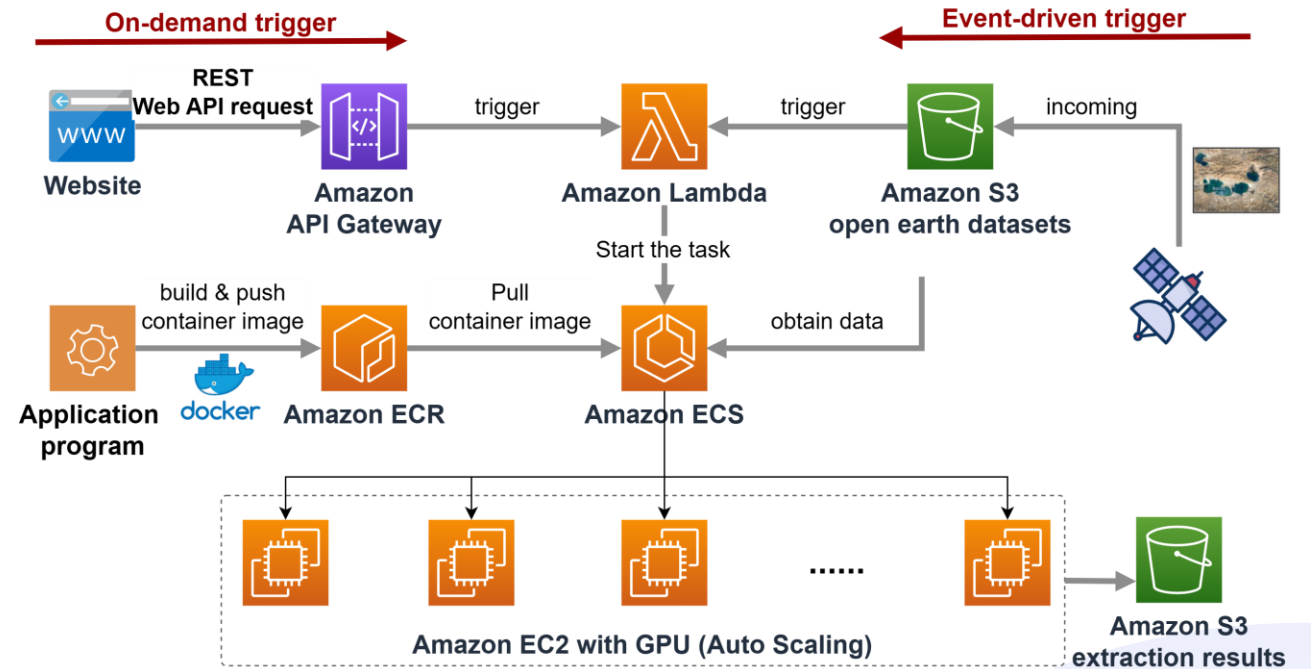
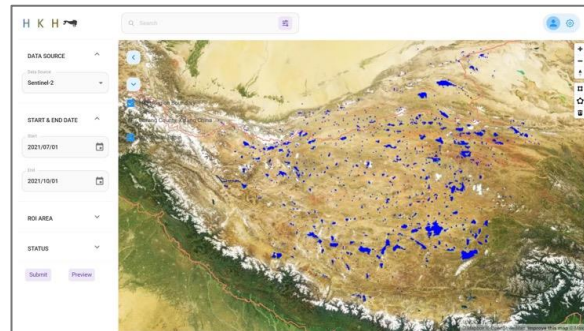
### ■ Elapsed time for a single image :

- 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**

