ICIMOD

USER MANUAL

Streamflow Prediction Tool

Author: Manish Shrestha

Contents

Abbreviations and acronyms

BYU	Brigham Young University, USA
DHM	Department of Hydrology and Meteorology, Nepal
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA-5	ECMWF Re-Analysis fifth generation
GIS	geographic information system
HKH	Hindu Kush Himalaya
HTESSEL	Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land
ICIMOD	International Centre for Integrated Mountain Development
NASA	National Aeronautics and Space Administration, USA
OSM	Open Street Map
RAPID	Routing Application for Parallel Computation of Discharge
SPT	Streamflow Prediction Tool
USA	United States of America
UTC	Coordinated Universal Time

Streamflow Prediction Tool (SPT)

Introduction

The mountainous Hindu Kush Himalaya (HKH) region is prone to water disasters because of its weak rock formations, steep slopes, and seasonal heavy rains. These disasters are made worse by the lack of clear communication of and information about risks. As climate change brings more extreme weather events, it is important to improve flood warnings systems.

To tackle flood risks in the HKH region, the International Centre for Integrated Mountain Development (ICIMOD), the USA's Brigham Young University (BYU) and the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory collaborated to create a flood forecasting system named the Streamflow Prediction Tool (SPT). SPT predicts river flow by using runoff forecasts from the Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land (HTESSEL) and then routing the forecasts through the Routing Application for Parallel Computation of Discharge (RAPID) model (ECMWF is the European Centre for Medium-Range Weather Forecasts).

The SPT produces a 10-day ensemble streamflow forecast. It also produces a hindcast. The forecast ensemble contains 51 members corresponding to each member of the runoff ensemble with three-hour temporal resolution and one 52nd deterministic runoff forecast from HTESSEL with a higher 1-hour temporal resolution.

The system covers most of the larger rivers of the HKH region. This tutorial uses the SPT-Nepal web application as an example for describing the interface and interpretation of results.

Interface

The Streamflow Prediction Tool (SPT) is comprehensive and easy to use. The tool is customised for Bangladesh, Bhutan, Nepal, and Pakistan and covers almost all major rivers in these countries as well as upstream transboundary rivers.

SPT is developed on the Tethys platform – an open-source web-GIS suite developed by BYU. It is regularly updated and customised to cater to stakeholder requirements. No registration is required to access and use the tool.

The SPT system is dynamic and interactive and can strengthen decision support systems for flood forecasting. Users have the option to select various base maps, river networks, and district layers. The river sections are colour-coded to represent different return periods. Upon clicking on the desired river section, the tool displays the forecasted discharge for the next 10 days. SPT also provides long-term historical discharge data based on ERA5-Land data. Users can download forecast and historical data for further analysis. Users also have the option to search for an area of interest by either using a location or river name. More information on the tool can be acquired from the link https://servir.icimod.org/science-applications/enhancing-flood-early-warning-systems/

Overview of the Streamflow Prediction Tool
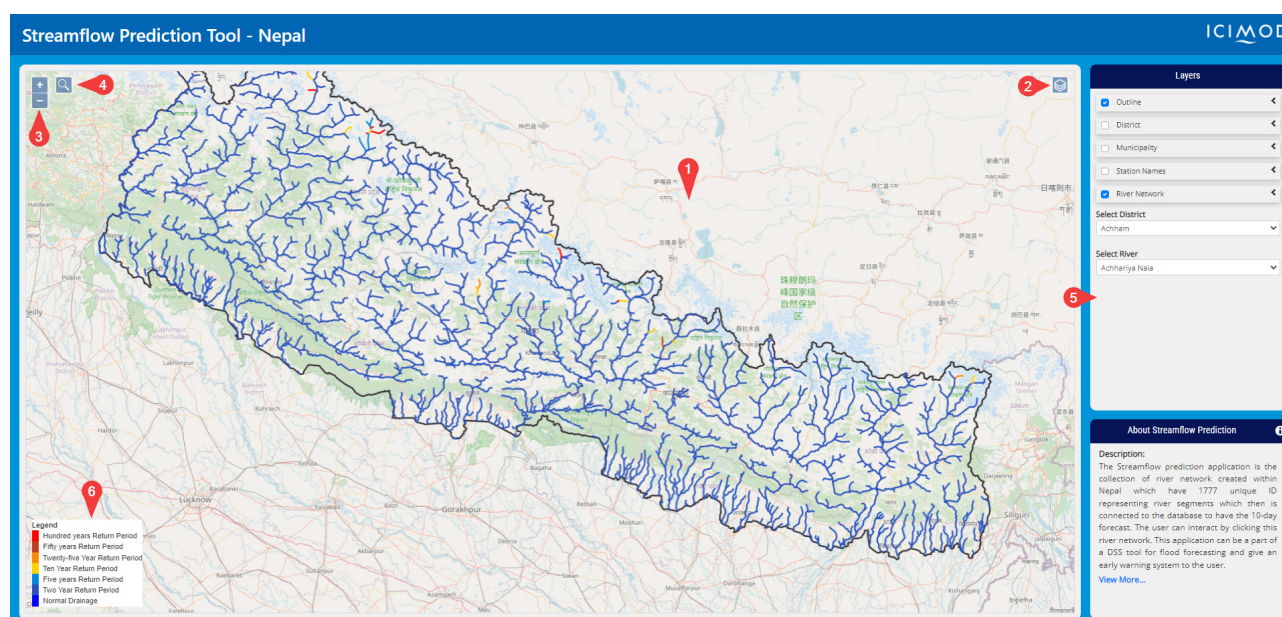
FIGURE 1	STREAMFLOW PREDICTION TOOL – NEPAL

TABLE 1	STREAMFLOW PREDICTION TOOL – NEPAL

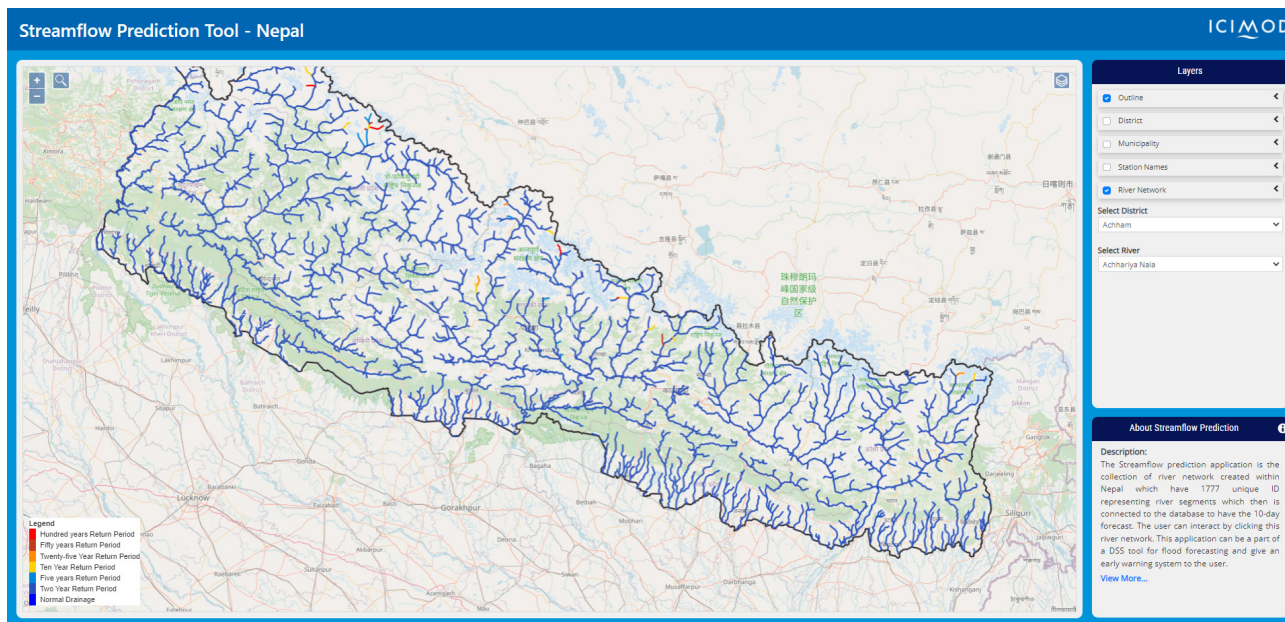| S. no.	Name	Purpose
1	Map view	Displays information selected by the user
2	Base map	Displays base map: Users can toggle between Open Street Map (OSM) and Bing map
3	Zoom slider	Provides interactive zoom control on the map. Alternatively, users can use the scroll wheel of a mouse
4	Search	Allows users to search an area of interest
5	Layers bar	Controls the data being shown in the Map View
6	Legend	Provides colour value based on the return periods

TABLE 2	LEGEND

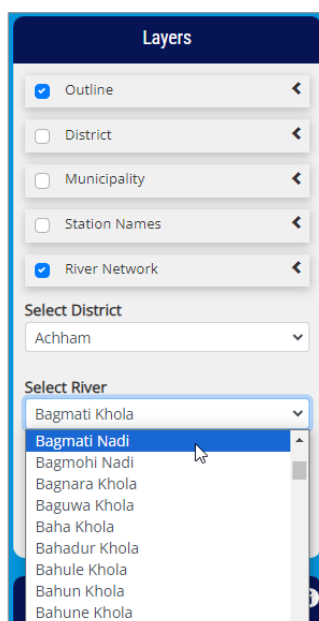| Colour	Return period	Description
Red	Hundred years	Water discharge may reach or cross the hundred-year return period point (calculated with historic data)
Brown	Fifty years	Water discharge may reach or cross the fifty-year return period point (calculated with historic data)
Orange	Twenty years	Water discharge may reach or cross the twenty-year return period point (calculated with historic data)
Yellow	Ten years	Water discharge may reach or cross the ten-year return period point (calculated with historic data)
Teal	Five years	Water discharge may reach or cross the five-year return period point (calculated with historic data)
Purple	Two years	Water discharge may reach or cross the two-year return period point (calculated with historic data)
Blue	Normal drainage	Water discharge is normal

Exploring the Streamflow Prediction Tool

1. Copy and paste the following URL on your web browser to visit the tool
    http://tethys.icimod.org/apps/streamflownepal/

2. A web-based tool will appear (Figure 2). Please refer to Figure 1, Tables 1 and 2 to learn about the different components of the tool. In the Layers bar, click on the **layers** that you wish to display in the map view. You have an option to display the country outline, district outline, municipality outline, hydrological stations operated by the Department of Hydrology and Meteorology (DHM), and the river network. The layers will help you identify your desired area of interest.

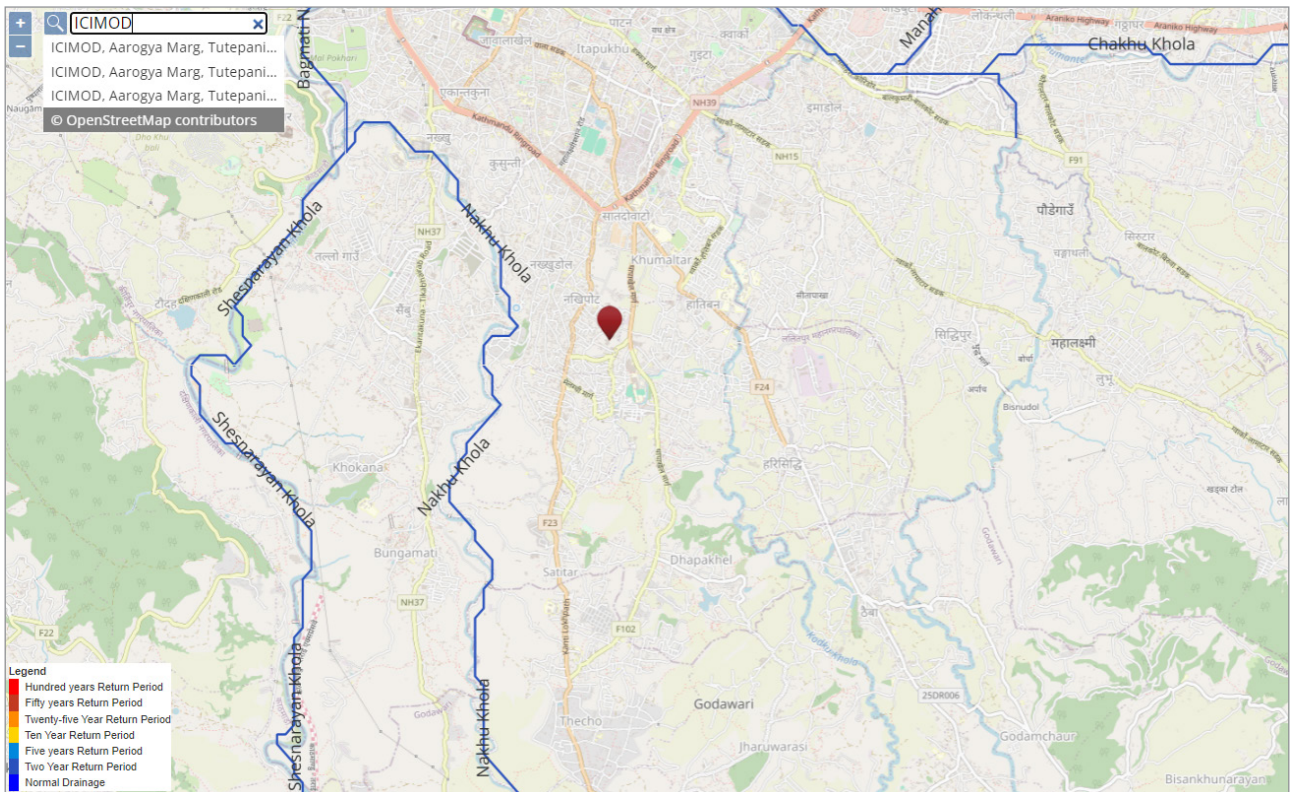| FIGURE 2	SCREENSHOT OF WEB PORTAL

3. You can also zoom into the area of interest by selecting a district or a river on the **Select District** or the **Select River** drop-down menus respectively (Figure 3).

FIGURE 3	SELECT DISTRICT AND SELECT RIVER DROP-DOWN MENUS

4. Zoom into the river of interest using the **zoom slider** or the mouse scroll wheel. You can also type in your area of interest in the **search bar** (Figure 4).

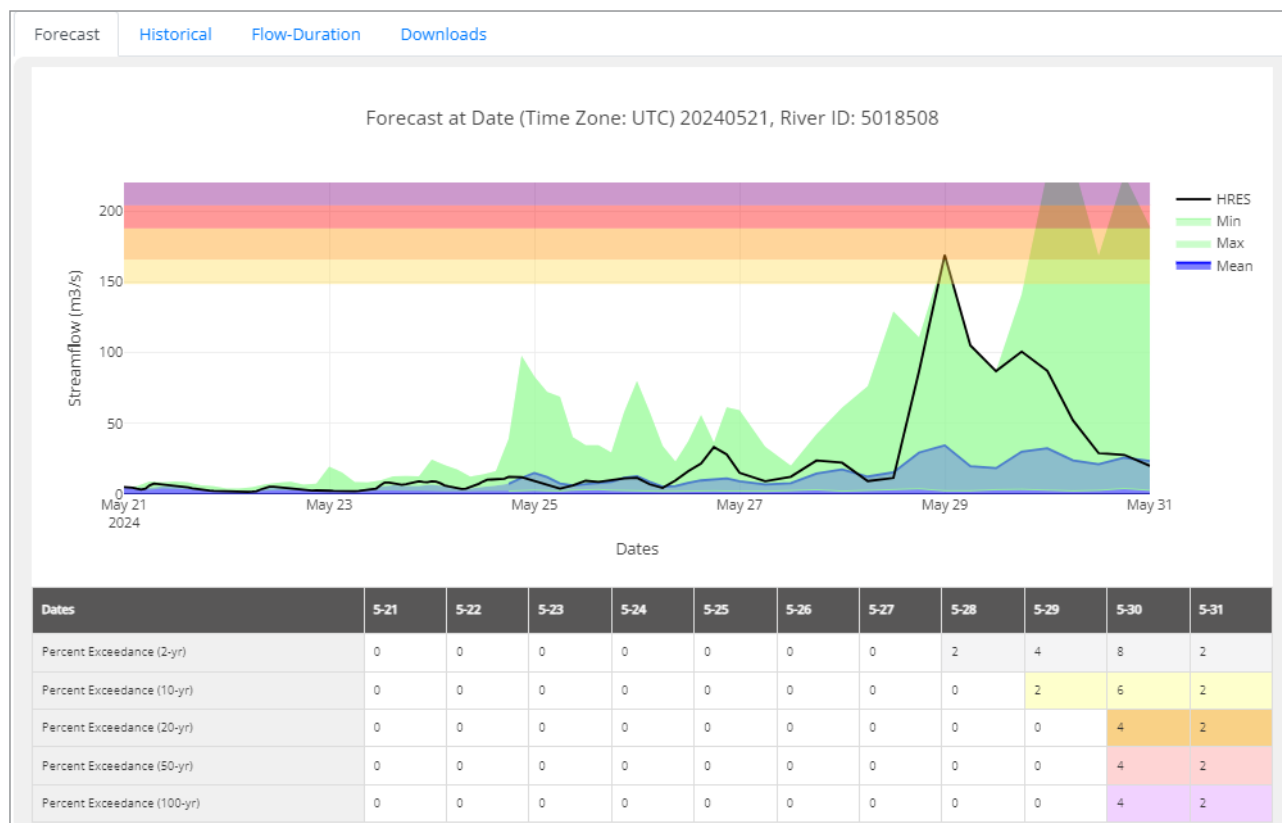5. Hover the mouse pointer over the river segment until the pointer icon changes (as shown in Figure 5). Left click on the river segment.
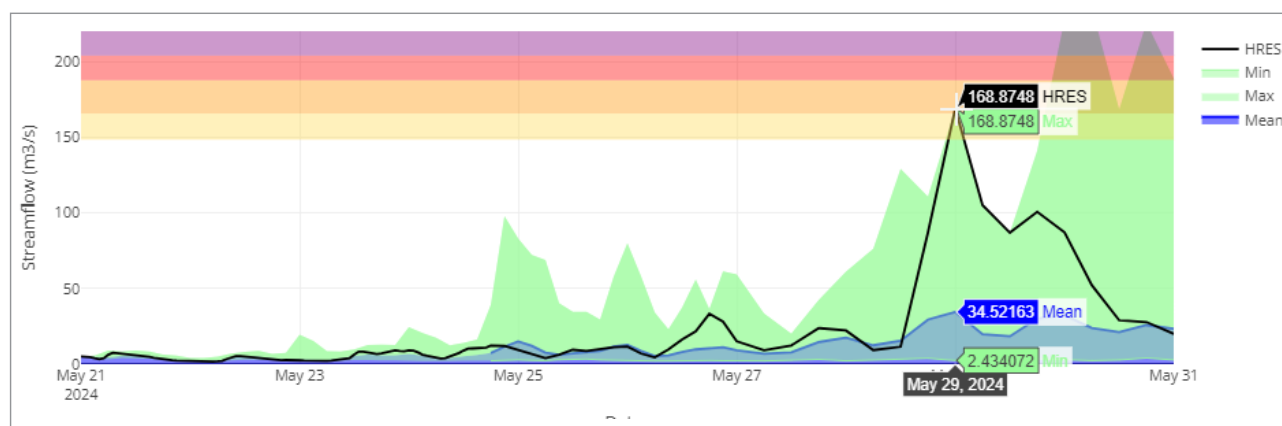
6. A new window should open displaying information about the river segment you selected, similar to Figure 6. Corresponding tabs allow users to view historical information and download the data.

A NEW WINDOW OPENS DISPLAYING INFORMATION ABOUT THE SELECTED RIVER SEGMENT

Dates	5-21	5-22	5-23	5-24	5-25	5-26	5-27	5-28	5-29	5-30	5-31
Percent Exceedance (2-yr)	0	0	0	0	0	0	0	2	4	8	2
Percent Exceedance (10-yr)	0	0	0	0	0	0	0	0	2	6	2
Percent Exceedance (20-yr)	0	0	0	0	0	0	0	0	0	4	2
Percent Exceedance (50-yr)	0	0	0	0	0	0	0	0	0	4	2
Percent Exceedance (100-yr)	0	0	0	0	0	0	0	0	0	4	2

7. Selecting the corresponding tab, users can view **Forecast**, **Historical or Flow-Duration Curve** graphs. An option to **download** the data is also available.

8. The **Forecast** tab displays predicted streamflow information for the next 10 days. Hover the mouse over the graphs to display the discharge value for that given time (Figure 7). Please see the section on **Interpretation of Results** below for insights into the graphs and tables.
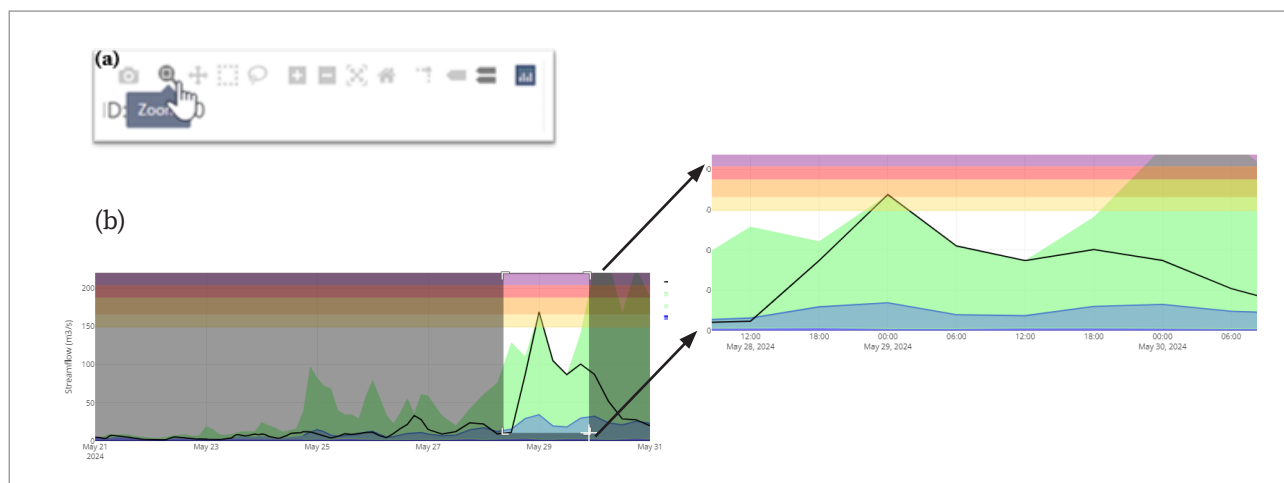
ONCE YOU HOVER THE MOUSE OVER THE GRAPH, YOU WILL SEE A DISCHARGE VALUE FOR THE GIVEN TIME

9. Once you hover the mouse over the graph, you will see a few tools at the top right side of the graph (Figure 8, a). Use the tools as required to zoom in or download the hydrograph displayed (Figure 8, b).
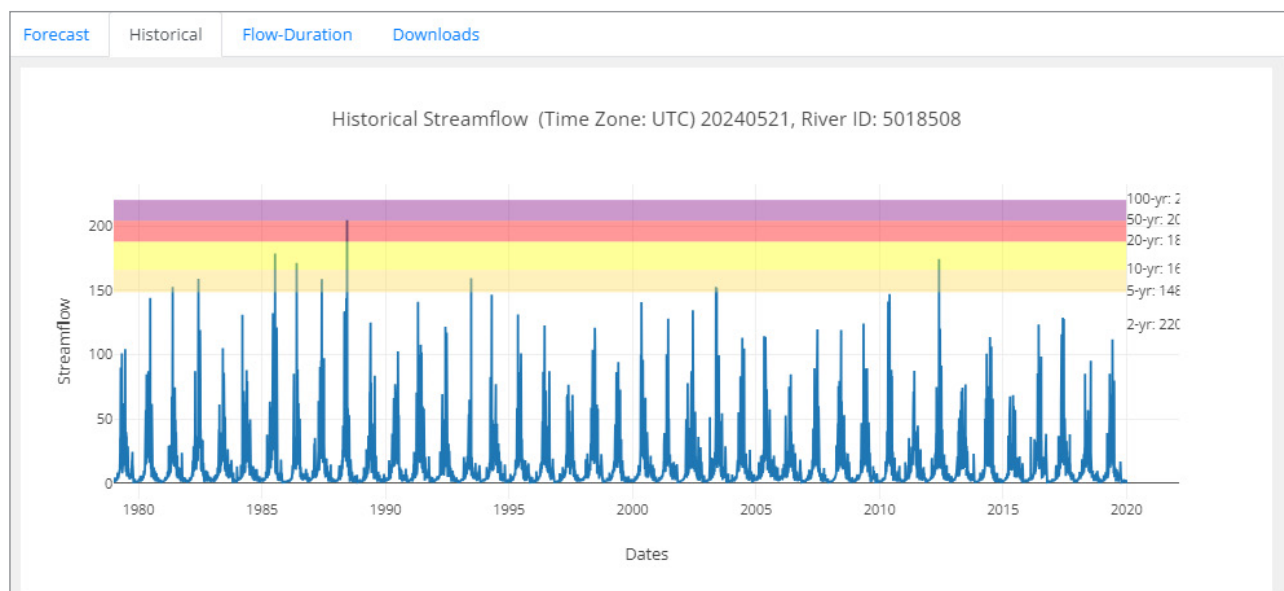
10. The **Historical** tab displays the historical streamflow of the selected river segment. The streamflow value here is not from the measured station data; instead, the data is simulated using the ERA5-Land data routed through the river segments in the RAPID model (Figure 9).
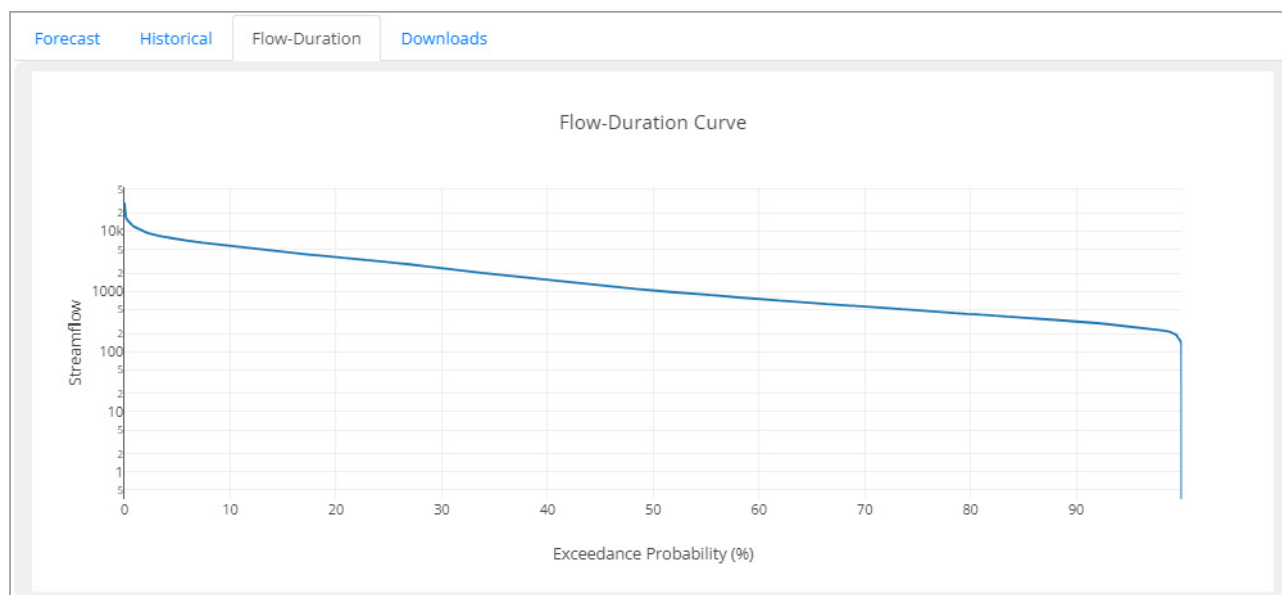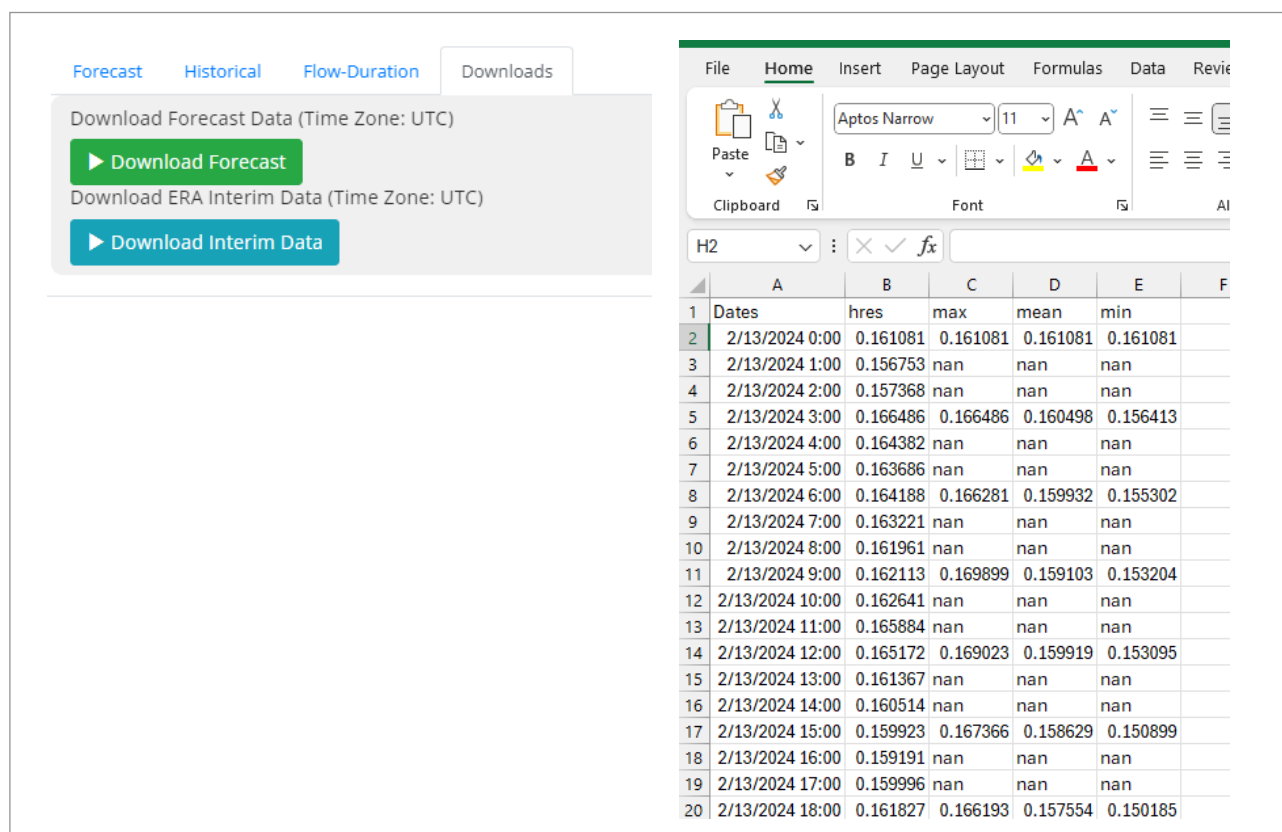
11. The **Flow-Duration** curve (Figure 10) shows the percentage of time when a specific discharge was equalled or exceeded during a given period. The graph is based on the process defined in **step 10**.

THE FLOW-DURATION TAB DISPLAYS THE FLOW DURATION CURVE OF THE SELECTED RIVER SEGMENT
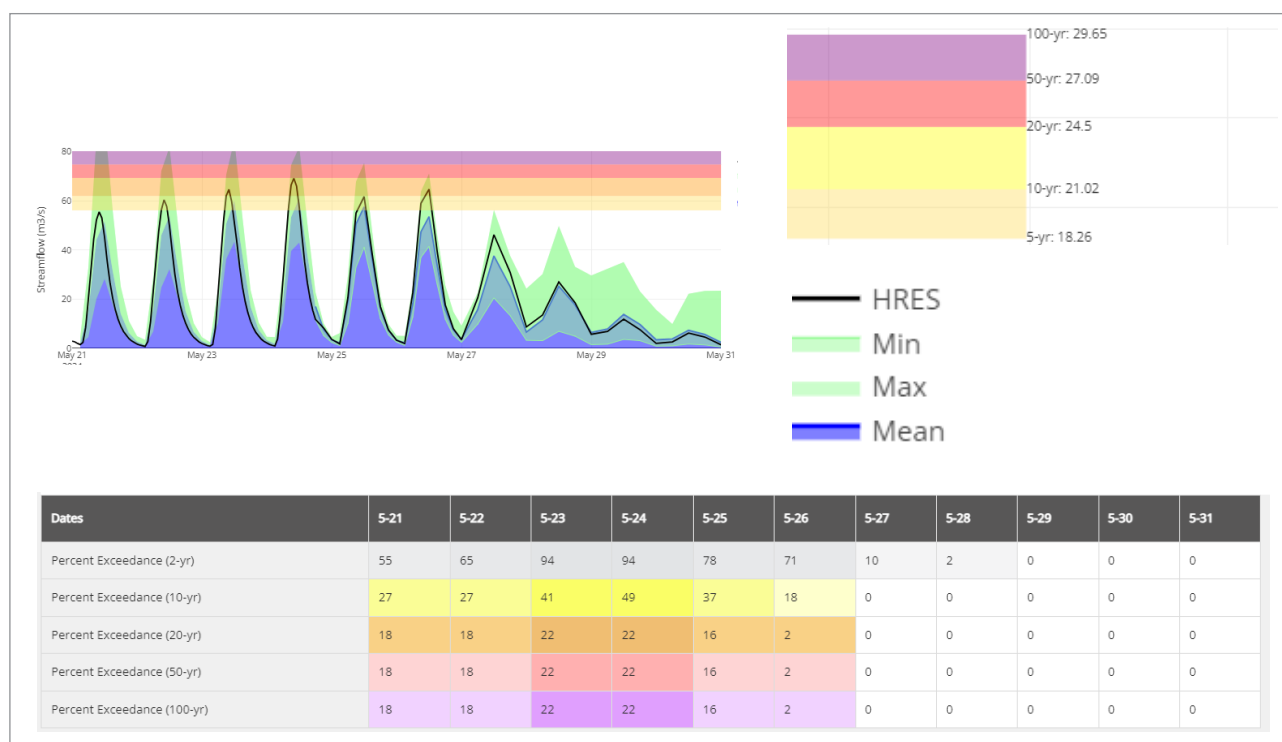

12. With the **Download** tab, forecasted and historical discharge can be downloaded in a CSV file format (Figure 11). The time zone of the downloaded data is UTC and should be converted to local time for further analysis.

THE HISTORICAL TAB DISPLAYS THE HISTORICAL STREAMFLOW OF THE SELECTED RIVER SEGMENT

Interpretation of results

Dates	5-21	5-22	5-23	5-24	5-25	5-26	5-27	5-28	5-29	5-30	5-31
Percent Exceedance (2-yr)	55	65	94	94	78	71	10	2	0	0	0
Percent Exceedance (10-yr)	27	27	41	49	37	18	0	0	0	0	0
Percent Exceedance (20-yr)	18	18	22	22	16	2	0	0	0	0	0
Percent Exceedance (50-yr)	18	18	22	22	16	2	0	0	0	0	0
Percent Exceedance (100-yr)	18	18	22	22	16	2	0	0	0	0	0

Zoom in or search an area of your interest. Once you find the desired river section, left click on the section to display the hydrograph. In the hydrograph, the x-axis represents the day/time, and the y-axis represents the streamflow values for the selected river section. Here, the day/time displayed is the local time.
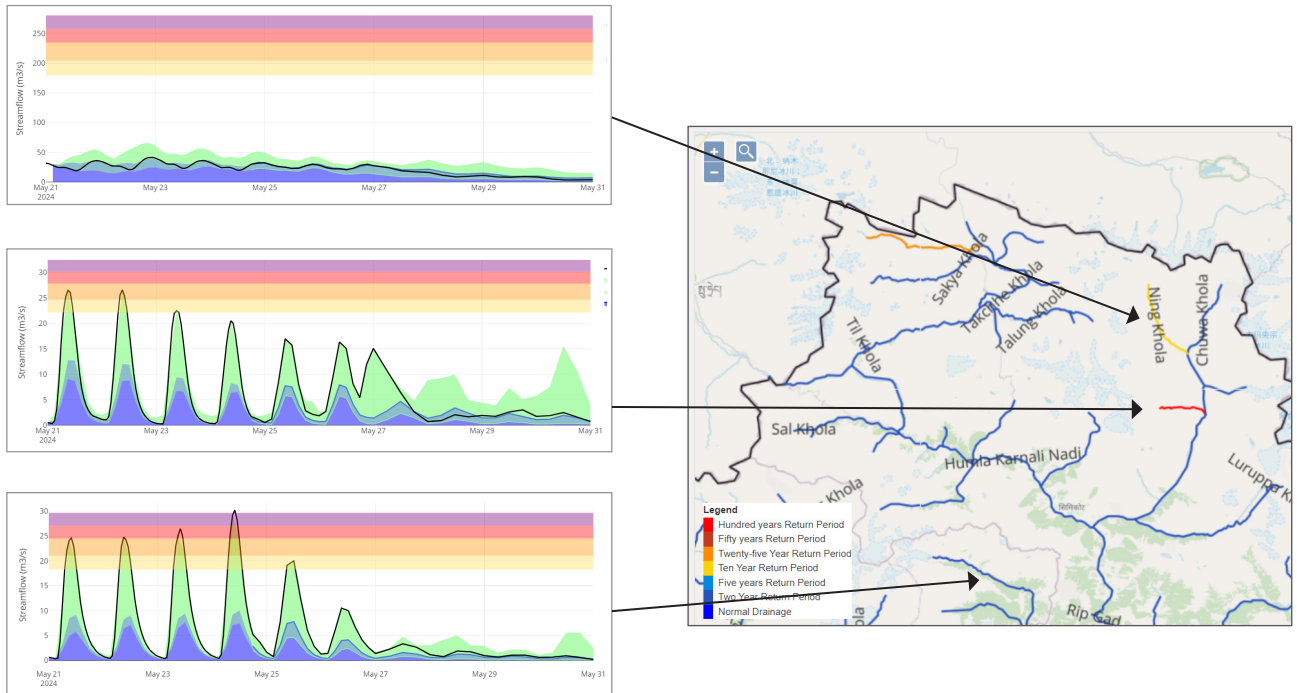
The SPT provides the hydrograph based on 51 ensemble and one (52nd) high temporal resolution model run for the upcoming 10 days. The blue lines represent the mean values and the green lines represent the max and min values of the 51-ensemble run, whereas the black line represents the 52nd high-resolution model run.

The beige, yellow, red, and purple horizontal bars represent 5-year, 10-year, 20-year, 50-year, and 100-year return periods for the river segment. These values were calculated using the ERA5-Land-based historical streamflow.

The table underneath the graphs shows the percentage of ensemble runs that exceed the specific return period. For example, in Figure 12, we see that there is a 55% probability that the discharge in the river will cross the 2-year return period on 21 May i.e. 28 (55% of 51) out of the 51 models suggest discharge in the river will cross the 2-year return period on 21 May. Similarly, there is an 18% probability that the flow in the river will cross 20-, 50-, and 100-year return periods i.e. 9 out of 51 models (18% of 51) suggest the river will cross the 20-, 50-, and 100-year return periods.

If the average value of the forecasted streamflow for the next 10 days crosses the certain threshold of the return period, the river segment in the main map will change its colour accordingly. The corresponding change in colour and the return period value are shown in Table 2.

FIGURE 13   RIVER SEGMENTS SHOWING VARIOUS RETURN PERIODS

About ICIMOD

The Hindu Kush Himalaya (HKH) region stretches 3,500km across Asia, spanning eight countries – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Encompassing high-altitude mountain ranges, mid-hills, and plains, the zone is vital for the food, water, and energy security of up to two billion people and is a habitat for countless irreplaceable species. It is also acutely fragile, and vulnerable to the impacts of the triple planetary crisis of climate change, pollution, and biodiversity loss.

The International Centre for Integrated Mountain Development (ICIMOD), based in Kathmandu, Nepal, is an international organisation established in 1983, that is working to make this critical region greener, more inclusive and climate resilient. For more information, read our Strategy 2030 and explore our website.

REGIONAL MEMBER COUNTRIES

AFGHANISTAN   BANGLADESH   BHUTAN   CHINA

INDIA   MYANMAR   NEPAL   PAKISTAN

© ICIMOD 2024   **International Centre for Integrated Mountain Development**
                        www.icimod.org