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Introduction to the Karnali Decision Support Tool

Karnali Decision Support Tool

- System-scale planning is about finding the trade-offs between the metrics that are important to stakeholders
- Discussing the trade-offs helps making better decisions that all can agree on, but only if the trade-offs can be made visible and quantifiable.
- The chart tools in the SSP Map Package have helped to start making the tradeoffs visible

→ But … analysing multiple metrics at the same time requires better tools.

Tiger Photo by Blake Meyer on Unsplash

Module 3 – Session 4
Karnali Decision Support Tool – "Karnali DST"

- We developed an online tool that presents the results of the SSP model
- Karnali Decision Support Tool → Karnali DST
- For this training located at https://hydrolab.io/paani_ssp/karnali/
- Original source of tool: https://github.com/syntagmatic/parallel-coordinates
- Examples from literature in other places are given below

(click on the picture to open study)

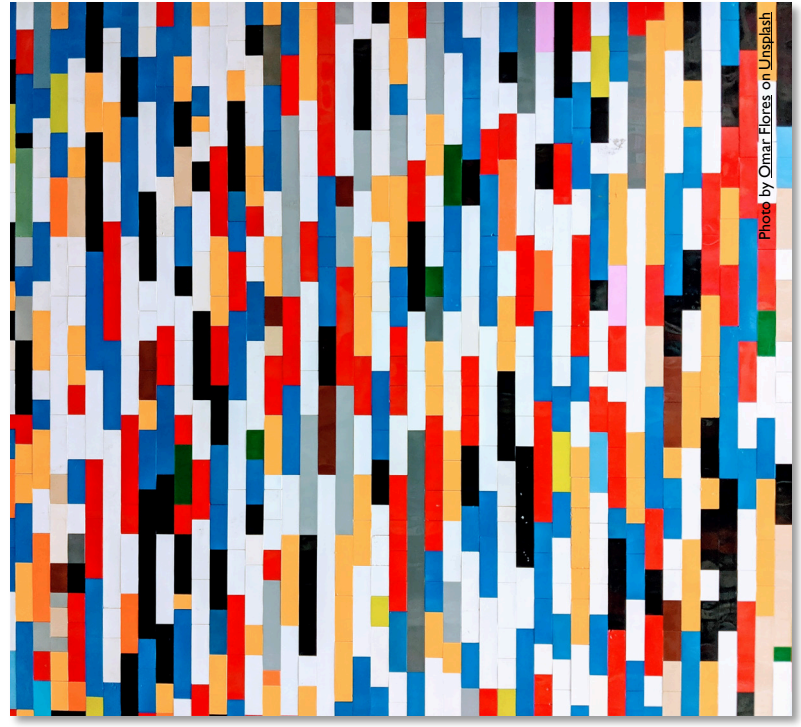
Module 3 – Session 4

Karnali Decision Support Tool – Characteristics

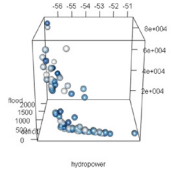
- Explore **multiple** portfolios and **multiple** metrics → more holistic and integrated
- Portfolios are **optimized** → suboptimal portfolios are weeded out by MOEA
- **Accessible and interactive** → promotes stakeholder engagement and discussion
- **Open source** and easy to adapt → additional metrics can be easily added
- Makes use of **Parallel Axis Plots** → powerful visualization, needs training to use

What are Parallel Axis Plots?

- Parallel axis plots are a type of graph that can facilitate the exploration of **multiple metrics** for **many thousands of data points**
- These can then be **interactively explored** by the user using filters and selections
- **Purpose in our case: to identify solutions and inform discussions** around which solutions have acceptable impacts across the multiple criteria.



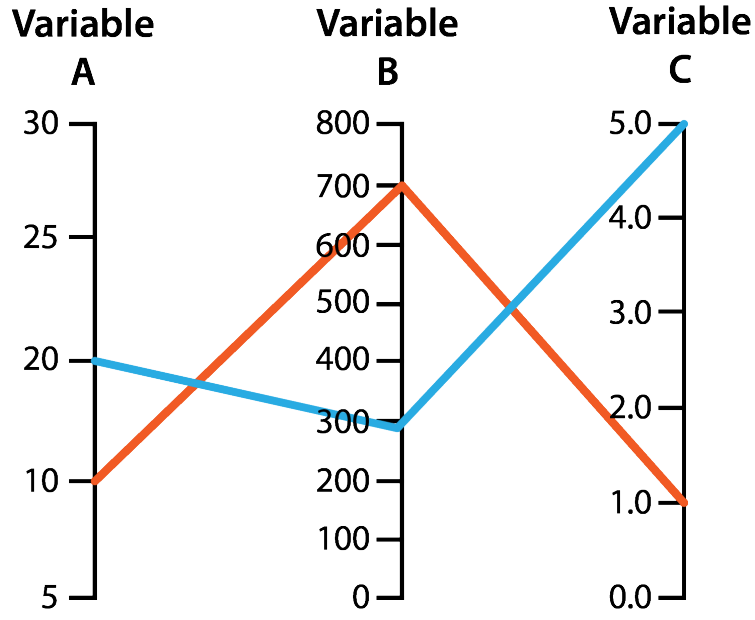
Parallel Axis Plots



- Scatterplots with more than two dimensions are difficult to understand

→ One of the best ways to explore multi-variate data are Parallel Axis Plots

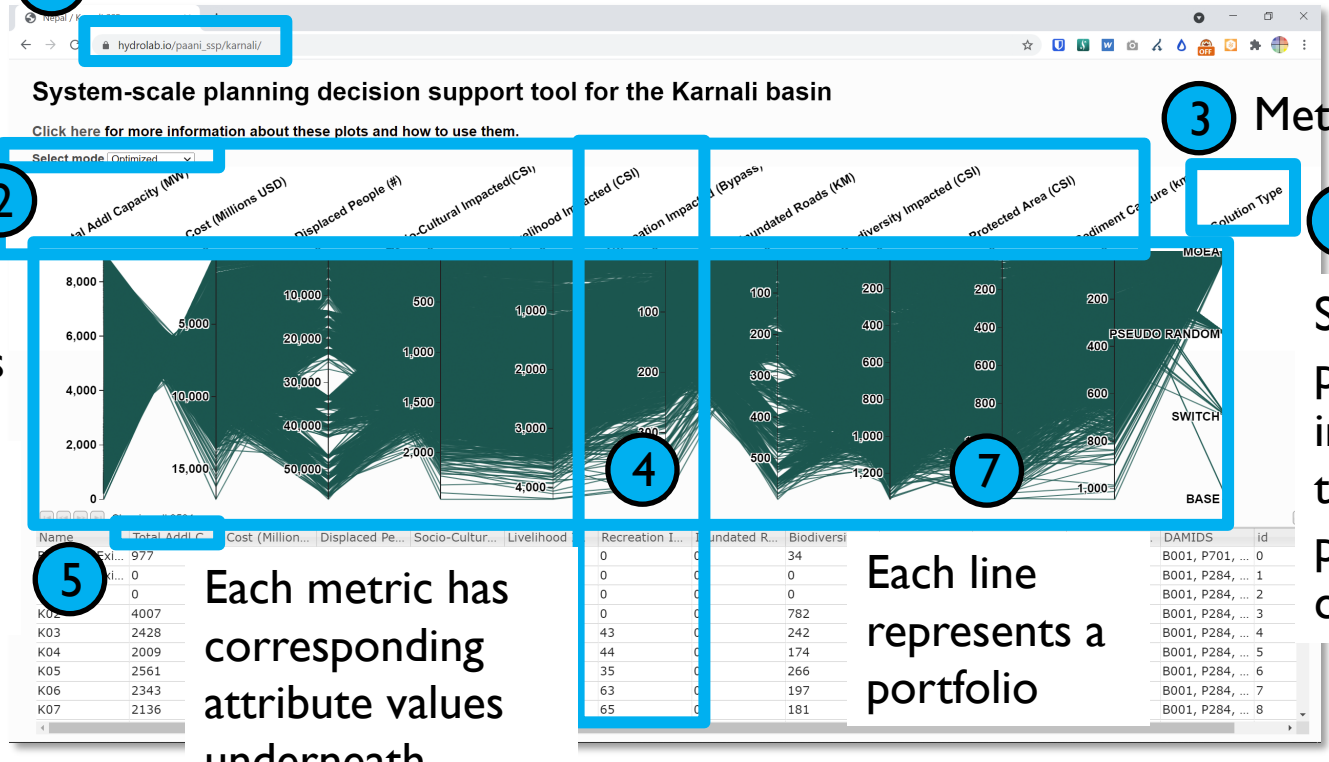
- How do they work?
  - Each variable (metric) is given its own axis and all the axes are placed in parallel to each other
  - Values are plotted as a series of lines that connect across all the axes
  - Lines represent the portfolios
  - Graph is linked to a table



Data			
	Variable A	Variable B	Variable C
Portfolio 1	10	700	1.0
Portfolio 2	20	300	5.0

Karnali DST - Overview

1 Website



Select among three different plot types

2

3 Metrics

6

Solution type provides more information on the way the portfolio was calculated

Click on the table column name to sort

5

Each metric has corresponding attribute values underneath

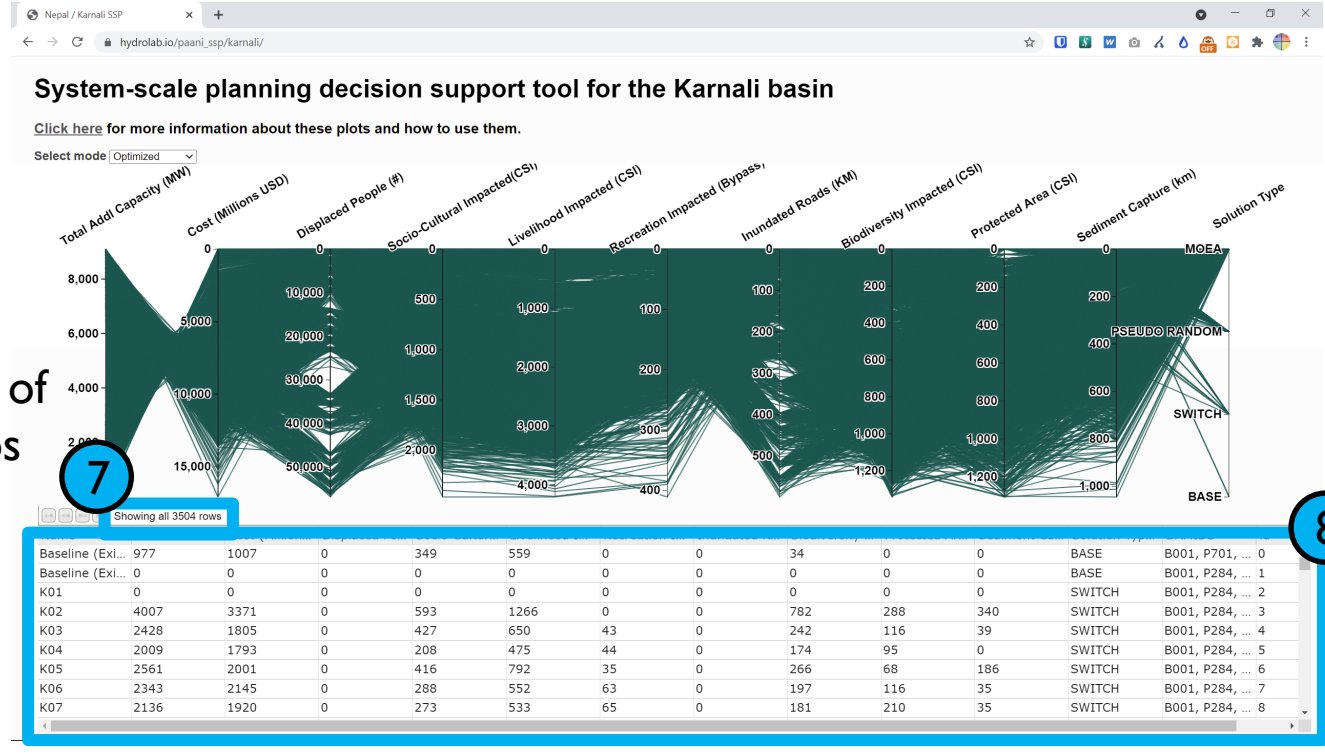
4

7

Each line represents a portfolio

Karnali Decision Support - Components

Number of portfolios selected



Baseline (Exi...	977	1007	0	349	559	0	0	34	0	0	BASE	B001, P701, ...	0
Baseline (Exi...	0	0	0	0	0	0	0	0	0	0	BASE	B001, P284, ...	1
K01	0	0	0	0	0	0	0	0	0	0	SWITCH	B001, P284, ...	2
K02	4007	3371	0	593	1266	0	0	782	288	340	SWITCH	B001, P284, ...	3
K03	2428	1805	0	427	650	43	0	242	116	39	SWITCH	B001, P284, ...	4
K04	2009	1793	0	208	475	44	0	174	95	0	SWITCH	B001, P284, ...	5
K05	2561	2001	0	416	792	35	0	266	68	186	SWITCH	B001, P284, ...	6
K06	2343	2145	0	288	552	63	0	197	116	35	SWITCH	B001, P284, ...	7
K07	2136	1920	0	273	533	65	0	181	210	35	SWITCH	B001, P284, ...	8

Attribute table = "results'" table in Map Package

Module 3 – Session 4

Karnali DST - Results table

Tip: Review the attribute fields of the results table

- Results table in Map Package has been edited and is used also for the online tool
- Reduced set of columns → only the columns that were used for optimization were included
- More descriptive names → Attribute (metrics) names have been edited
- Reduced set of portfolios → mostly the optimized portfolio (pareto-optimal) are included
- Tip: 'SCEID' and 'Name' column in the online tool refer to the same field, used to identify the portfolio of projects

Karnali DST

Showing all 543 rows

name	Total Addl Capacity (MW...	Cost (Millions USD)
2_1003	254	74
2_1005	809	629
2_1006	380	200
2_1008	680	500
2_103	900	720
2_1038	1177	997
2_1040	585	405
2_1047	949	769
2_1057	967	787
2_1060	240	60

Link

SSP Map Package

Table

results

OBJECTID	SCEID	BASIN_ID	BASIN_NAME	REGION_NAME	BASE_DAMS_COUNT	PLANNED_DAMS_COUNT	TOTAL_DAMS_COUNT	SCEN_TOT_MW_ADDED	BASI_PERC_TOT_MW	BASE_BASIN_CON_KM
2	2_2	2	Karnali	NEPAL	5	31	36	1500	5.06	205
3	2_3	2	Karnali	NEPAL	5	23	28	2565	8.65	205
4	2_4	2	Karnali	NEPAL	5	40	45	2160	7.28	205
5	2_5	2	Karnali	NEPAL	5	37	42	1026	3.46	205
6	2_6	2	Karnali	NEPAL	5	21	26	391	1.32	205
7	2_7	2	Karnali	NEPAL	5	12	17	303	1.02	205
8	2_8	2	Karnali	NEPAL	5	31	36	773	2.61	205
9	2_9	2	Karnali	NEPAL	5	20	25	558	1.88	205
10	2_10	2	Karnali	NEPAL	5	54	59	1297	4.37	205
11	2_11	2	Karnali	NEPAL	5	4	9	139	0.47	205
12	2_12	2	Karnali	NEPAL	5	47	52	1227	4.14	205
13	2_13	2	Karnali	NEPAL	5	7	12	215	0.72	205
14	2_14	2	Karnali	NEPAL	5	9	14	279	0.94	205

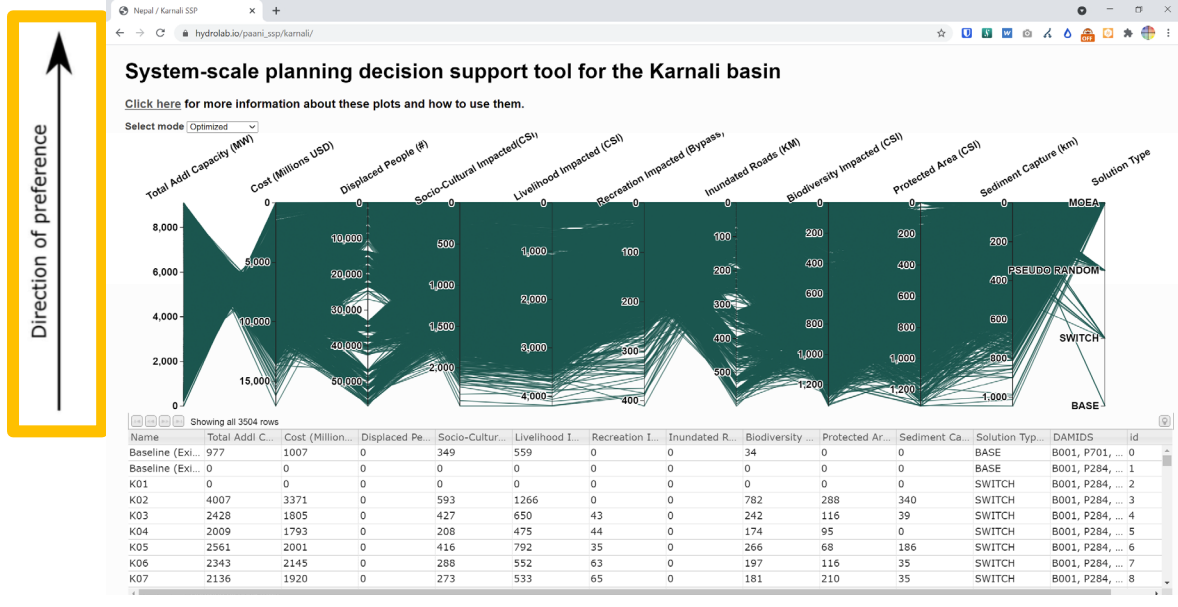
(394 out of *2000 Selected)

Karnali DST - Controls

- **Direction of preference**

→ Preferred values are show at the top of each axis

  - For example, total additional Capacity → the higher the better
  - Cost → the lower the better



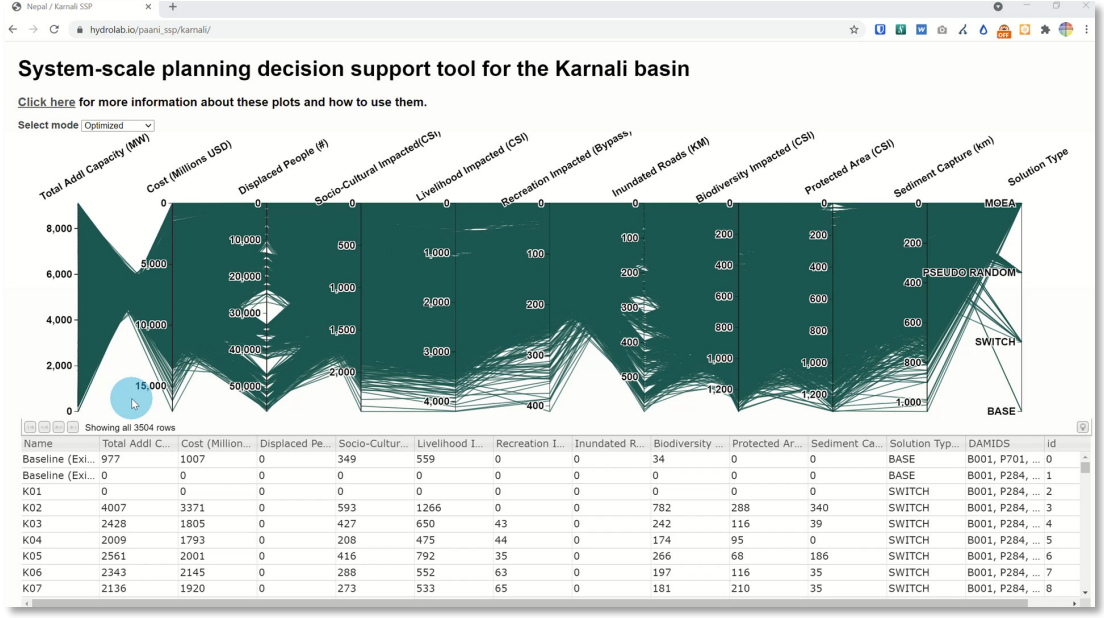
Name	Total Addl C...	Cost (Million...	Displaced Pe...	Socio-Cultur...	Livelihood I...	Recreation I...	Inundated R...	Biodiversity ...	Protected Ar...	Sediment Ca...	Solution Typ...	DAMIDS	id
Baseline (Exi...	977	1007	0	349	559	0	0	34	0	0	BASE	B001, P701, ...	0
Baseline (Exi...	0	0	0	0	0	0	0	0	0	0	BASE	B001, P284, ...	1
K01	0	0	0	0	0	0	0	0	0	0	SWITCH	B001, P284, ...	2
K02	4007	3371	0	593	1266	0	0	782	288	340	SWITCH	B001, P284, ...	3
K03	2428	1805	0	427	650	43	0	242	116	39	SWITCH	B001, P284, ...	4
K04	2009	1793	0	208	475	44	0	174	95	0	SWITCH	B001, P284, ...	5
K05	2561	2001	0	416	792	35	0	266	68	186	SWITCH	B001, P284, ...	6
K06	2343	2145	0	288	552	63	0	197	116	35	SWITCH	B001, P284, ...	7
K07	2136	1920	0	273	533	65	0	181	210	35	SWITCH	B001, P284, ...	8

Karnali DST- Controls

- **Brushing**

→ Purpose: Filtering and selecting values of interest for a particular metric

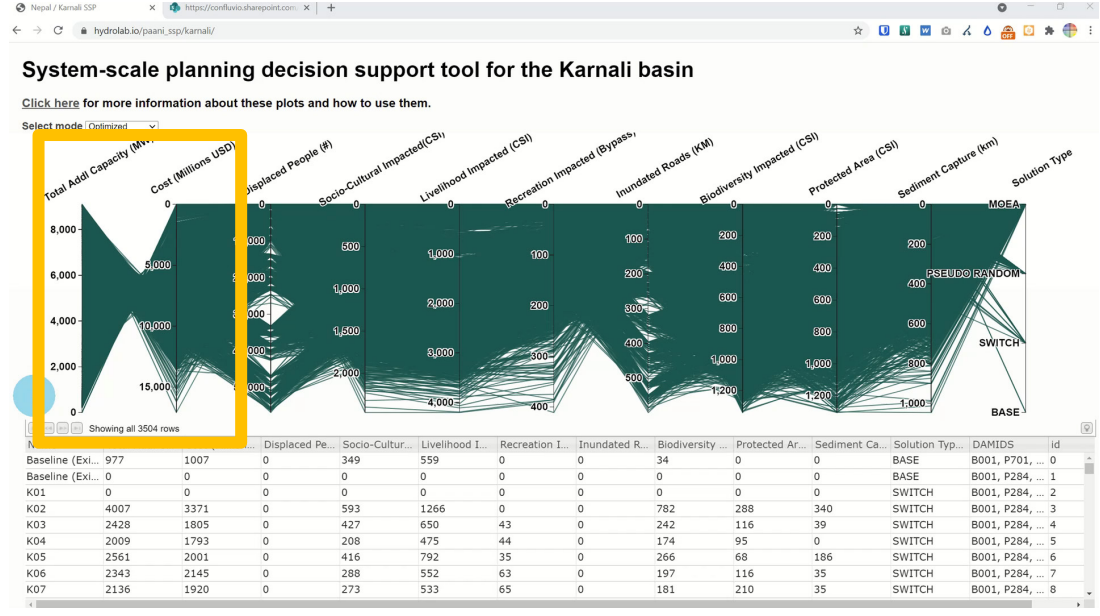
  - **Brush**: Click and drag vertically along an axis.
  - **Adjust brushed selection:**
    - **Move** selection box up and down the axis
    - **Extend or** reduce the size of the selection at each end of the box
  - **Remove Brush**: Click the axis background.



Click on video for demonstration

Karnali DST – Examine patterns

- **Examine the line pattern that the tool produces**
  - Focus on two metrics at a time
  - Brush along the "Capacity" Axis and select a range of values.
  - Move the selection up and down the axis.
  - What is the relationship between capacity and cost? (see Video)
    - Tip: Strong relationship. Cost increases with increasing capacity → trade-off
  - Now move the Capacity Axis next to the column "Displaced people".
  - What is the relationship between capacity and displaced people, and how does it differ?
    - Tip: Weak relationship --> For a certain amount of increase in capacity, there is a wider range of impacts regarding displacement, from low to high



			Displaced Pe...	Socio-Cultur...	Livelihood I...	Recreation I...	Inundated R...	Biodiversity ...	Protected Ar...	Sediment Ca...	Solution Typ...	DAMIDS	id
Baseline (Exi...	977	1007	0	349	559	0	0	34	0	0	BASE	B001, P701, ...	0
Baseline (Exi...	0	0	0	0	0	0	0	0	0	0	BASE	B001, P284, ...	1
K01	0	0	0	0	0	0	0	0	0	0	SWITCH	B001, P284, ...	2
K02	4007	3371	0	593	1266	0	0	782	288	340	SWITCH	B001, P284, ...	3
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K07	2136	1920	0	273	533	65	0	181	210	35	SWITCH	B001, P284, ...	8

Click on video for demonstration

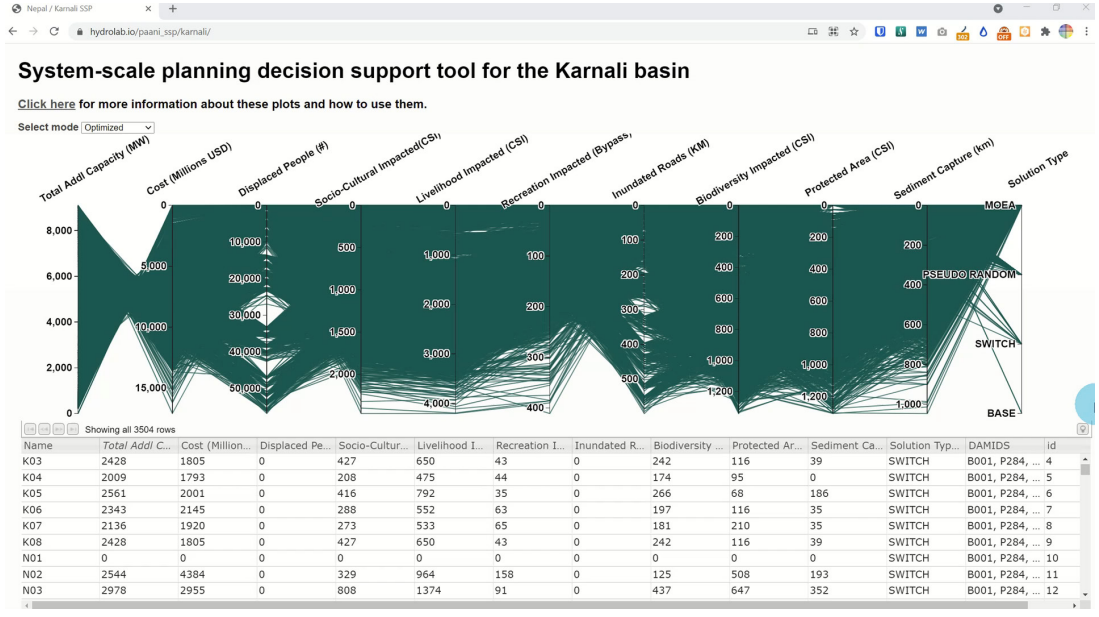
Module 3 – Session 4

Karnali DST – Comparing portfolios

Examine conservation scenarios (portfolios produced by SWITCH)

- Brush along the axis "Solution Type" and select the SWITCH conservation portfolios
- examine the results
- Remove selection and now brush and select portfolios in the 2-3GW range
- Move over the conservation scenarios in the table under the graph and examine the portfolios relative to the other portfolios with similar installed capacity.
- What conclusion can be drawn from the selected portfolios?

→ Tip: Compared to other potential portfolios, the conservation scenarios show relatively low cost and impact (they are close to the 'top' of graph), but … some still have high impact in some metrics



Name	Total Addl C...	Cost (Million...	Displaced Pe...	Socio-Cultur...	Livelihood I...	Recreation I...	Inundated R...	Biodiversity ...	Protected Ar...	Sediment Ca...	Solution Typ...	DAMIDS	id
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K07	2136	1920	0	273	533	65	0	181	210	35	SWITCH	B001, P284, ...	8
K08	2428	1805	0	427	650	43	0	242	116	39	SWITCH	B001, P284, ...	9
N01	0	0	0	0	0	0	0	0	0	0	SWITCH	B001, P284, ...	10
N02	2544	4384	0	329	964	158	0	125	508	193	SWITCH	B001, P284, ...	11
N03	2978	2955	0	808	1374	91	0	437	647	352	SWITCH	B001, P284, ...	12

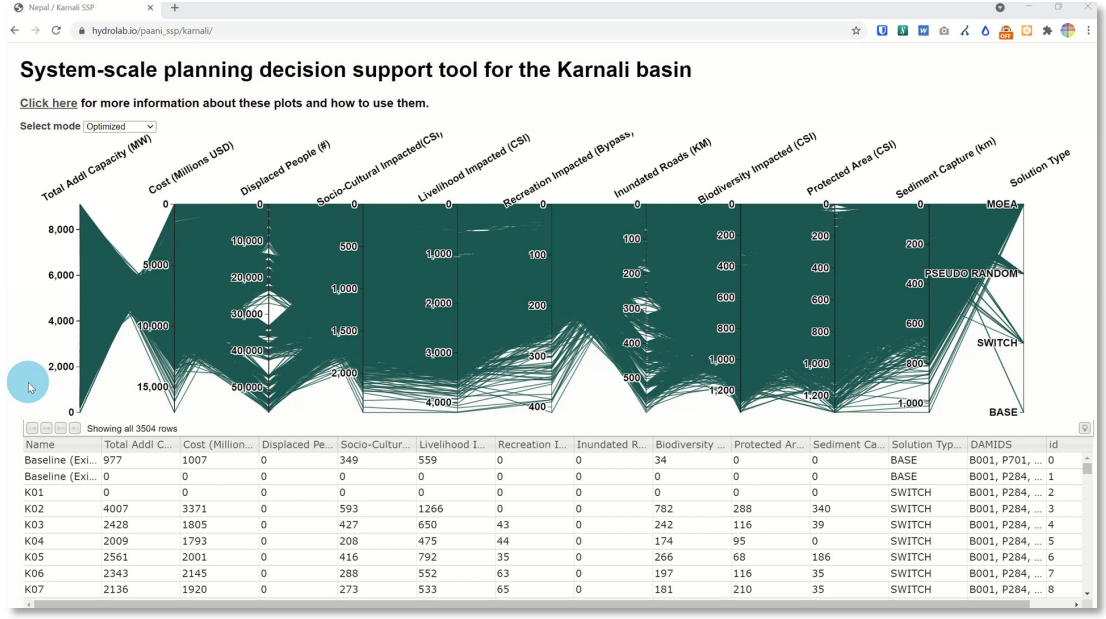
Top: Click on video for demonstration

Left: Click on graph for cost comparison of conservation scenarios

Karnali DST – Selecting portfolios using multiple filters

- **Using the tool to select portfolios**
  - Brush more than once on each axis to select distinct value ranges
  - Add selections on multiple axis
  - By adding multiple brushed selections, then number of portfolio that meet the criteria reduced accordingly

→ **The process helps narrow down acceptable portfolios**



Name	Total Addl C...	Cost (Million...	Displaced Pe...	Socio-Cultur...	Livelihood I...	Recreation I...	Inundated R...	Biodiversity ...	Protected Ar...	Sediment Ca...	Solution Typ...	DAMIDS	id
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Baseline (Exi...	0	0	0	0	0	0	0	0	0	0	BASE	B001, P284, ...	1
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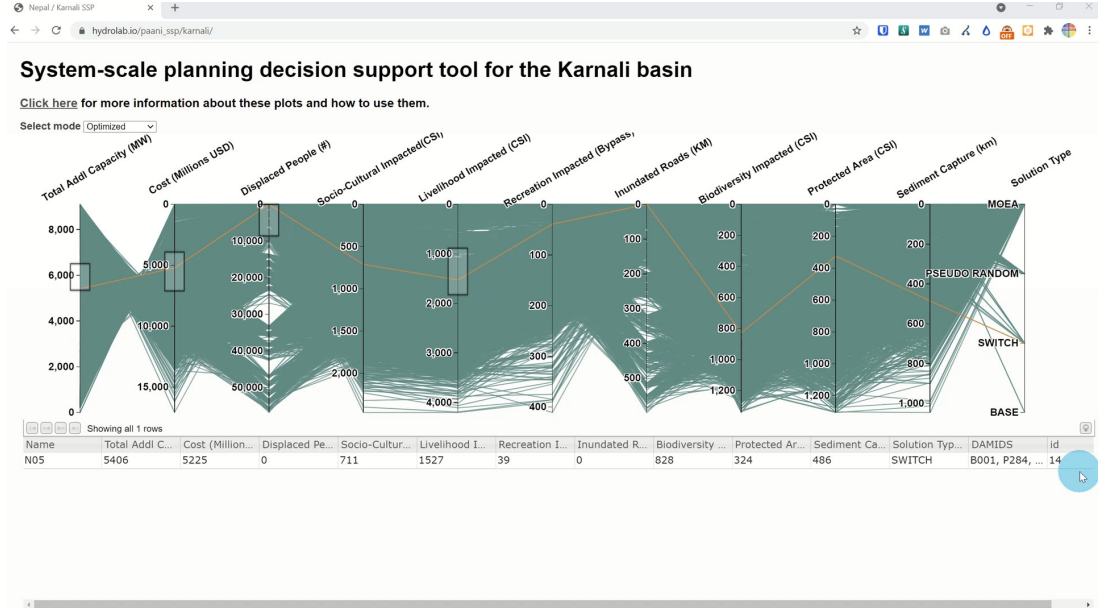
K06	2343	2145	0	288	552	63	0	197	116	35	SWITCH	B001, P284, ...	7
K07	2136	1920	0	273	533	65	0	181	210	35	SWITCH	B001, P284, ...	8

Click on video for demonstration

Karnali DST – Interactive adjustments

- If the portfolio solutions do not satisfy stakeholders expectations, for example if one of the metrics are unacceptable, the selections on each axis can be adjusted
- Review each portfolio and further discuss the characteristics (what are the added value and impacts)?



Click on video for demonstration

Use the Map Package to examine selected portfolios

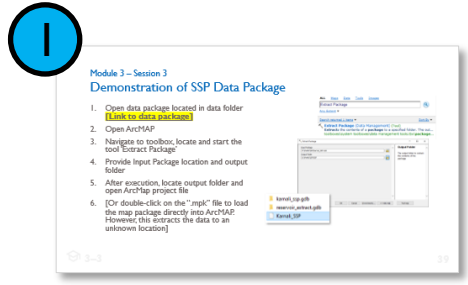
Once candidate portfolios have been identified, use the Map Package and the SSP Portfolio Selection Tool to generate a map of the candidate portfolios

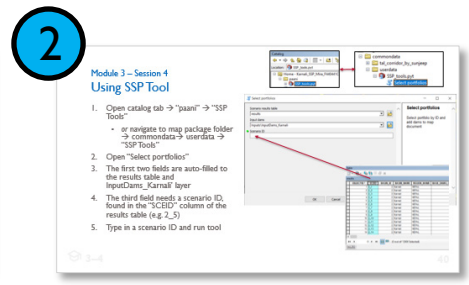
Step 1: Open the Map Package

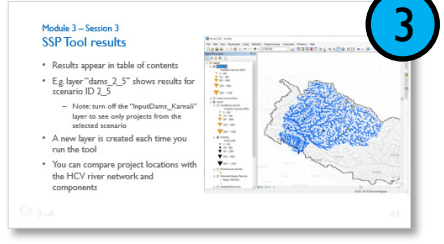
Step 2: Follow instructions to use SSP Portfolio Selection Tool

Step 3: Review results

Step 4: Review the selection of projects and further examine the location and selection of projects in each candidate portfolio.



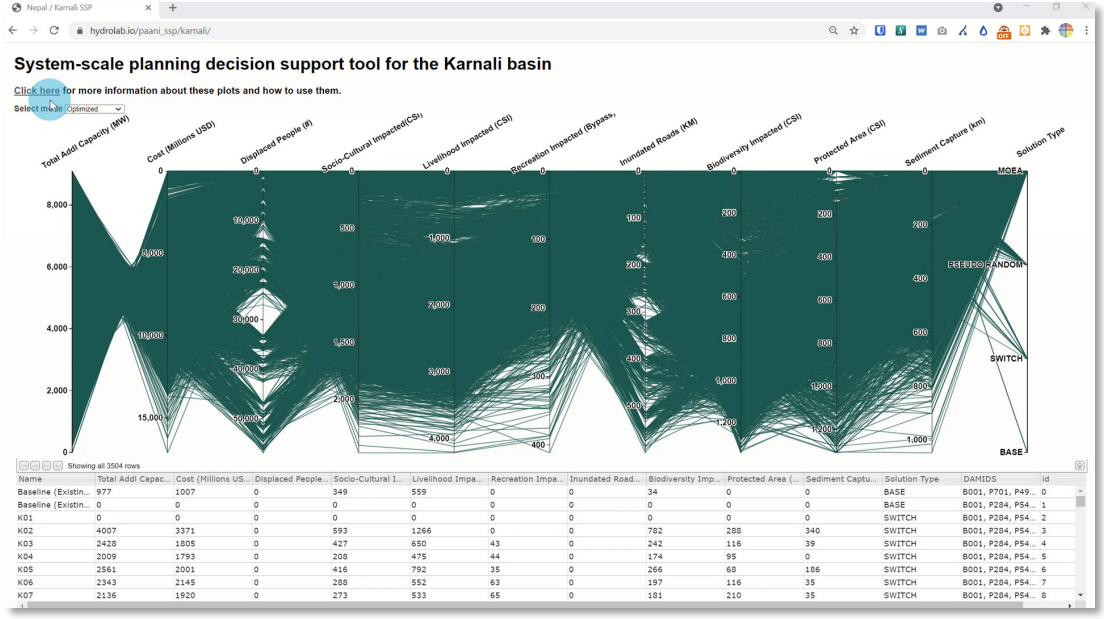




Karnali DST – Advanced analysis mode

Choose among three settings

- **Optimized**
  - Tool includes "Pareto-Optimal" portfolios (n=3504)
  - Ten optimized metrics
- **Full set**
  - Tool includes all calculated portfolios (n=55,233) including non-pareto optimal ones
  - Ten optimized metrics
  - Three new axis allowing for advanced filters
- **More attributes**
  - Tool includes all calculated options (n=55,216).
  - Three new axis allowing for advanced filters
  - Ten optimized metrics plus 22 non-optimized metrics



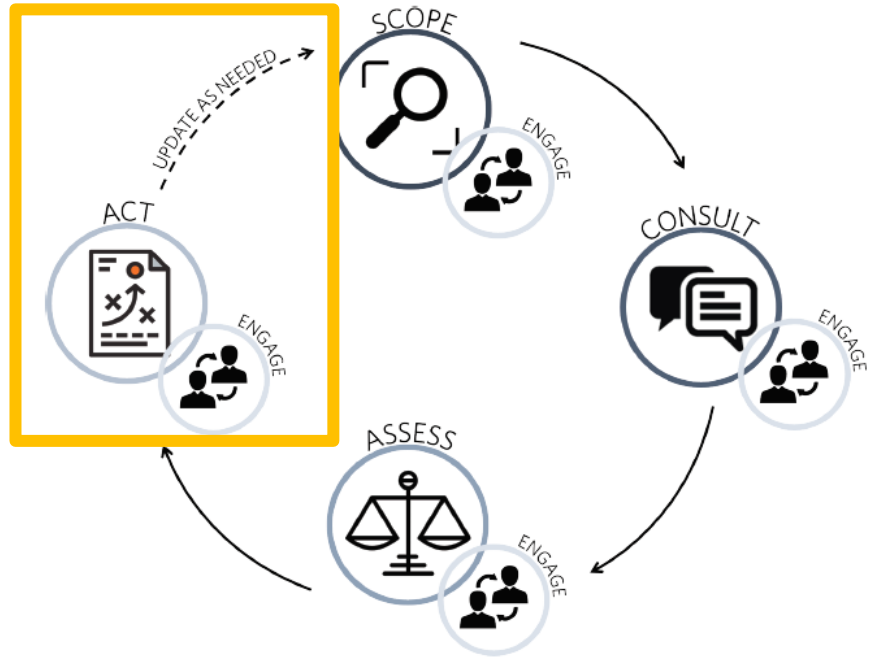
Click on video for demonstration

Key messages: trade-off analysis and using the online tool

- Online tool helps analyzing portfolio and searching for "best-possible" solution
- Promotes dialogue → "Best solution" is a solution that the stakeholders can agree to.
- A solution without trade-offs rarely exists, all development options carry benefits and impacts → compromise is necessary
- The map of projects in a portfolio can be easily visualized using the portfolio id found in the column "name" and the SSP portfolio selection tool in the map package
- "Advanced mode" allows to examine more metrics and portfolios

Key messages: System-Scale Planning

- System Scale Planning in Nepal was based on the "Hydropower-by-design" approach, which occurs in distinct phases
- Unique coupling of High-Conservation River Assessment (HCV), SSP Portfolio tool (SSP), and Energy Expansion Model (SWITCH)
- Government of Nepal, Investors in Nepal, Communities in Nepal and the freshwater environment including the rivers and streams of Nepal benefit from this approach
- Opportunity to improve the framework and embed in planning and decision-making processes
- → **Module 4: Integration of tools and policy implementation**



Hydropower-by-design phases and implementation cycle