

SRAT Exposure Risk Adaptation Assessment Data

Climate-related risk analytics for road & rail transport infrastructure in East Africa

The Systemic Risk Assessment Tool (SRAT) supports climate adaptation decision-making by identifying spatial criticalities and risks under current and future climate scenarios.

Road
Major and minor roads.

Rail
Rail lines and stations.

The research, analysis and development has been led by researchers in the University of Southampton's [Transportation Research Group](#) and the [Oxford Programme for Sustainable Infrastructure Systems](#), University of Oxford, supported by engagement with infrastructure and climate specialists and related government bodies.

Funding and support
This research was funded by UKAID through the UK Foreign, Commonwealth & Development Office under the High Volume Transport Applied Research Programme, which is managed by DT Global.

Photo credit: Flooding in the Tana River, Kenya, 1988. US National Archives, Public domain.

Sustainability and Risk Analysis Tool: User Guide

January 2023

Project HVT/043

Decision Support Systems for Resilient Strategic Transport Networks in Low Income Countries

This research was funded by UKAID through the UK Foreign, Commonwealth & Development Office under the High Volume Transport Applied Research Programme, managed by DT Global UK.

The views expressed in this report do not necessarily reflect the UK government’s official policies.

Reference No.	HVT/043
Lead Organisation/ Consultant	University of Southampton
Partner Organisation(s)/ Consultant(s)	University of Oxford
Title	Sustainability and Risk Analysis Tool: User Guide
Type of document	Project Report
Theme	Long distance transport
Sub-theme	Sustainability
Author(s)	Tom Russell, Raghav Pant, Diana Jaramillo, Adrian Hickford, Simon Blainey
Lead contact	Simon Blainey
Geographical Location(s)	Southampton/Oxford, UK (Researchers) Kenya, Tanzania, Uganda, Zambia (Case study countries)
Abstract	
<p>This user guide accompanies a web-based “Systemic Risk Assessment Tool” developed as part of the project “Decision Support Systems for Resilient Strategic Transport Networks in Low Income Countries” focussing on Kenya, Tanzania, Uganda and Zambia. Building on previous outputs (WP1: Scenarios and Interventions; WP2: Data review; WP3: Risk and resilience analysis; and WP4: Sustainability indicators and tool development), the web-based assessment tool (WP5) presents the results of data collection and risk and resilience analysis, enabling exploration of flood risks to long-distance land transport networks and systematic prioritisation or initial screening of adaptation options, leading to an indicator-based multi-criteria sustainability assessment tool which supports project or programme-level appraisal according to a set of sustainability indicators. The tool is available at https://east-africa.infrastructureresilience.org.</p>	
Keywords	Long-distance transport; Sustainability; Climate Risk; Decision Support
Funding	FCDO High Volume Transport Applied Research Programme



CONTENTS

Executive Summary	iv
1. How to use this guide.....	1
2. Navigate the tool	2
2.1 Minimum access requirements	2
2.2 Navigating within the tool	2
3. Explore data and results.....	6
3.1 Explore transport network data	6
3.2 Explore hazard data	8
3.3 Explore climate risk results.....	10
3.4 Explore adaptation options	11
4. Risk and adaptation analysis use case example	13
4.1 Identify asset	13
4.2 Display return period damages	14
4.3 Select different epochs.....	15
4.4 Risk.....	16
4.5 Adaptation options	17
5. Prioritise adaptation interventions	18
6. Evaluate the sustainability of an intervention	22
6.1 Start an assessment.....	22
6.2 Select intervention and scenario options.....	23
6.3 Agree expected impacts for each sustainability indicator	26
6.4 Agree relative weighting of indicators	29
6.5 Review results.....	31
6.6 Save and load assessment files.....	32
7. Further Support	32
Bibliography	33



FIGURES

Figure 1: SRAT – home page.....	2
Figure 2: Exposure – main page	3
Figure 3: Using the search function.....	4
Figure 4: Illustrating the zoom function and map layers menu	4
Figure 5: Illustrating alternative map layer views	5
Figure 6: Displaying different infrastructure assets – roads	6
Figure 7: Displaying different infrastructure assets – rail	7
Figure 8: Displaying flood depth.....	8
Figure 9: Displaying estimated asset damages.....	9
Figure 10: Displaying expected direct damages	10
Figure 11: Selecting adaptation options.....	11
Figure 12: Displaying adaption option details	12
Figure 13: Risk and adaptation analysis use case example – Step 1 Identify asset.....	13
Figure 14: Risk and adaptation analysis use case example – Step 2 Display Return Period Damages	14
Figure 15: Risk and adaptation analysis use case example – Step 3 Select different epochs	15
Figure 16: Risk and adaptation analysis use case example – Step 4 Display ‘Risk’	16
Figure 17: Risk and adaptation analysis use case example – Step 5 Display ‘Adaptation Options’	17
Figure 18: Prioritise adaption interventions use case example – Step 1 Display Benefit-Cost Ratios	18
Figure 19: Prioritise adaption interventions use case example – Step 2 Investigating adaptation options	19
Figure 20: Prioritise adaption interventions use case example – Step 3 Displaying Expected Annual Damages (EAD) and Expected Annual Economic Losses (EAEL).....	20
Figure 21: Prioritise adaption interventions use case example – Step 4 Summary of adaptation option results	21
Figure 22: Sustainability assessment use case example – Step 1 Start new assessment	22
Figure 23: Sustainability assessment use case example – Step 2 Select Intervention type.....	23
Figure 24: Sustainability assessment use case example – Step 3 Changing overall intervention impact.....	24
Figure 25: Sustainability assessment use case example – Step 4 Select scenarios.....	25
Figure 26: Sustainability assessment use case example – Step 5 Agree impacts on sustainability indicators ...	26
Figure 27: Sustainability assessment use case example – Step 6 Display relative weighting of sustainability indicators	29
Figure 28: Sustainability assessment use case example – Step 7 Altering weighting of indicators.....	30
Figure 29: Sustainability assessment use case example – Step 8 Display results	31
Figure 30: Sustainability assessment use case example – Step 8 Display summary	31
Figure 31: Saving, loading and deleting assessments.....	32

TABLES

Table 1: Sustainability Assessment Interventions	23
Table 2: Sustainability Assessment Indicators.....	27



ABBREVIATIONS/ACRONYMS

BCR	Benefit-Cost Ratio
EAD	Expected Annual Damages
EAEL	Expected Annual Economic Losses
FCDO	Foreign, Commonwealth & Development Office
HVT	High Volume Transport
LDT	Long-distance Transport
RCP	Representative Concentration Pathway
RP	Return Period
WP	Work Package



EXECUTIVE SUMMARY

Investments in long-distance land transport networks can help drive regional and national development in low-income countries, but while such developments can contribute to economic growth, they often impact negatively on society and the environment. Climate-related hazards, such as flooding, pose severe risks to transport networks. Infrastructure assets may be damaged and require rehabilitation. Economic and social activities further depend on transport infrastructure, for transport of goods and access to services and society. Flooding already causes severe disruption under present conditions and in many places this will worsen with increasing frequency and severity of flood events under future climate scenarios.

The focus of this project, “Decision Support Systems for Resilient Strategic Transport Networks in Low Income Countries”, is to provide decision-makers with tools to help understand sustainability and climate risk. This report builds on previous project outputs to: provide an understanding of the interactions between scenarios and transport interventions that emerged from WP1, present the data collected in WP2, support explanation and exploration of the risk and adaptation analysis undertaken in WP3, and support evaluation of projects according to the assessment methodology, based on sustainability indicators, developed in WP4.

The tool first presents the quantitative results of the risk and resilience analysis in order to provide an initial assessment of climate adaptation options for long-distance transport networks in Kenya, Tanzania, Uganda and Zambia. It then provides a guided route through the process developed for the qualitative assessment of transport interventions. These interventions may aim at improving sustainability, whether motivated initially by the need for adaptation and risk reduction, or by other aspects of sustainability.

The intended end users of the web-based assessment tool are envisioned to fall into two broad groups: those users who are interested to understand the methodologies developed here, and those who are more directly interested in the systemic risk and adaptation screening and sustainability appraisal relating to assets or networks for which they have some responsibility or interest. The former group may come from a fairly wide range of job roles and organisations. The tool was used in a series of workshops to support the presentation of methodologies and give direct access to the detailed risk results and sustainability indicator analysis. Participants included students, researchers, consultants, analysts and executives within national road and rail agencies, and international organisations. The latter group are more likely to be asset owners or operators, planners or policy-makers, or actors concerned with funding or financing, and may have specific needs for information, some of which can be answered using the tool directly, and some of which may raise further questions and the need for further analysis or engagement. Specific case studies and user engagement activities are documented in the project final report, Hickford et al (2023).



1. How to use this guide

This guide is intended to accompany the interactive web-based platform, which is part of the Systemic Risk Assessment Tool (SRAT) for the project case study countries. The SRAT visualises the results of a climate risk and adaptation analysis (conducted in 2022) of long-distance transport networks in Kenya, Tanzania, Uganda and Zambia, and provides a sustainability assessment tool to assess climate change adaptation and mitigation options for transport interventions.

The overall objectives of the SRAT are to:

1. Present the results of a climate risk analysis for long-distance transport networks to estimate the economic impacts of physical climate risks and identify critical locations of vulnerability;
2. Enable evaluation and prioritisation of policies and investment options to reduce losses and enhance infrastructure resilience;
3. Assess transport interventions against indicators of economic, social and environmental sustainability.

This guide aims to convey an understanding of the tool's content and capabilities. First, it introduces how to navigate around the tool (Section 2). Then it introduces each of the major data and results layers (Section 3). Finally, it works through three use cases: stepping through the climate risk and adaptation analysis for a single asset (Section 4), prioritising adaptation interventions based on cost-benefit analysis (Section 5); and evaluating a potential intervention against a broad set of sustainability indicators (Section 6).

The tool is freely and openly available online at <https://east-africa.infrastructureresilience.org/>.

The scope of this user guide is to explain the interactive use of the tool and introduce each of its sections. For further background on the methodologies used to create the tool and the analysis presented, please refer to the final report for this project, Hickford et al (2023). The climate risk analysis and adaptation sections of the tool are primarily a data visualisation aiming to support the exploration and scrutiny of the analysis documented in WP3. The sustainability assessment section of the tool implements a multi-criteria assessment documented in WP4. For a full understanding of the tool's contents, this guide assumes that that report is available for reference.

The end users of the tool are expected to fall into two broad groups: those users who are interested to understand the methodologies developed throughout the project, and those who are interested in the systemic risk and adaptation screening and sustainability appraisal relating to assets or networks for which they have some responsibility or interest.

To support the first group of users, the tool was used in a series of workshops to support the presentation of methodologies and give direct access to the detailed risk results and sustainability indicator analysis, in a workshop setting. Participants included students, researchers, consultants, analysts and executives within national road and rail agencies, and international organisations. Demonstration and hands-on access to the tool accompanied presentations and detailed discussion of risk and sustainability assessment.

The second group of users, who are more likely to be asset owners or operators, planners or policy-makers, or actors concerned with funding or financing, may have specific needs for information. Some analytical questions can be answered using the tool directly, and some of the data and results presented within the tool may raise further questions and the need for further analysis or engagement. Specific case studies and user engagement activities are documented Hickford et al (2023).

For software developers, the source code for the tool is developed and documented at github.com/nismod/infra-risk-vis. The analysis for the case study countries is produced using the code and models at github.com/nismod/east-africa-transport. All code is published open-source under an MIT license.



2. Navigate the tool

2.1 Minimum access requirements

The tool is hosted online and can incur a reasonably large amount of data transfer (in the range of tens of megabytes for a ten-minute session), so users require a stable internet connection, with 10 MB/s or better bandwidth, and a computer with a recent browser (Safari, Firefox, Chrome or Edge). In terms of hardware, any tablet, laptop or desktop with 4GB or more RAM and four or more cores should be sufficient for good usability.

2.2 Navigating within the tool

Start by opening a browser and visiting <https://east-africa.infrastructureresilience.org/>.

The top level of navigation for the tool is in the top bar (see Figure 1).

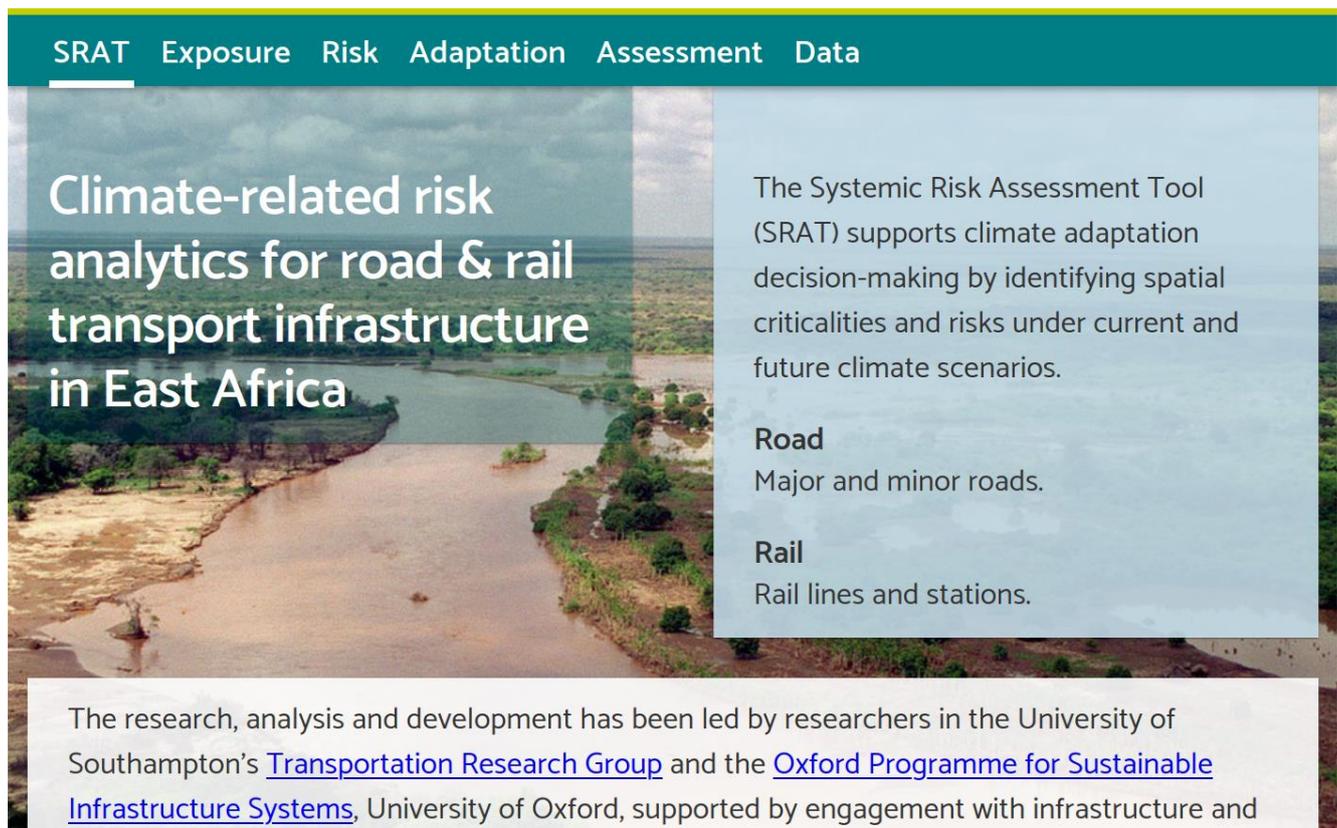
“SRAT” brings you to the home page, which gives a brief introduction and summary of the analysis.

Click across the links in the top navigation bar to see the “Exposure”, “Risk” and “Adaptation” stages of the infrastructure risk assessment and adaptation analysis.

“Assessment” is the place to start assessment of interventions against sustainability indicators.

“Data” includes a summary of and references to open data used in the tool.

Figure 1: SRAT – home page

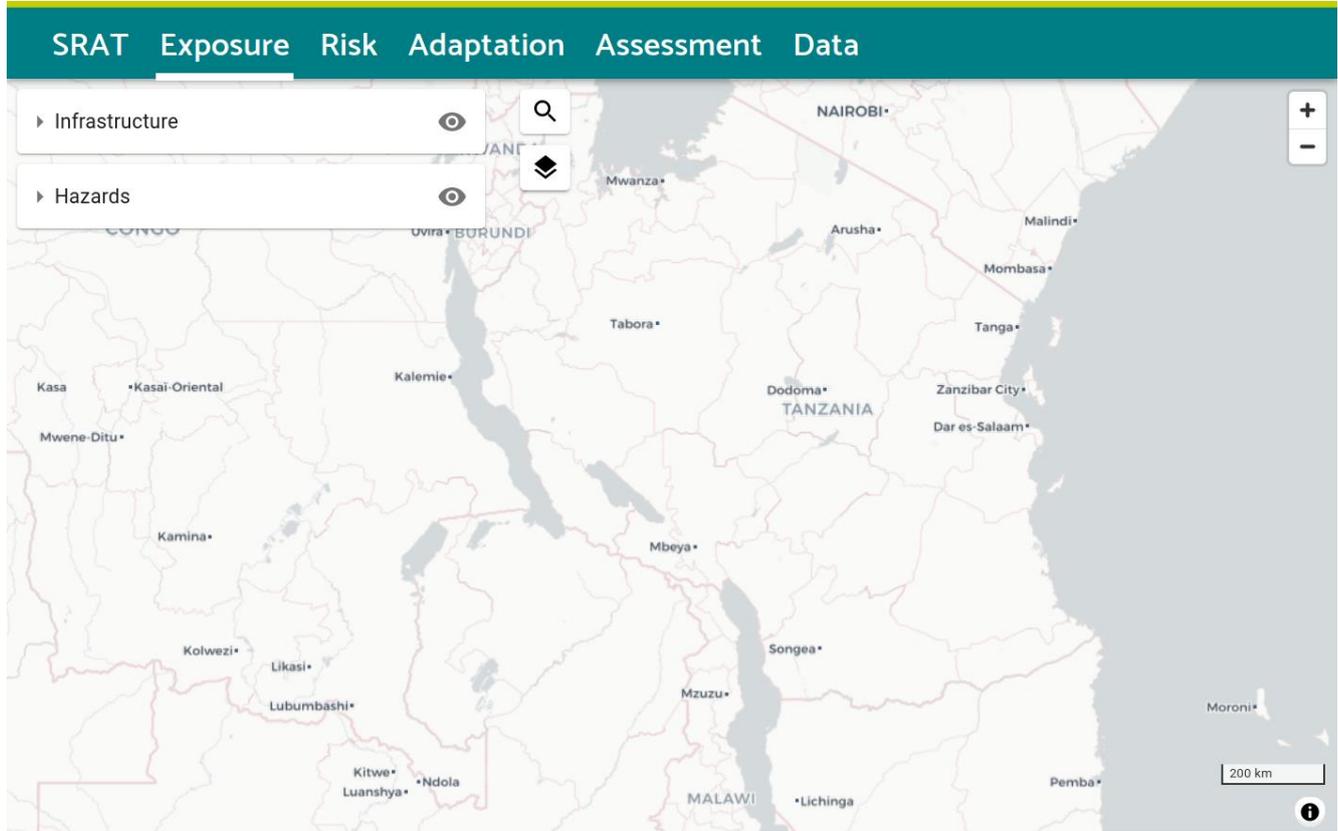




Click on “Exposure” to show the map view (see Figure 2).

The left sidebar has various sections which control the data that is shown on the map. The main controls on this screen are used throughout.

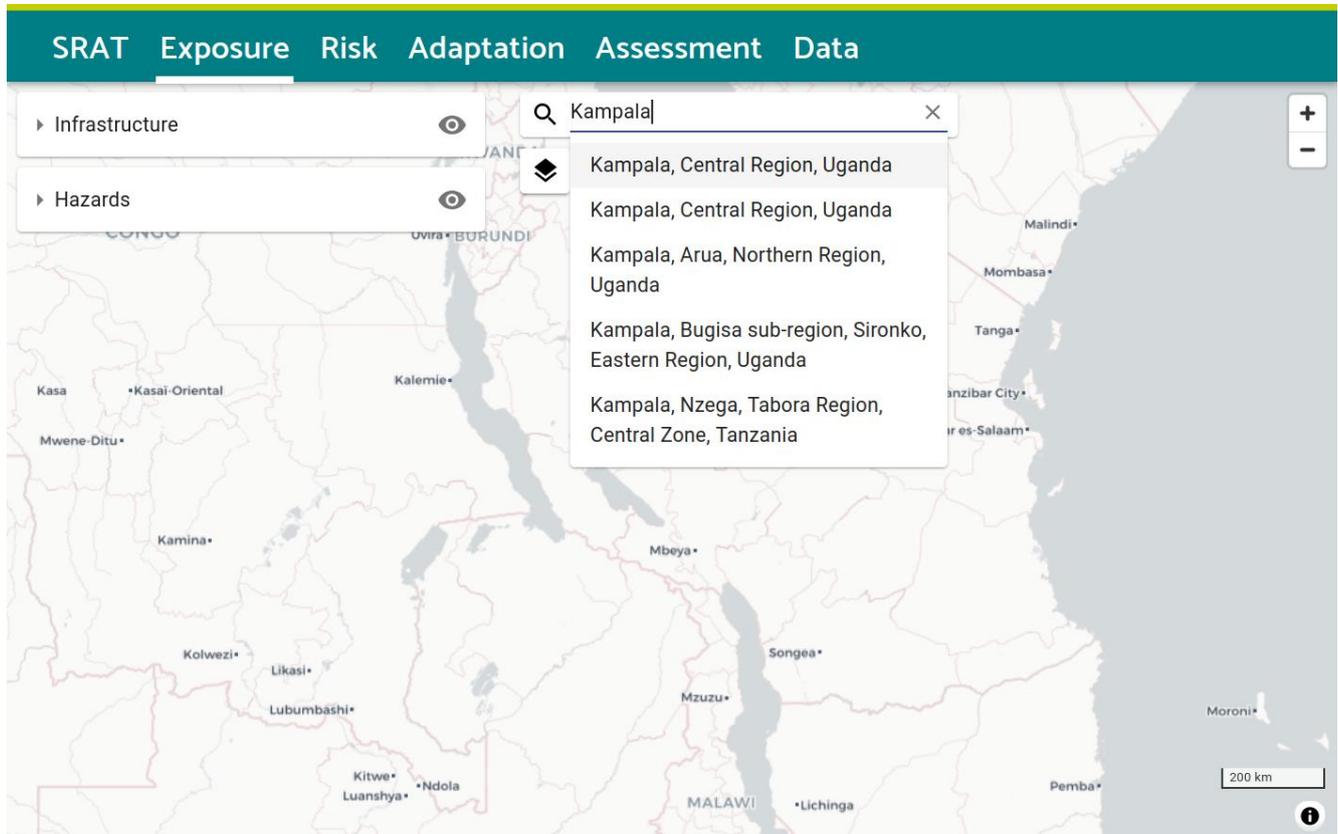
Figure 2: Exposure – main page





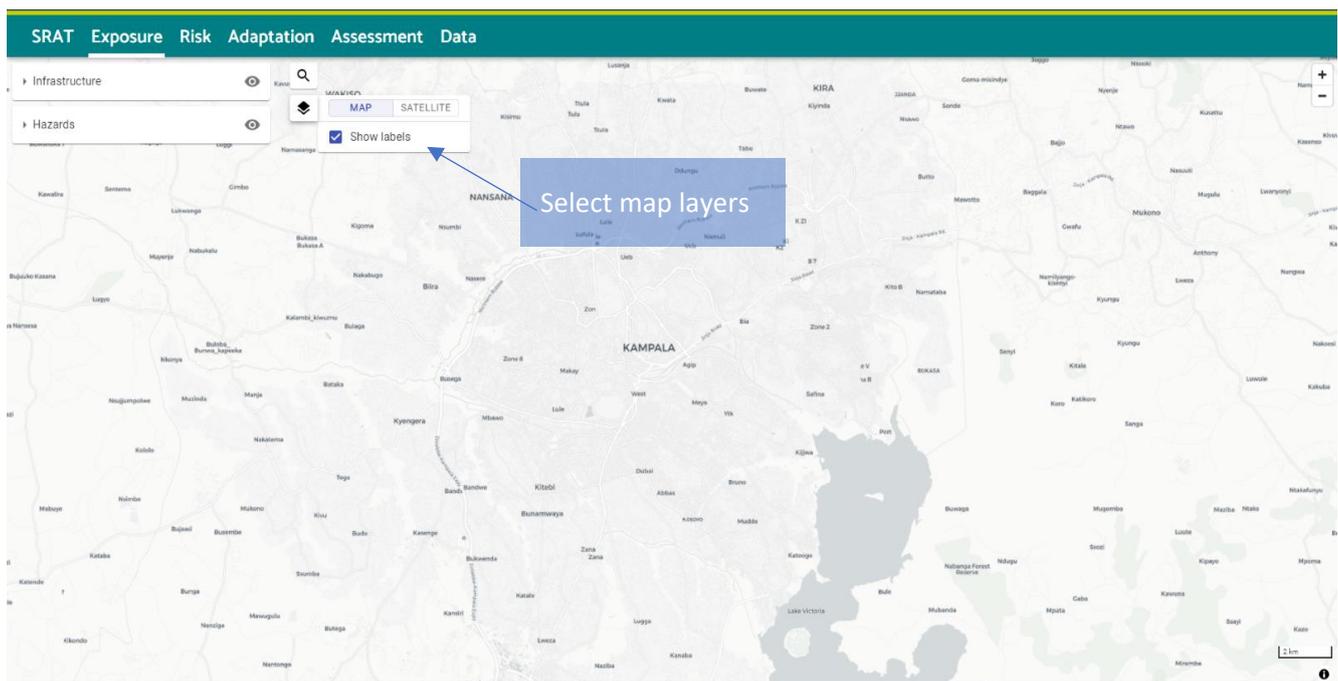
Click the search icon which is just to the right of the sidebar sections to search for places. This uses the OpenStreetMap Nominatim service and should find parishes, towns, some roads and some addresses by name. For example, search for “Kampala” (see Figure 3).

Figure 3: Using the search function



Click the first result to zoom to the city (see Figure 4, where the map is centred on Kampala).

Figure 4: Illustrating the zoom function and map layers menu



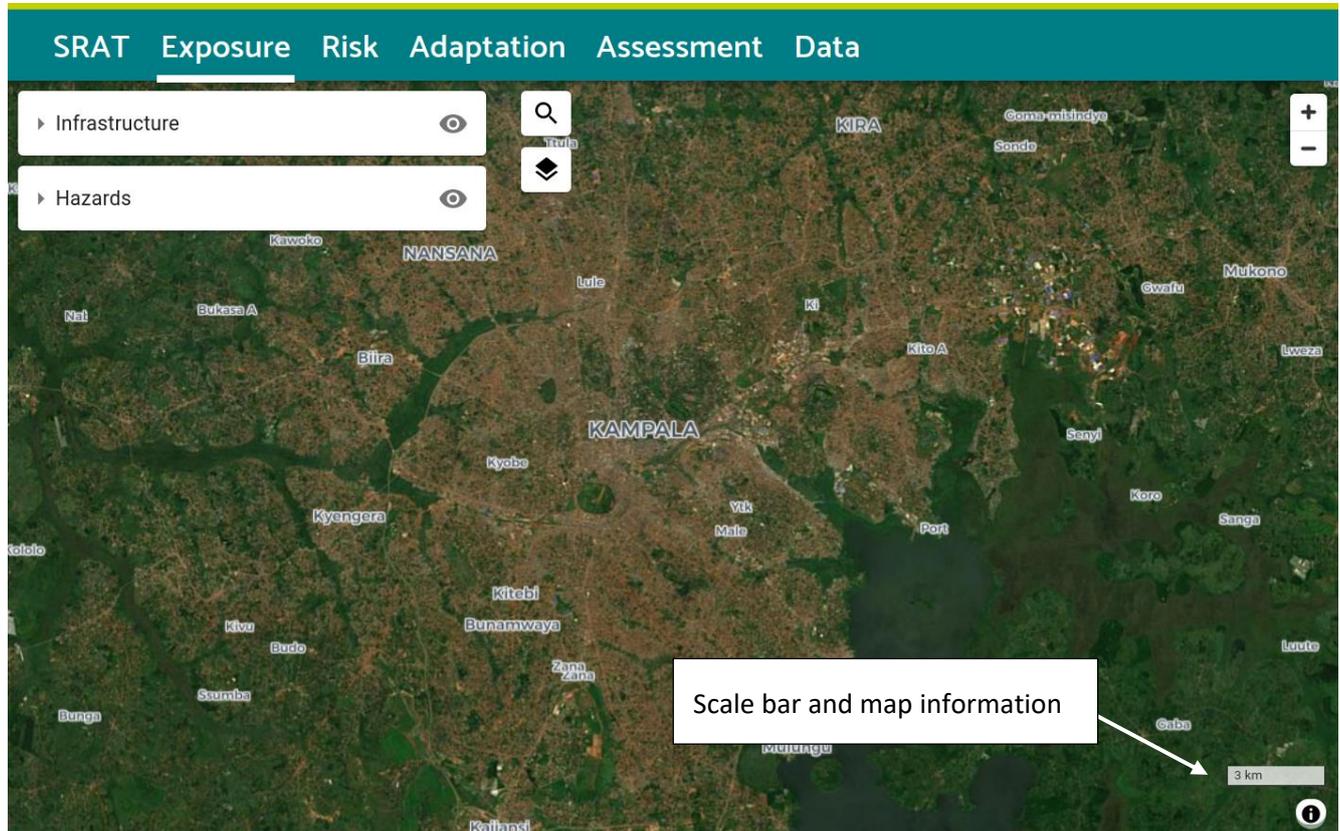
Below the search box, there is a map layer control. Hover over the layers icon to show it (see Figure 4). Check or uncheck the box to hide or “Show labels”.



Switch the map background from the light grey “Map” background to the “Satellite” imagery background – see Figure 5.

Check or uncheck the box to hide or “Show labels”

Figure 5: Illustrating alternative map layer views



In the top-right corner of the map, the plus and minus buttons control the map zoom. You can also scroll to zoom or double-click to zoom in and hold the shift key and double-click to zoom out.

To pan the map view, click and drag on the map, or click on the map once then use the arrow keys to move up, down, left or right.

In the bottom-right corner of the map, there is a scale bar for reference and an “i” icon which shows or hides information about the “Map” background¹ and “Satellite” imagery background² maps when clicked.

¹ designed by CARTO using OpenStreetMap data

² produced by EOX from Copernicus Sentinel-2 data



3. Explore data and results

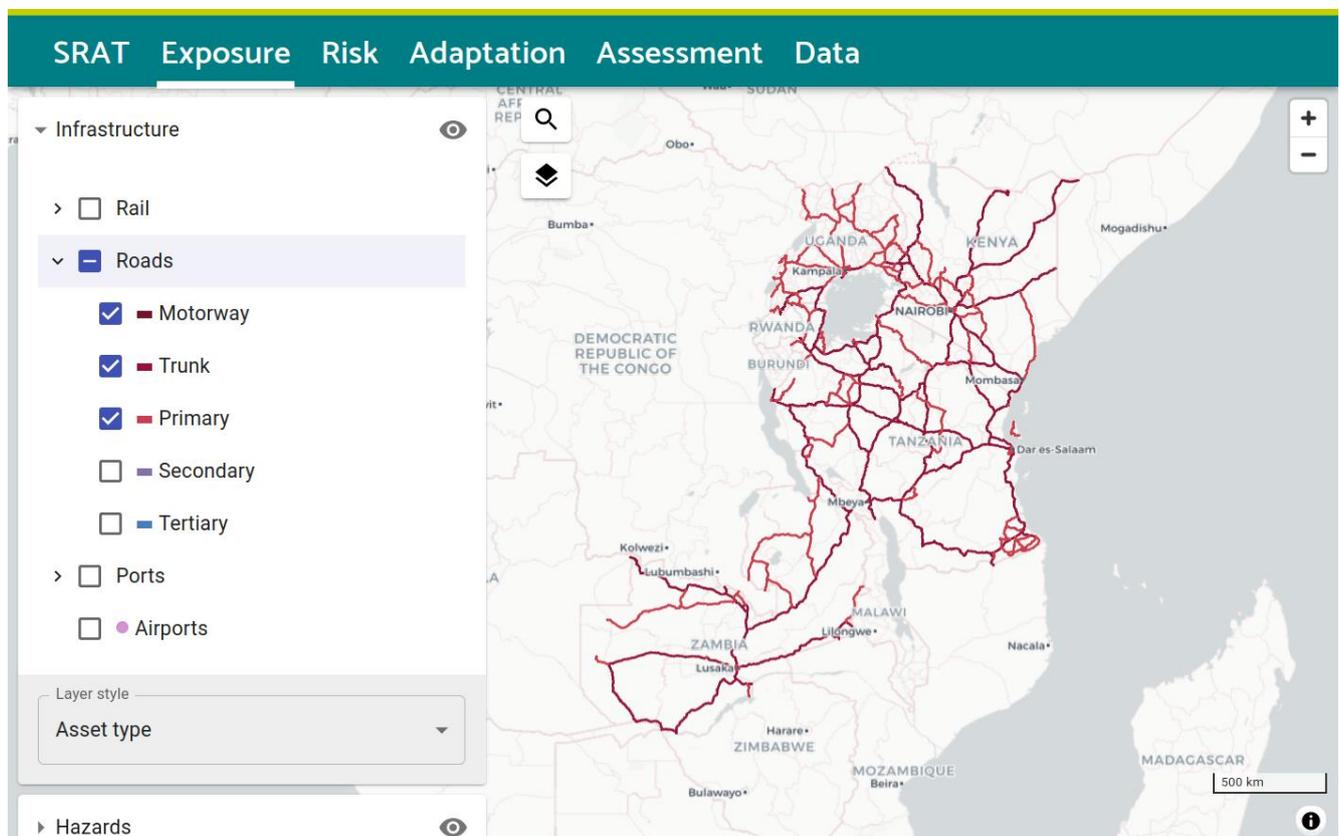
The “Exposure”, “Risk” and “Adaptation” tabs follow a consistent layout. The left sidebar controls the data that is shown on the map.

Start on the “Exposure” tab. Click on the “Infrastructure” section to expand or collapse it. Use the “eye” icons to hide or show all of a section’s layers at once.

3.1 Explore transport network data

Under “Infrastructure”, expand “Roads” and select “Motorway”, “Trunk” and “Primary” roads (Figure 6). Explore the other transport layers to see the elements of the network as they are included in the analysis. The tool includes rail, roads, ports and airports. Ports and airports are included where they are key nodes in the long-distance transport network, as sources or destinations for freight flows, though they are not assessed for flood risk or adaptation.

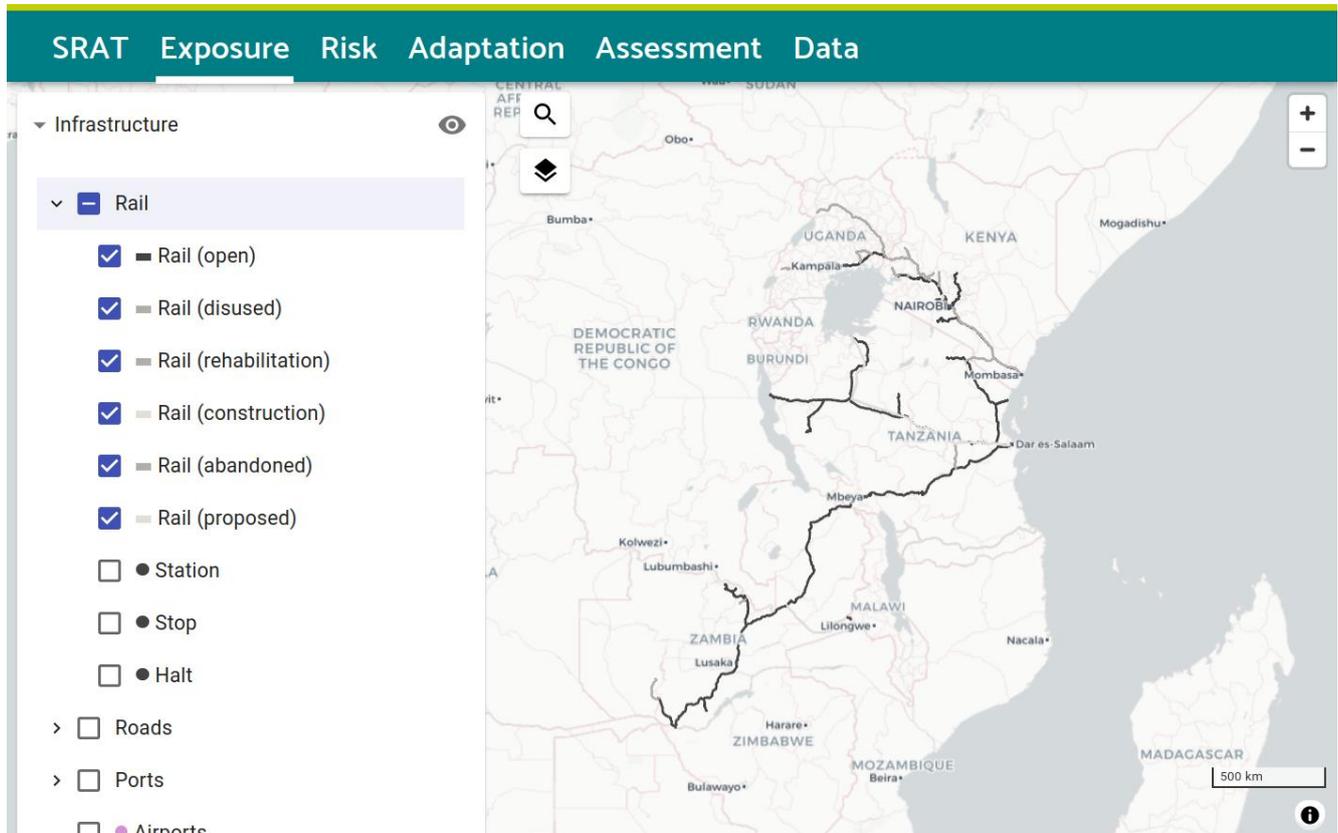
Figure 6: Displaying different infrastructure assets – roads





Use the top “Roads” checkbox to deselect all road assets, and expand the “Rail” section to bring in railway layers, selecting each of the linear asset “Rail” layers (Figure 7).

Figure 7: Displaying different infrastructure assets – rail



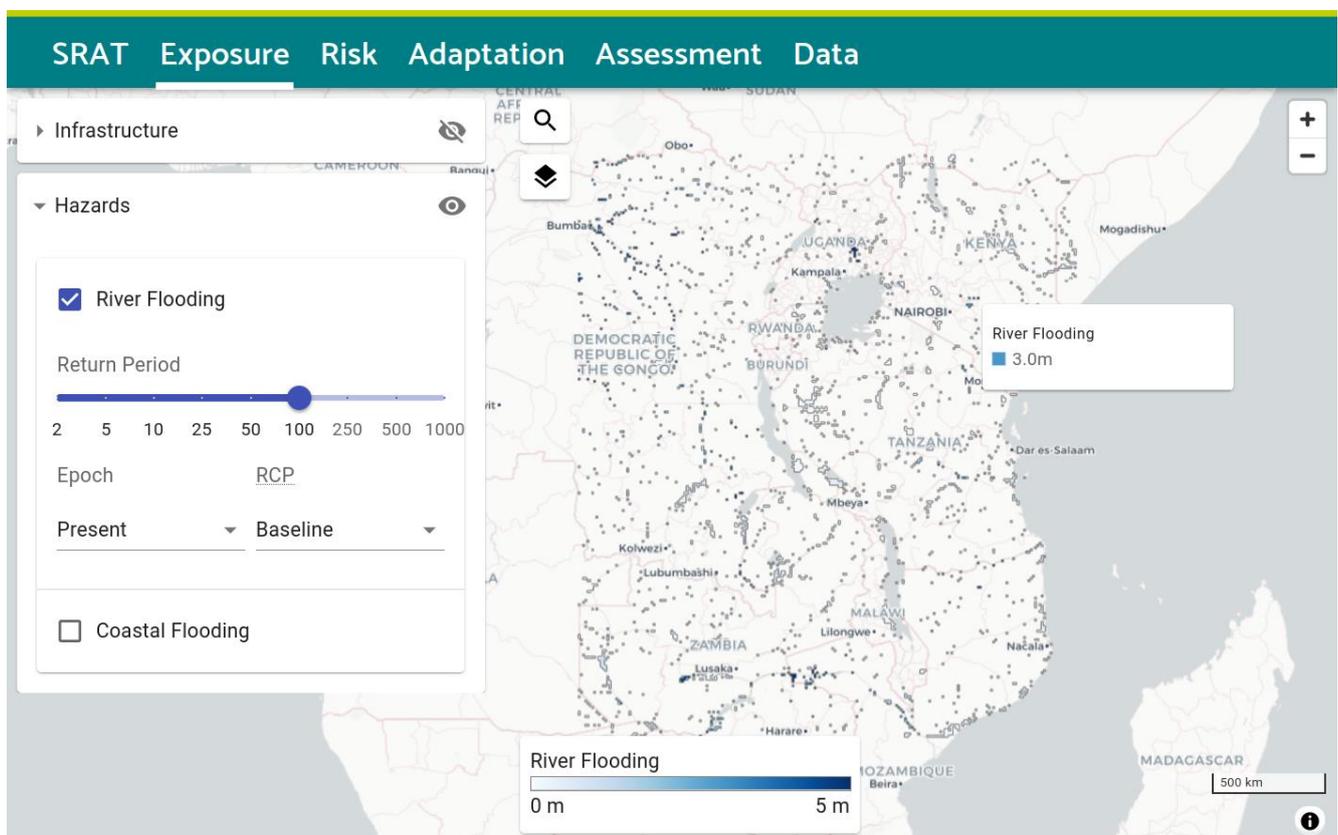


3.2 Explore hazard data

Open the “Hazards” section. The hazards considered in this study are river and coastal flooding, under present, baseline climate conditions, and in future epochs (time periods: 2030, 2050 and 2080) under two different climate scenarios, Representative Concentration Pathways (RCPs) 4.5 and 8.5, which are respectively medium- and high-emissions scenarios. The hazard data and choice of scenario are covered in more detail in Hickford et al (2023), section 3.1.

Select “River Flooding” to show potential flooding on the map (Figure 8). This is a return period map, showing the depth of flooding in any location across the case study area which is expected to be exceeded once in some number of years (once in 25 years, for example). Hover over shaded blue areas to see the depth of flooding in metres. The legend at the bottom of the map shows the shades of blue used to represent depths of flooding.

Figure 8: Displaying flood depth



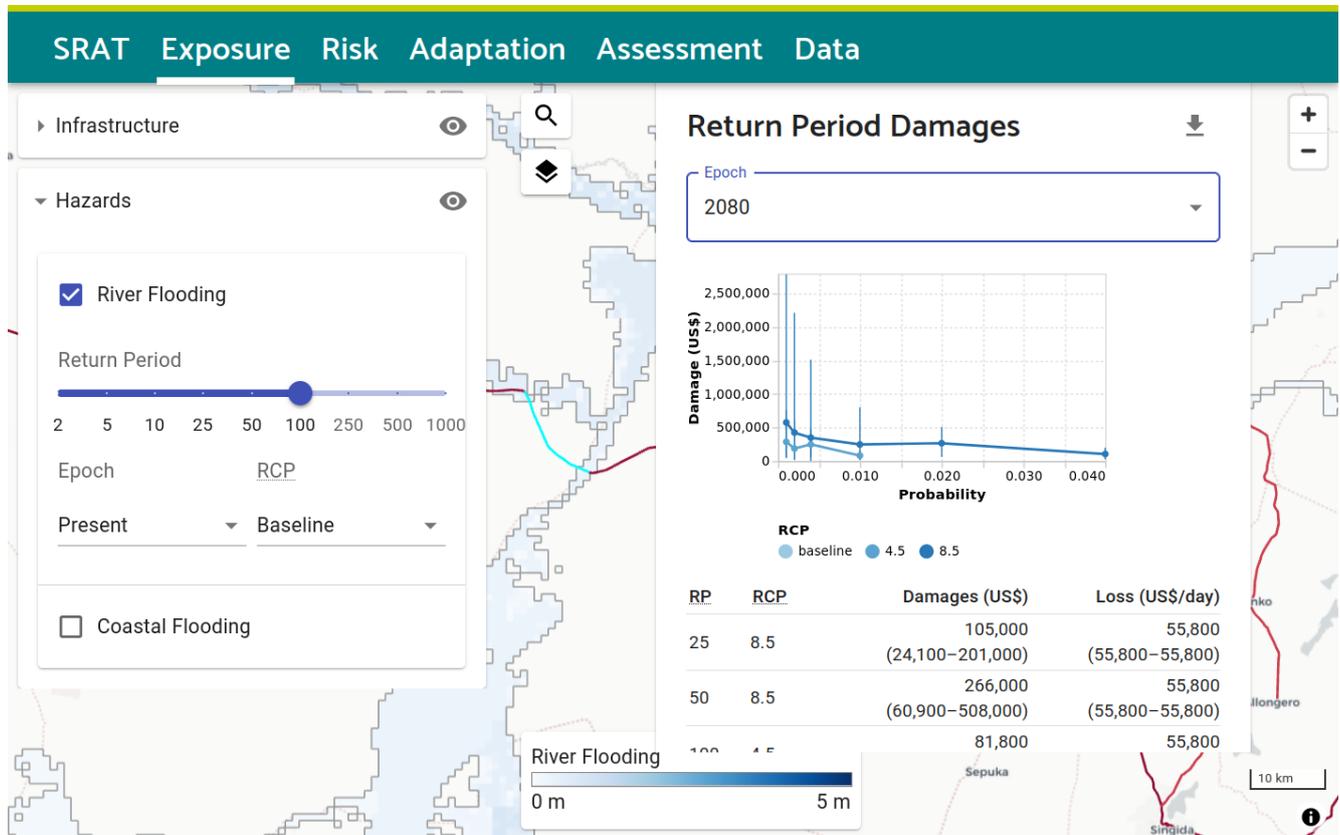
In the sidebar, move the slider to show flooding for different return periods. A 500-year return period flood is much less likely and more intense, with deeper water levels and more area covered by the flood.

While looking at the hazards, infrastructure networks can be overlaid to see where they might be affected.



Click on a road, for example, to see more detail. This brings up a right sidebar, first showing asset details and attributes. Scroll down to the “Return Period Damages” section which includes a chart and table of damages calculated from the length of road exposed to different depths of flooding at each return period (Figure 9).

Figure 9: Displaying estimated asset damages



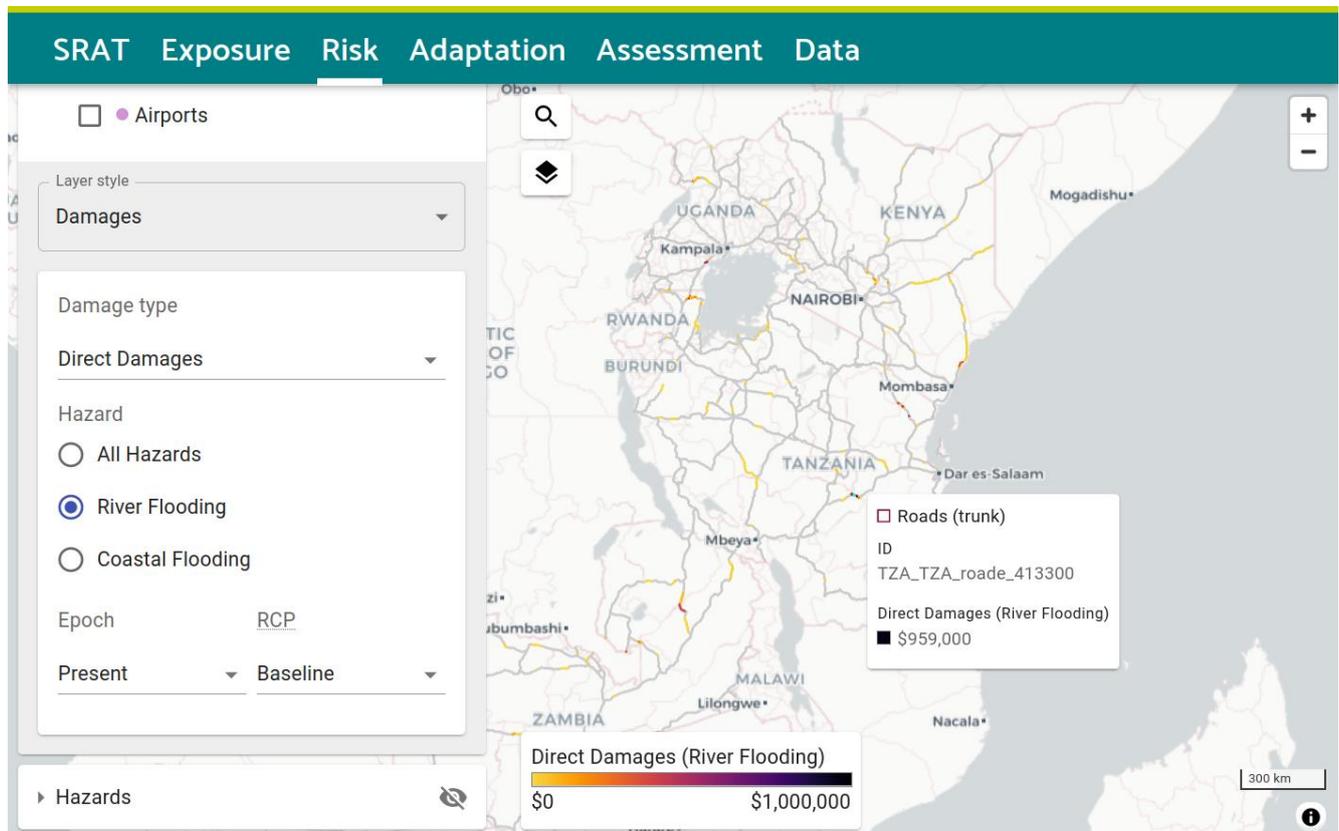
3.3 Explore climate risk results

On the “Risk” page, in the “Infrastructure” sidebar section, the “Layer style” defaults to show damages. Select the “Roads” layers to show expected direct damages or economic losses as evaluated for all of the major and minor (down to tertiary) roads (Figure 10). As shown, hovering over an asset brings up the asset type, ID and



damages. Clicking on the asset brings up the right sidebar (shown in Figure 9, section 3.2 above) with more detail on the individual asset and assessed damages.

Figure 10: Displaying expected direct damages



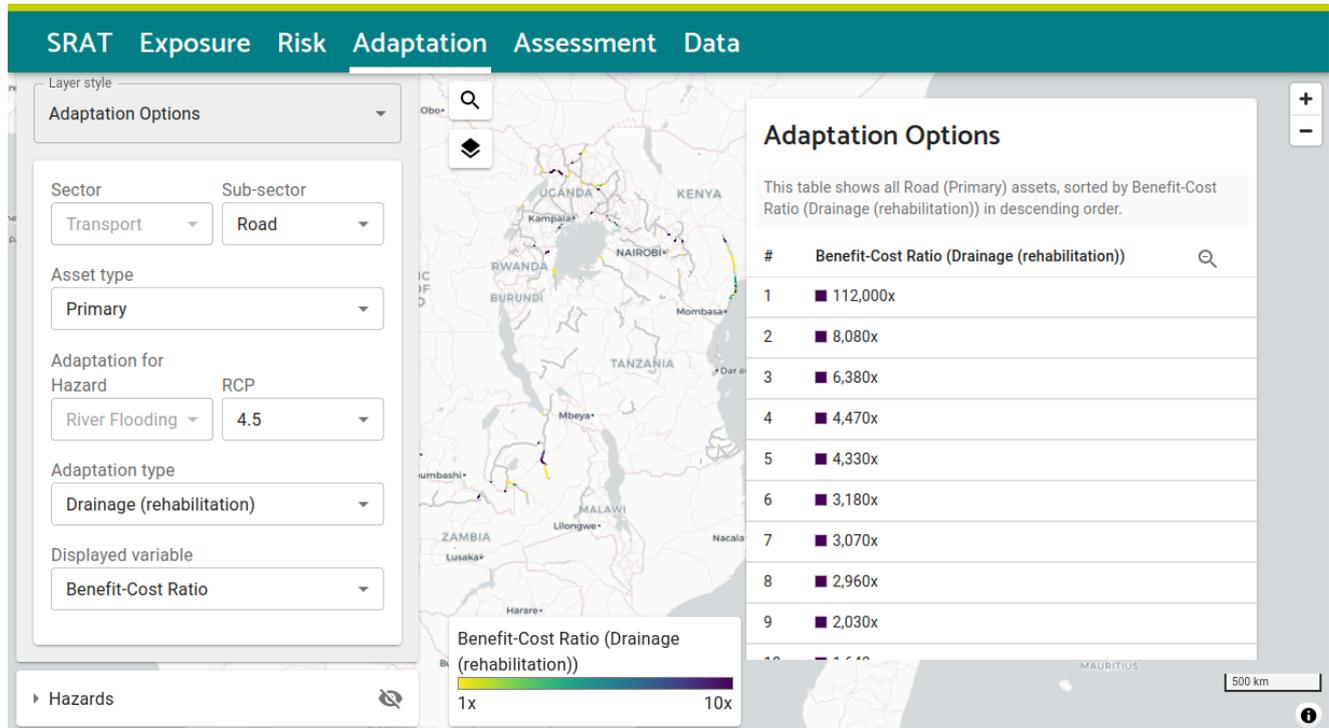
From the controls in the sidebar, explore the contribution of individual hazards, and select the epoch (time period or decade) and RCP (Representative Concentration Pathway, a climate scenario) to see how risks change as the hazards change. At this point in the analysis the outputs do not account for economic growth or discounting over time: the comparison is holding everything constant except for the hazard maps.



3.4 Explore adaptation options

On the “Adaptation” page, the left sidebar includes an “Adaption Options” layer style. Select a sector, sub sector and asset type to display the generic adaptation options that have been evaluated. For example, for “Roads”, “Primary”, you can look at “Drainage (rehabilitation)” or several other adaptation options which may reduce flood risk (Figure 11).

Figure 11: Selecting adaptation options



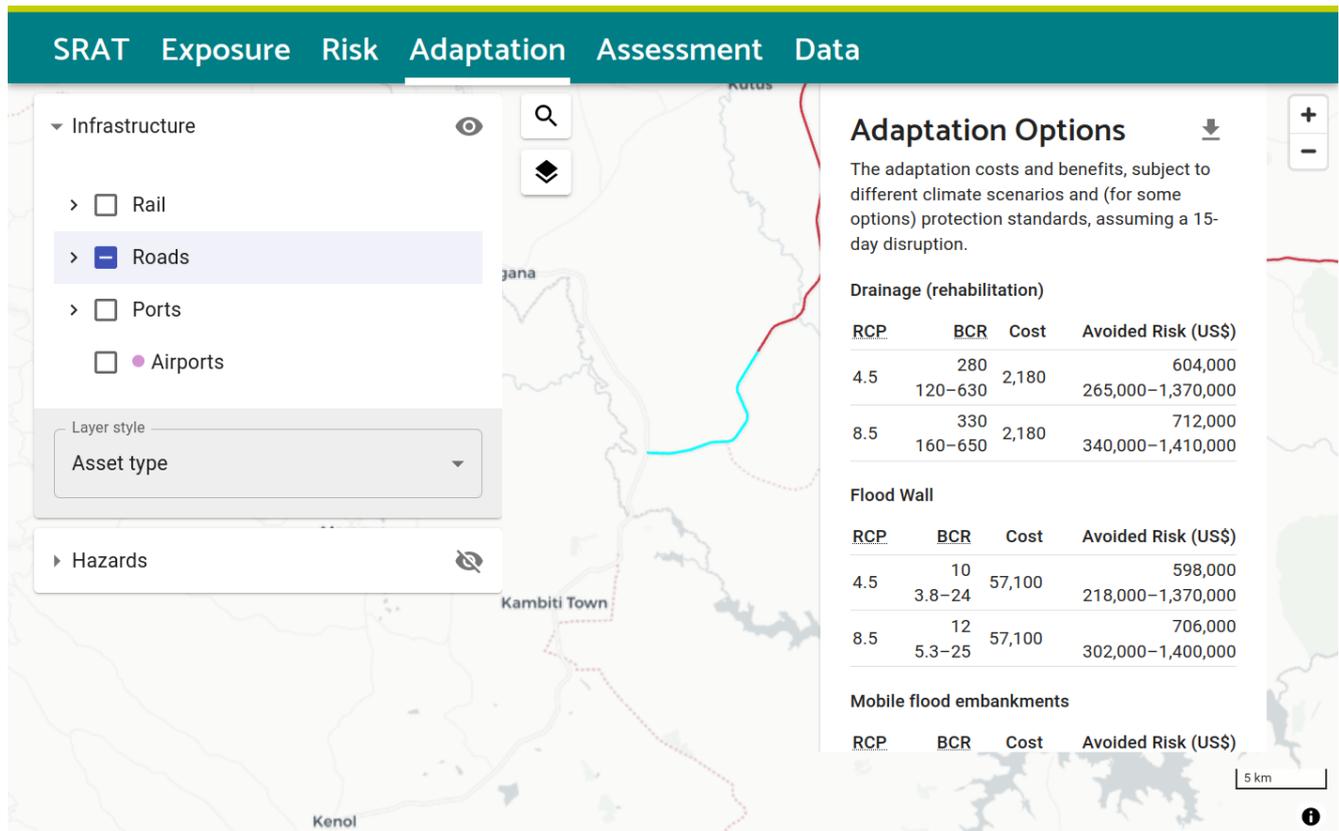
From here, the assets are shown on the map and ranked in the table on the right, according to the choice of “Displayed variable”, which includes net present value of avoided direct damages or economic losses, total adaptation cost, or the benefit-cost ratio.

Hover over the rows of the table on the right to highlight asset locations. Click the magnifying glass icon to zoom in. Click the “zoom out” magnifying glass icon at the top of the table to get back to the full view. Click on a row of the table to see the main asset attributes.



Once you have identified an asset of interest, click on it on the map to highlight it in blue, then switch the layer style to “Asset Type” or “Damages” – or switch the page to “Risk” – to show the full asset details in the right sidebar (Figure 12). Scroll down for the full details on Adaptation Options for this particular asset. This section shows a table for each assessed adaptation option, with BCR (Benefit-Cost Ratio, where any value greater than one indicates that the expected benefits outweigh the expected costs), Cost and Avoided Risk in USD. Both BCR and Avoided Risk are given with a range encompassing the uncertainty inherent in the hazard maps and rehabilitation cost estimates that drive the risk calculation.

Figure 12: Displaying adaption option details





4. Risk and adaptation analysis use case example

This use case revisits many of the previous stages, looking at a single infrastructure asset to understand the process of climate risk and adaptation analysis. It assumes that there is a particular asset of interest to assess for risk and potential adaptation.

4.1 Identify asset

This example will use the stretch of primary road just north of Malindi in Kalifi County, Kenya, with id “KEN_KEN_roade_31215”.

Start on the “Exposure” tab.

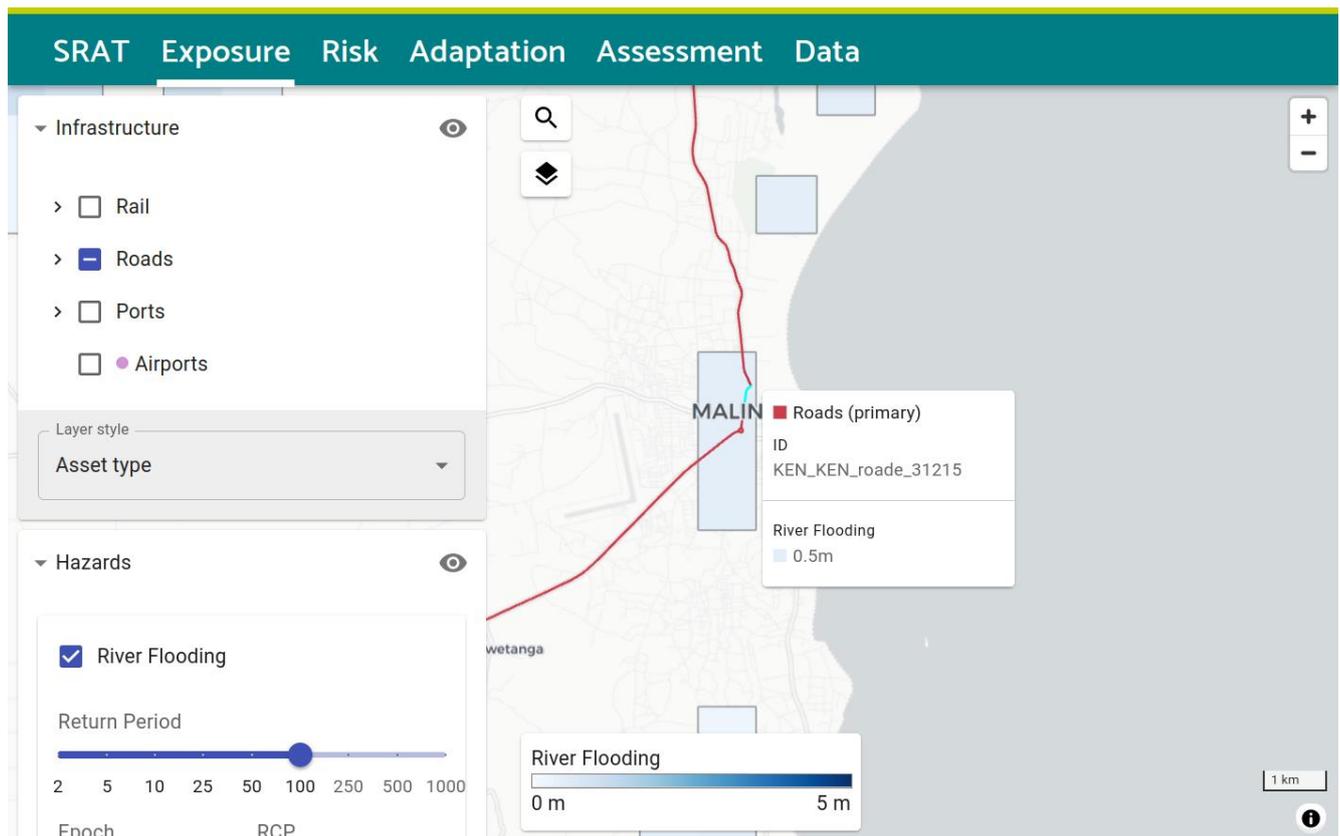
Under “Infrastructure” in the left sidebar, select “Roads > Primary” to show all primary.

In the map search box, type “Malindi” and click on “Malindi, Kalifi County, Kenya” to zoom to the town.

Under “Hazards” in the left sidebar, select “River flooding” to add a flood outline to the map. Set the Return Period to 100. Select “Present” epoch and “Baseline” RCP.

Hover over the road going north from the town centre to see its ID and depth of flooding (Figure 13).

Figure 13: Risk and adaptation analysis use case example – Step 1 Identify asset



The road intersects with different fluvial (river) flood outlines under baseline and future climate scenarios. From the depth of flooding, the analysis has estimated the direct damages to the road itself, and indirect economic losses from transport disruption.

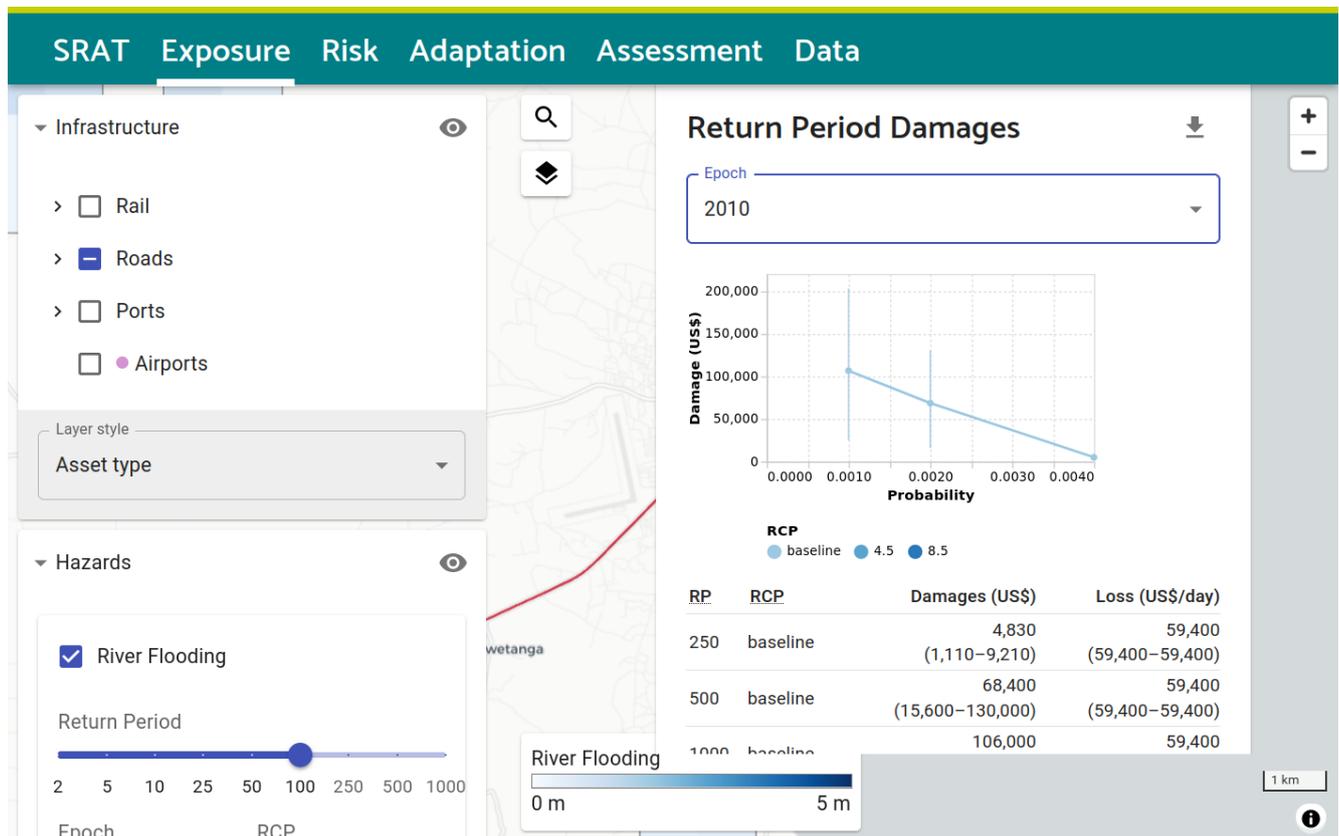


4.2 Display return period damages

Click on the road to show the calculated results in the right sidebar. Under the “Risk” section (Figure 16, explained in section 4.4 below), the chart and table show the expected annual damages or losses.

Under the “Return Period Damages” section (see Figure 14), the chart and table display in more detail the damages or losses which would result from a flood of a particular return period (or probability).

Figure 14: Risk and adaptation analysis use case example – Step 2 Display Return Period Damages

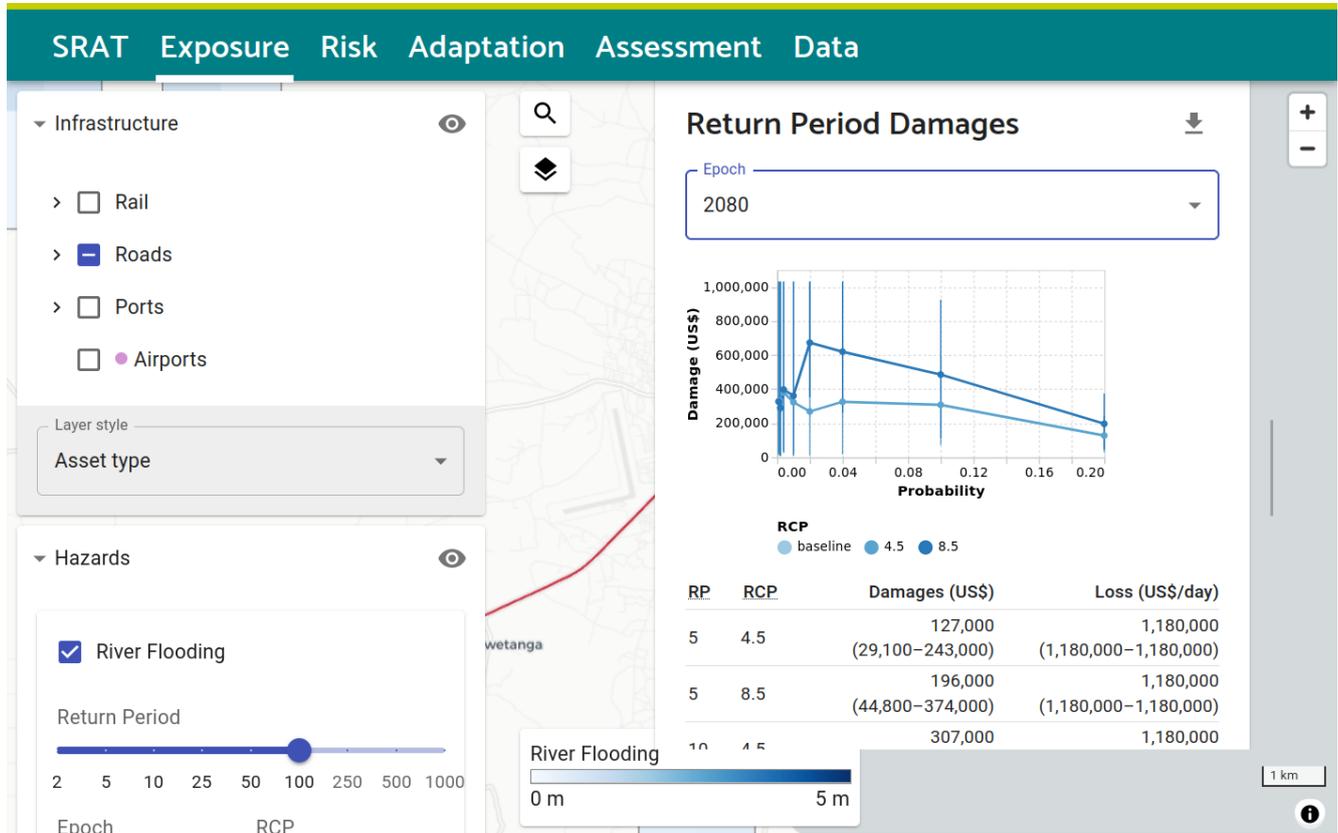




4.3 Select different epochs

In the “Return Period Damages” section, change the “Epoch” dropdown from 2010 to 2080 to see the change in damages under climate change scenarios (RCP 4.5 and 8.5) (Figure 15).

Figure 15: Risk and adaptation analysis use case example – Step 3 Select different epochs



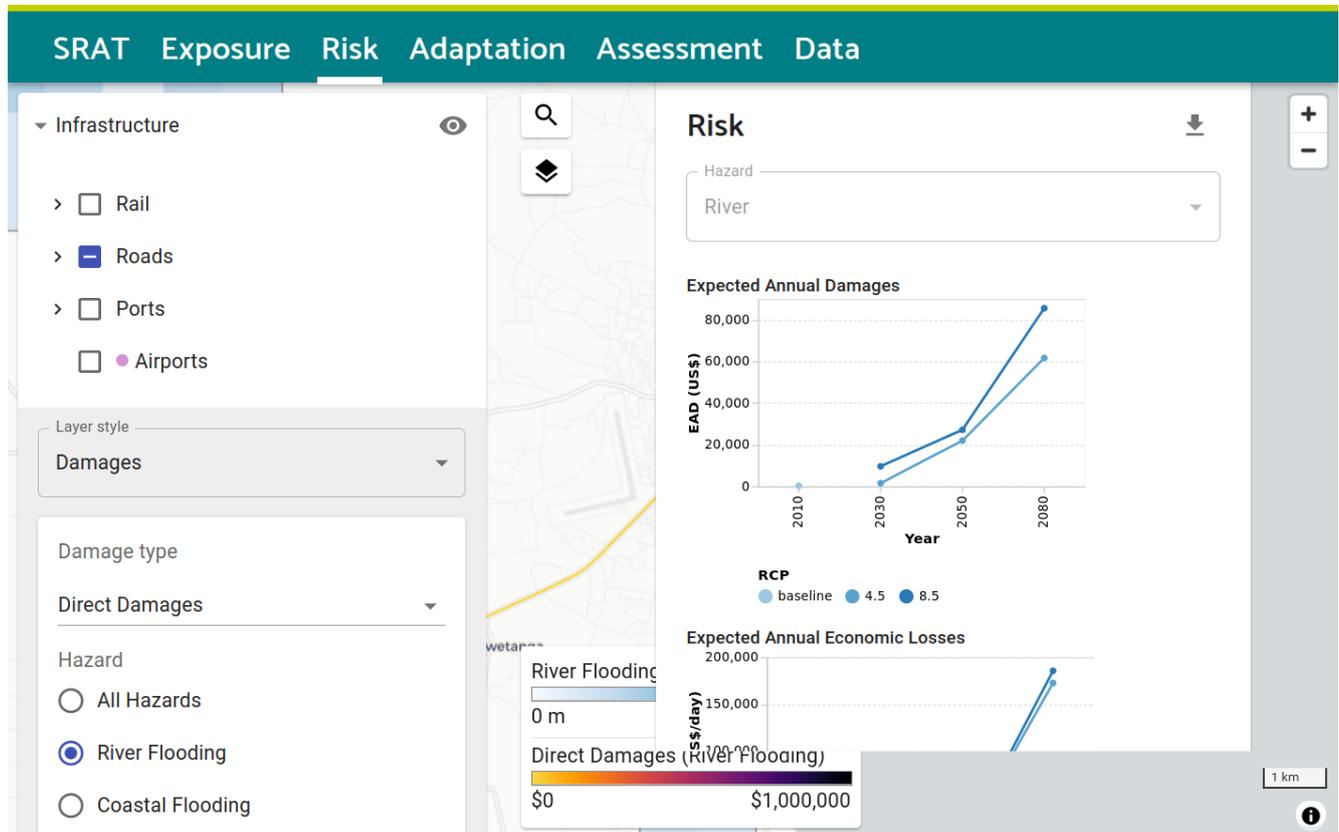


4.4 Risk

In the top menu, click on the “Risk” tab. This may change the background flood map but will leave the map location and asset selection unchanged.

Scroll back up to the “Risk” section in the right sidebar (Figure 16).

Figure 16: Risk and adaptation analysis use case example – Step 4 Display ‘Risk’



One important thing to note is that (so far) only the flood hazard has been changing in the calculations above. The “2080” risk values and return period damages have not yet considered any changes in population or the economy. These changes are included in the next step.



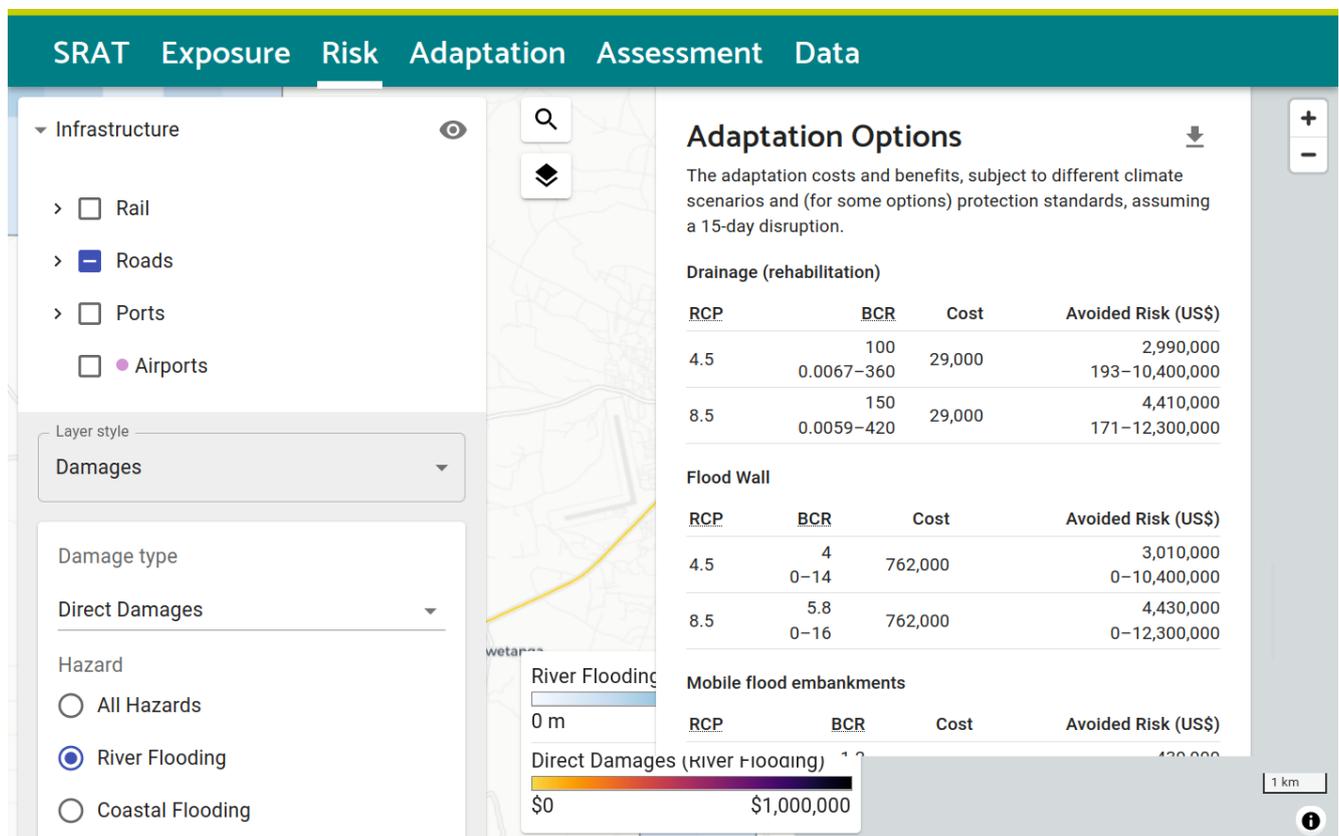
4.5 Adaptation options

Once all the climate risks have been estimated, the analysis considers a chosen adaptation option for this road, and estimates the present values of costs and benefits (in terms of avoided risks), then the Benefit-Cost Ratio (BCR) for each case.

Net Present Value is calculated over the asset lifetime, and both economic growth scenarios and discount rates go into the calculation. Population change is considered in some sectors – particularly in water, when calculating the risk of drought. The adaptation investment and maintenance costs, or the direct or indirect risk values, are calculated for each year into the future, discounted and summed to give a single number for the present value. For more detail on these calculations, see Hickford et al (2023), section 5.

Scroll down to the “Adaptation Options” section (Figure 17). This shows adaptation costs and benefits, subject to different climate scenarios, assuming a 15-day disruption. 15 days is justified as a typical period for disruption of freight flows in Hickford et al (2023), and it is a key sensitivity in the analysis of economic losses.

Figure 17: Risk and adaptation analysis use case example – Step 5 Display ‘Adaptation Options’



In this example, the Adaptation Options section shows the estimate that, for example, drainage rehabilitation would incur a cost of US\$29,000 over time and result in avoiding mean risks of US\$2.9 million under RCP 4.5 flooding scenario, which results in BCR of approximately 100 (rounded to two significant figures, with a wide range of uncertainty given for both risk reduction and BCR). For this asset the chosen adaptation option presents a potentially strong case for investment: the benefits are much greater than the costs, at least in the central estimate and at the upper end of the uncertainty range. For a better understanding of the uncertainties in the risk calculation, see Hickford et al (2023) section 5 on risk and adaptation analysis and section 8 for case studies.



5. Prioritise adaptation interventions

This use case covers reviewing and prioritising adaptation options for a transport mode, then going into detail for a specific asset to evaluate the direct and indirect risks, and costs and benefits of adaptation. It assumes that the user starts from a system- or sector- wide perspective and wants to go through a process of screening assets for risk and potential adaptation.

Start from the “Adaptation” tab, chosen from the top menu bar.

In the left sidebar, make sure “Adaptation Options” is the layer style.

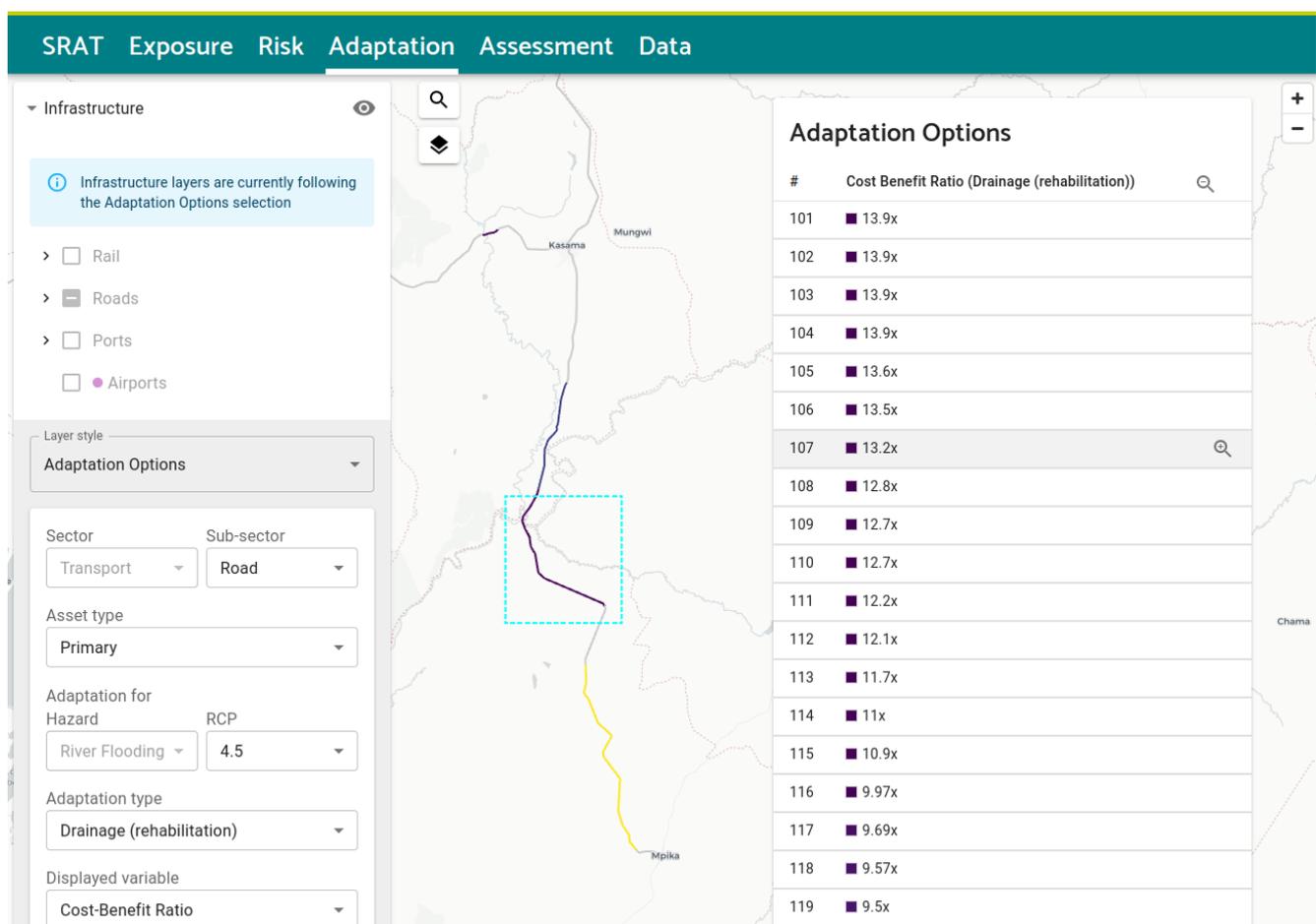
Select the sector as “Roads” and asset type as “Primary” using the dropdown menus (the sector check boxes on top left are not functional on this tab).

Select details of the hazard (“Flooding” is the only one available for this asset type) against which the adaptation option will protect. Here you can also change the climate scenario and adaptation option.

Select “Benefit-Cost Ratio” as the displayed variable.

The map then shows assets coloured by Benefit-Cost Ratio for prioritisation. In the right sidebar, the table shows assets, sorted in descending order with the most cost-beneficial at the top.

Figure 18: Prioritise adaption interventions use case example – Step 1 Display Benefit-Cost Ratios



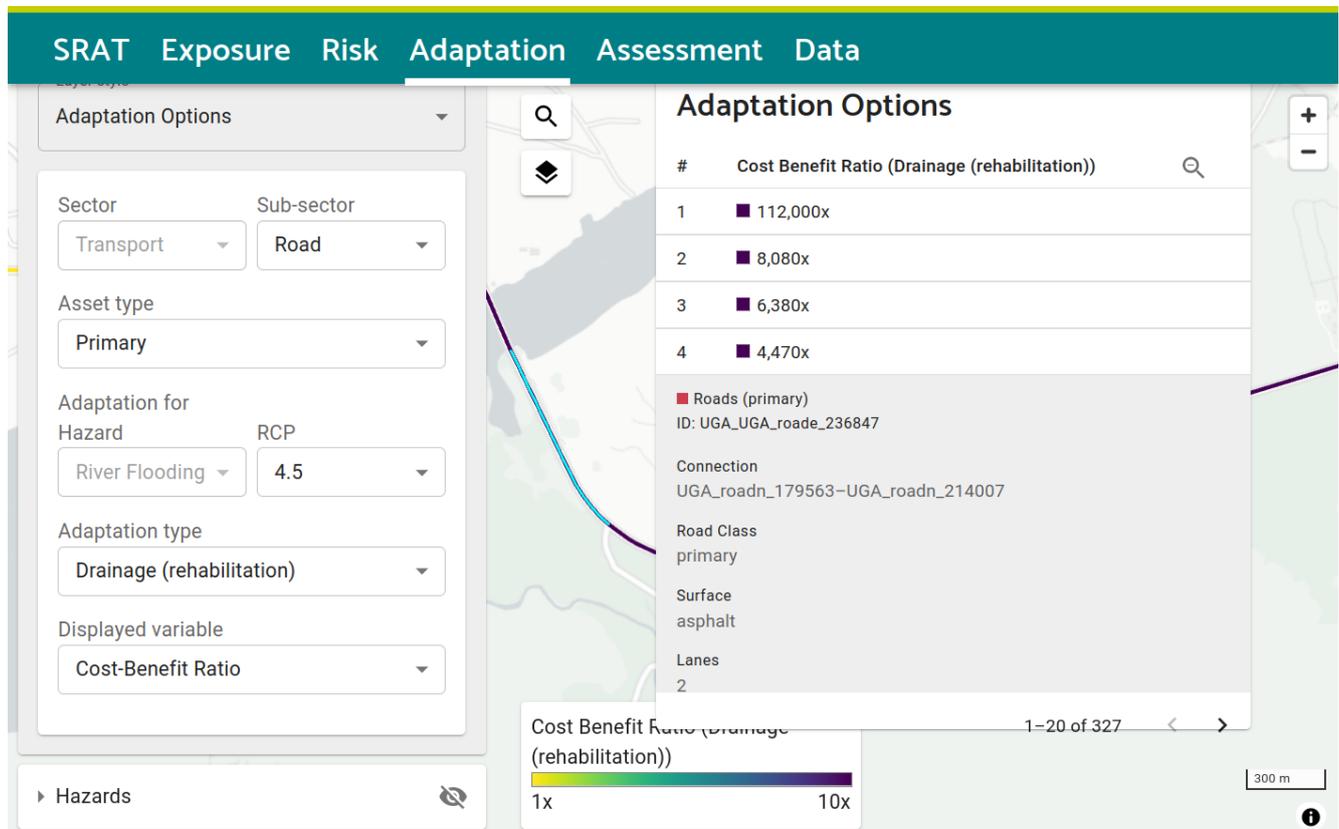
Hover over a row to indicate the asset on the map, drawing a dashed bright blue line around its location (Figure 18).

Click on a row for more details about the asset. At the right-hand end of the row, click on the zoom-in magnifying glass icon (🔍) with a plus sign to zoom to the asset location (*you will need to move the cursor back onto the row to see this, if it has moved elsewhere*).



To zoom out again, click on the magnifying glass icon (🔍) with a minus sign, which is at the top-right corner of the sidebar.

Figure 19: Prioritise adaption interventions use case example – Step 2 Investigating adaptation options

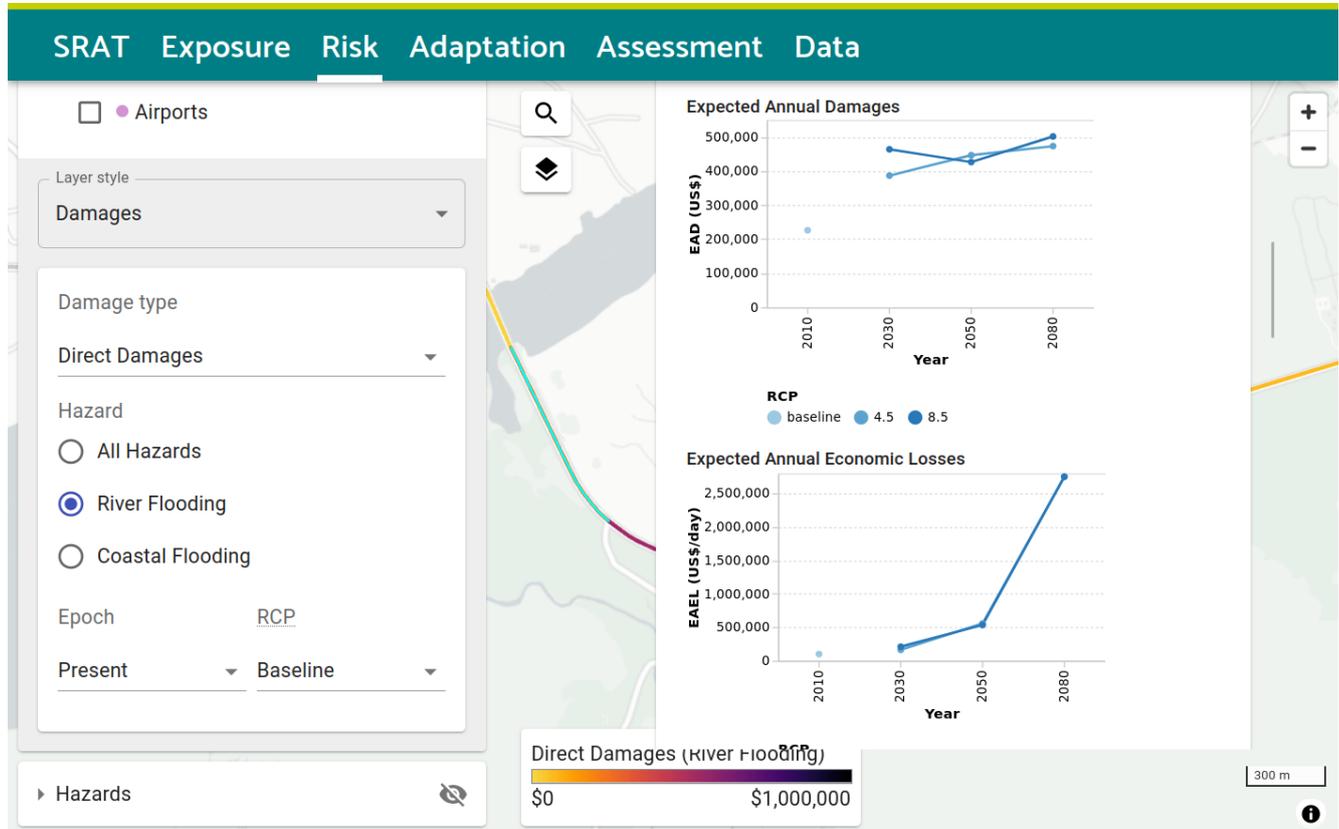


Once you have identified a candidate for prioritisation, zoom to its location so that it is clearly in view. You can then switch back to the “Exposure” or “Risk” tabs to bring up more details about the asset risk. In this example (Figure 19), the road with id “UGA_UGA_roade236847” has been prioritised



Click on the “Risk” tab in the top menu bar, then click on the asset to highlight it and show details in the right sidebar. Here, as has been seen previously, there are details of asset risk under different hazards and climate scenarios, both direct damages and indirect economic losses (Figure 20).

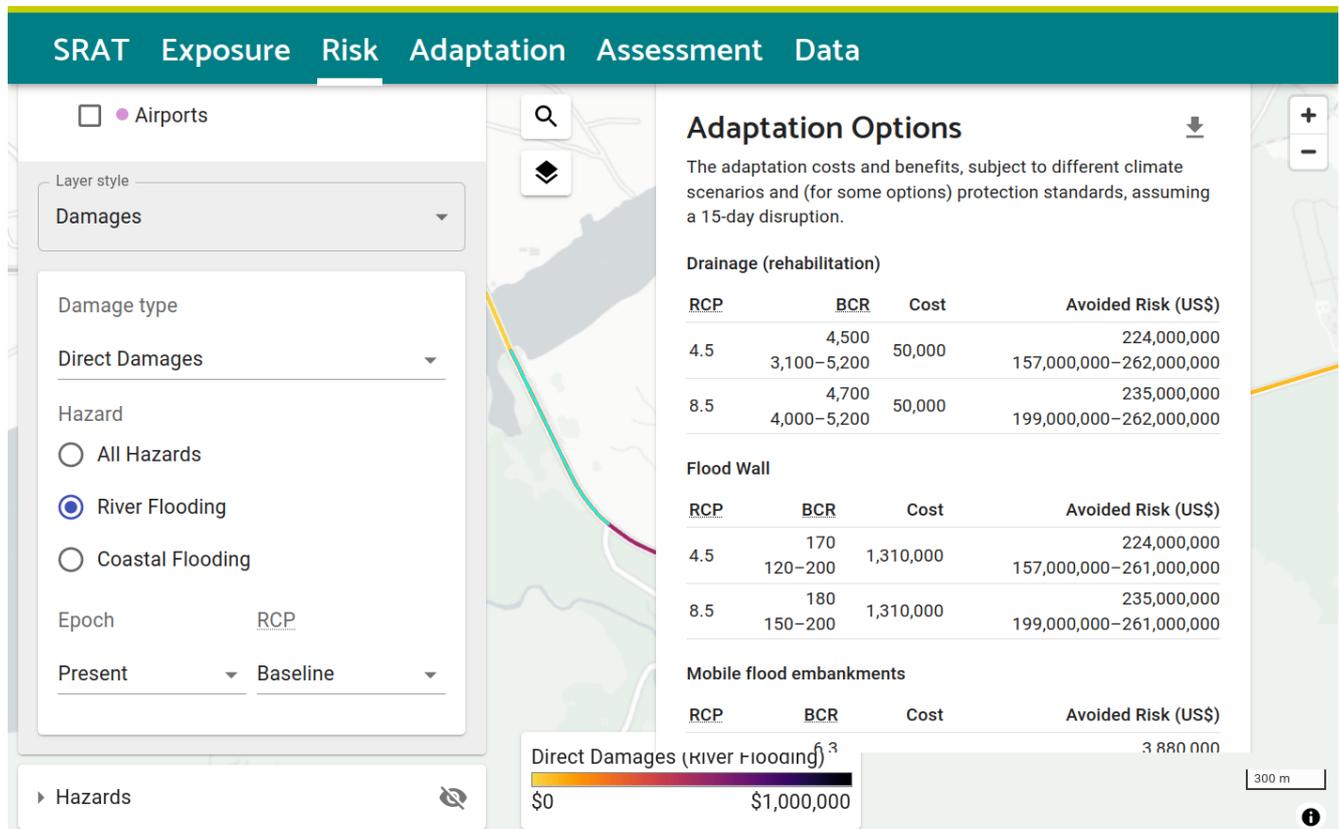
Figure 20: Prioritise adaption interventions use case example – Step 3 Displaying Expected Annual Damages (EAD) and Expected Annual Economic Losses (EAEL)





Scroll down to the “Adaptation Options” section to find the evaluated Present Value costs and benefits of different adaptation interventions under different hazards and climate scenarios (Figure 21).

Figure 21: Prioritise adaption interventions use case example – Step 4 Summary of adaptation option results



From any of the asset details sections (e.g. Adaptation Options as shown above), click on the download icon (↓) to save a CSV of all the table values, including all hazards/epochs. The CSV files can be opened using any spreadsheet program, for example Microsoft Excel, then further calculations can be made. For example, add a “bcr” column, calculated as $(\text{avoided_ead_mean} + \text{avoided_eael_mean}) / \text{adaptation_cost}$, then sort the data by that column to find the most cost-beneficial option, or filter the rows to find all options with $(\text{bcr} > 1)$ and look for the least costly option. Compare the climate scenarios (rcp) to see which options are robust across a range of possible futures, or filter one particular scenario to make an assumption about which is more relevant to the analysis.



6. Evaluate the sustainability of an intervention

This use case steps through the process of evaluating an intervention for sustainability. The example used takes a portfolio of highly-prioritised adaptation options from the risk analysis that might comprise a major infrastructure maintenance scheme aiming to improve the overall condition of the long-distance infrastructure.

6.1 Start an assessment

Click on “Assessment” in the top bar to navigate to the sustainability assessment screen. By default, this starts with an empty table of assessments (Figure 22).

Figure 22: Sustainability assessment use case example – Step 1 Start new assessment

SRAT Exposure Risk Adaptation **Assessment** Data

Sustainability Assessments

Click "Start New" to start a sustainability assessment.

Assessments are stored in the current browser window and not shared or saved online. To share an assessment, save it as a file using the download icon. Load shared files using the import box below.

#	Assessment	Action
		<div style="border: 1px solid #0070C0; border-radius: 5px; padding: 5px; display: inline-block;"> ▶ START NEW </div>

Import from file

Drag an assessment file over this area, or click to select files

Assessments are not shared online or uploaded, so there is no risk of them being accessed by other users of the tool. They are saved in the browser’s local storage so they should persist if the tab or browser window is closed.

Click “Start New” to begin an assessment.



6.2 Select intervention and scenario options

The assessment page has several sections to complete. Start by giving the assessment a title, for example “Maintenance and drainage programme”. There is also space here for general notes.

Select an intervention or interventions for assessment. To follow along with this worked example, check “Infrastructure maintenance” to select the maintenance category for interventions (Figure 23).

Figure 23: Sustainability assessment use case example – Step 2 Select Intervention type

SRAT
Exposure
Risk
Adaptation
Assessment
Data

ID: 6cb60817-7fa6-4740-b4bf-6b2ba86020fa
Created: 29/11/2022, 15:17:54

Sustainability Assessment

Title
Maintenance and drainage programme

Notes

Select Interventions

Select one or more interventions for assessment. This will provide a template with some preset values for the sustainability indicators.
If none of the below are relevant, select “Custom intervention”.

Intervention	Description
<input type="checkbox"/> Infrastructure construction	The construction of new road and rail routes, or expansion of existing routes. This is likely to have an impact on route choice at a local level.
<input checked="" type="checkbox"/> Infrastructure maintenance	Improvements made to existing roads and rail. These are unlikely to have any major effect on transport volumes, but there will be slight capacity improvements.
<input type="checkbox"/> Demand for goods	Behaviour change that results in a reduced or increased demand for goods. This could change the requirement for long-distance freight services, with the potential to impact the whole LDT

Table 1 gives a short description of each intervention that is configured within the tool. If none of the options are relevant, the user can choose a “Custom intervention” and configure the effect that it has on each indicator.

Table 1: Sustainability Assessment Interventions

Intervention	Description
Fleet electrification	The construction of new road and rail routes, or expansion of existing routes. This is likely to have an impact on route choice at a local level.
Vehicle efficiencies	Improvements made to existing roads and rail. These are unlikely to have any major effect on transport volumes, but there will be slight capacity improvements.
System efficiencies	Behaviour change that results in a reduced or increased demand for goods. This could change the requirement for long-distance freight services, with the potential to impact the whole LDT network usage.
Demand for	Any societal behaviour change which affects demand for long-distance travel. This could have



goods	a wide-ranging impact on LDT (long-distance transport) passenger services.
Demand for travel	Co-operation between logistics providers and national authorities. The impact that better logistics planning can have on the overall use of the long-distance transport networks is relatively small, but better planning should result in more efficient loading and freight management, together with an easing of restriction at border crossings.
Infrastructure construction	Technological improvements to vehicle routing and increased use of web-based mobility tools. This will benefit both freight and passenger vehicles on the long-distance transport network, and may help to reduce transport volumes and reduce congestion.
Infrastructure maintenance	Improvements to engine efficiencies and use of lighter materials during manufacture. This is likely to reduce emissions and energy consumption very slightly.
Logistics planning	An indication of the number of electric vehicles, particularly freight vehicles using LDT networks. This is likely to be very small in the future, but plans to introduce legislation to phase out fossil-fuelled vehicles are starting to be developed in some sub-Saharan countries.
Road user charging	The implementation of long-distance road user charging schemes through tolling interurban toll roads. This could have a significant impact on the long-distance freight movements of specific routes, but as freight companies can pass on any extra costs to customers, there are only likely to be relatively minor impacts on emissions, energy consumption and freight transport volumes.
Custom intervention	An intervention that can be configured to represent any other change to the transport system.

Scroll down to see the selected intervention option details. Select “Increase/improve” to reflect the increase in maintenance from implementing this programme (Figure 24). The alternative options here would be to reset to “No intervention” or to consider the negative effect of “Decrease/lessen”.

Figure 24: Sustainability assessment use case example – Step 3 Changing overall intervention impact

SRAT Exposure Risk Adaptation Assessment Data

Intervention Options

The table below shows the interventions that have been selected for evaluation.

Choose a direction of change for each intervention. The default is "No intervention" and assumes doing nothing. For example, set this to "Increase/Improve" in order to evaluate a project or positive change.

Expand each row to evaluate the impact of the intervention against each indicator. This will show the default (preset) value and any changes to the indicators. Make a note of reasons for any changes from the default values.

Intervention	Change
^ Infrastructure maintenance	Infrastructure maintenance Increase/Improve



Scroll down again to select scenarios. To allow direct comparisons with other interventions, set the same socio-economic scenario for each. Population change, economic growth and transport costs are set to the default “Central” options (Figure 25). The alternative options here would be to consider “Low” or “High” scenarios, with positive or negative effects compared with the neutral baseline “Central” scenario.

Figure 25: Sustainability assessment use case example – Step 4 Select scenarios

SRAT Exposure Risk Adaptation **Assessment** Data

Scenarios

The table below shows the scenarios that have been selected for evaluation.

Choose a direction of change for each scenario. The default is "Central" which gives a baseline scenario with neutral effects. For example, test interventions under a range of scenarios to evaluate how there may be a range of sustainability outcomes.

Expand each row to evaluate the impact of the scenario against each indicator. This will show the default (preset) value and any changes to the indicators. Make a note of reasons for any changes from the default values.

Scenario	Change
▼ Population	Population Central
▼ Economic	Economic Central
▼ Energy Costs	Energy Costs Central



6.3 Agree expected impacts for each sustainability indicator

Click the downward-pointing arrow on the left to expand the intervention options table and see values for each indicator. The left column shows the default values for each indicator. The central column allows the user to change the value. The right column displays the value used in the assessment (where the revised value may have changed from the default).

The change for “Infrastructure Maintenance” is set to “Increase/Improve” so all effective values in the right column see a positive effect. The other dropdown options allow for assessing the baseline “No Intervention”, which would set all effective values in the right column to zero, or the negative change “Decrease/Lessen”, which would change the sign of all the effective values. The underlying assumption here is that if doing more of something would have an effect on an indicator, doing less of it would have the reverse effect, and doing nothing would have no effect.

For example, increase the multiplier for ‘average passenger journey time’ to +1.0, as the planned maintenance is expected to reduce frequent disruptions. This is a positive change as it reflects an improvement: the user expects reduced journey times as there should be reduced likelihood of unplanned road or lane closures (Figure 26). When the indicator value is changed from the default value, there is the option to add a note recording the reason for the change.

Figure 26: Sustainability assessment use case example – Step 5 Agree impacts on sustainability indicators

The screenshot shows the 'Assessment Data' section of the SRAT tool. It features a table with columns for 'Indicator', 'Default', 'Revised', and 'Effective' values. Each indicator has a slider and a dropdown menu to adjust its value. A note is visible for 'Average passenger journey time'.

Indicator	Default	Revised	Effective
GHG emissions	0.5	0.5	0.5
Energy consumption (non-renewable)	0.5	0.5	0.5
Road quality	1	1	1
Average passenger journey time	0.5	1	1
Population affected by traffic noise	0.5	0.5	0.5

Note for Average passenger journey time: Could be measured in terms of average journey speed. Faster is better.

Anticipate reduction in disruptions.



Table 2 shows the full list of sustainability indicators, along with notes on potential methods for measurement and how those measures (or estimated or modelled values) should translate into the abstract positive-to-negative scoring. These notes are also shown in the tool when hovering over the “?” icon next to each indicator (see Figure 26 above).

Table 2: Sustainability Assessment Indicators

Group	Indicator	Potential measurement and scoring
Environmental	GHG emissions	Transport-related greenhouse gas (GHG) emissions could be measured in tons of CO ₂ per capita. This indicator relates to SDG 9.4. Lower levels of emissions are better.
	Air quality	PM2.5 air pollution, mean annual exposure. This indicator relates to SDG 3.9. Higher air quality and lower levels of exposure are better.
	Energy consumption (non-renewable)	Non-renewable energy used by mode (ktCO ₂ e). Lower consumption of fossil fuels is better.
	Habitat and ecosystem disruption	Proportion of land area of particular habitat type disrupted by transport infrastructure. Less disruption is better.
	Land take by transport	Proportion of land area required for transport infrastructure. Less land take is better.
Economic	Passenger transport volumes (passenger-km)	Number of passengers. This indicator relates to SDG 9.1. Scoring is context-dependent: less congestion may be an improvement, or greater access may be more
	Freight transport volumes (tonne-km)	Freight tonnage. This indicator relates to SDG 9.1. Scoring is context-dependent: less congestion may be an improvement, or greater access or trade may be more
	Passenger vehicle occupancy rates	Number of people per vehicle. Higher occupancy is better.
	Freight transport load factors	Average load factor. More efficient is better (although there could be problems of overloading).
	Average age of vehicle fleet	Average age in years. Newer vehicles tend to have lower operating emissions, but these have to be traded off against the embodied carbon in vehicle production.
	Road quality	An infrastructure quality index. Higher quality is better (although "gold plating" could be an issue).
	Length of transport networks	Route km of road/rail. Scoring is context-dependent: less congestion is better, but excess capacity is a waste of resources.



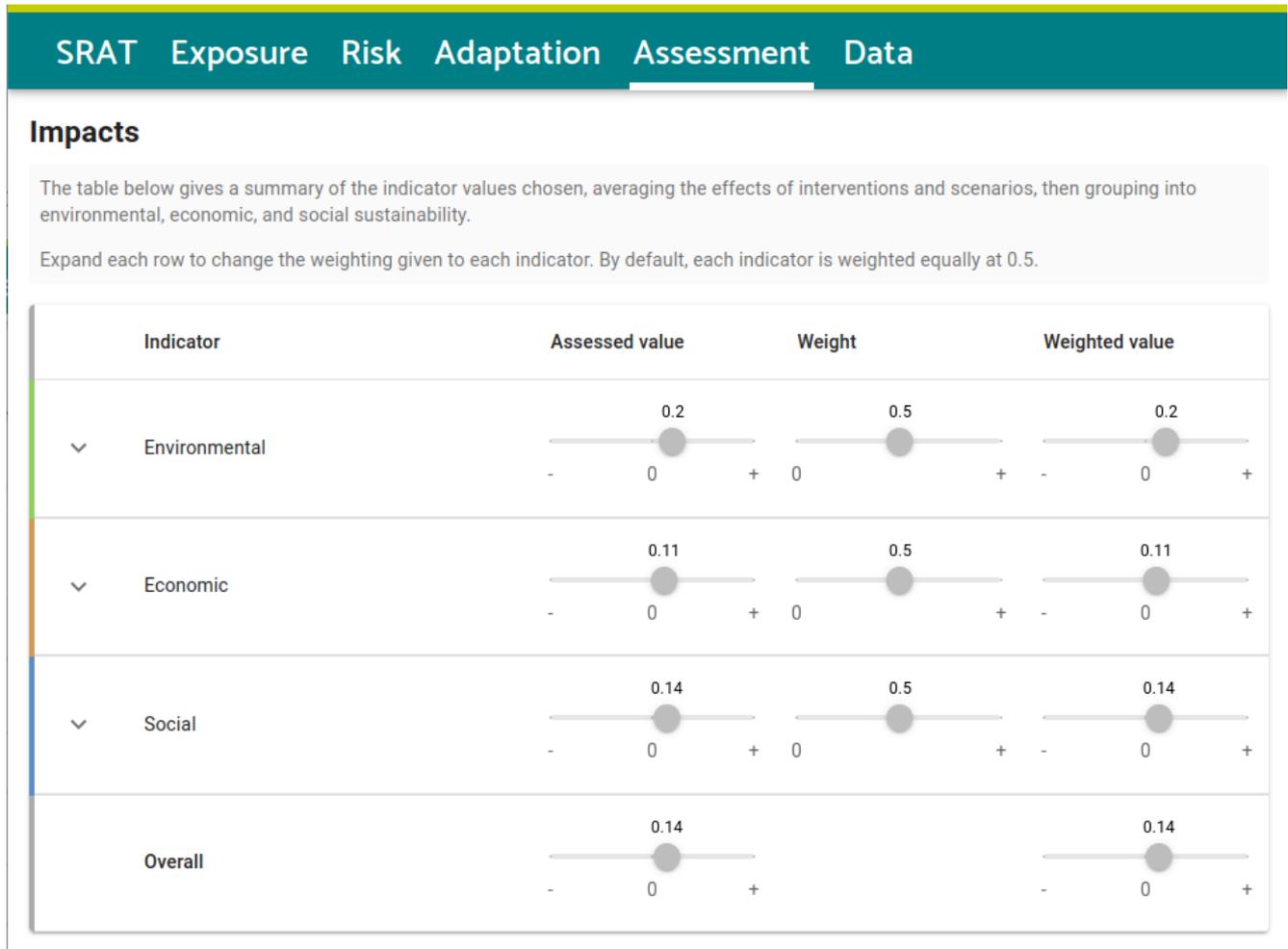
	Density of transport networks	Km of infrastructure per km ² . Scoring is context-dependent: less congestion and greater access is better, but excess capacity is a waste of resources.
	Border restrictions	Average delay to freight vehicles at border crossings. Less delay is better.
Social	Average passenger journey time	Average journey speed. Faster is better.
	Average passenger journey length	Km per average journey. Scoring is context-dependent: unnecessary travel has negative costs, but longer journeys can increase social inclusivity.
	Total number killed in traffic accidents	Number of deaths by mode. This indicator relates to SDG 3.6. Fewer deaths are better.
	Number of injury traffic accidents	Number of accidents by mode. Fewer accidents are better.
	Per capita fatal accident rate	Number of deaths in traffic accidents per capita. Lower rates are better.
	Per capita injury accident rate	Number of injuries in traffic accidents per capita. Lower rates are better.
	Population affected by traffic noise	Percentage of population affected (by mode). Less exposure is better.
	Cases of respiratory disease	Percentage of population with respiratory diseases. Fewer cases are better.
	Diversity	Gender/ethnic split of passengers or labour force. A split which is representative of the local or national population is better.
	Equality and fairness	Magnitude of gender/ethnic pay gaps. Smaller pay gaps are better.
Inclusivity	The proportion of population served by intervention who are in the 'most excluded' quartile of the national/regional population. Higher inclusivity is better.	



6.4 Agree relative weighting of indicators

Scroll down to the “Impact” section. Here there is a summary of the indicator values combined from each non-zero intervention and scenario (Figure 27). The assessment tool calculates the mean effective value of each indicator (across interventions and scenarios), then groups them into the three categories (environmental, economic and social). This gives a mean “assessed value”, which is shown in the left column in Figure 27, alongside the mean weight given to each indicator in the central column and the weighted value in the right column.

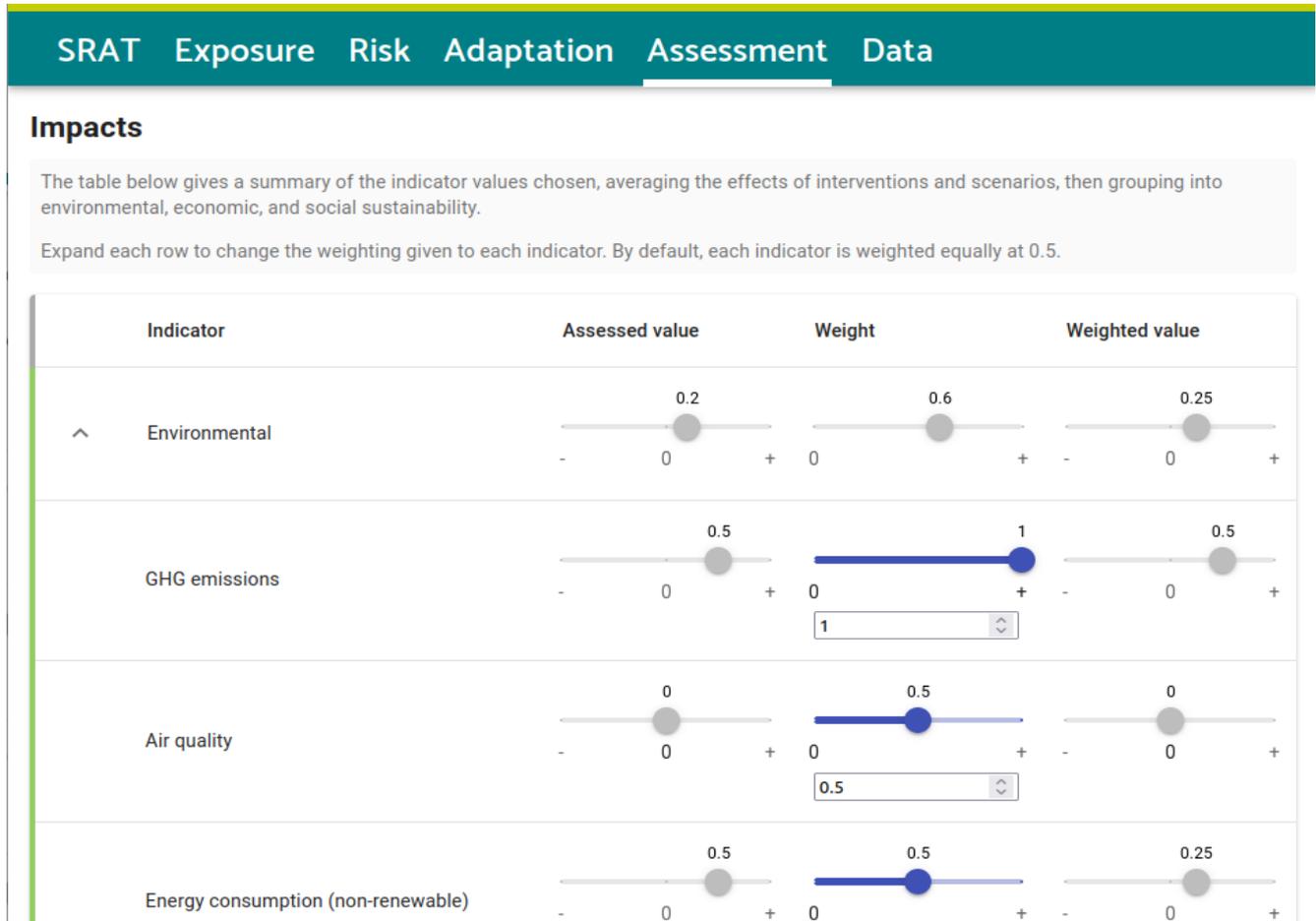
Figure 27: Sustainability assessment use case example – Step 6 Display relative weighting of sustainability indicators





Click the downward-pointing arrow on the left of the "Environmental" section to review the weight given to each indicator. By default, all are set equally to 0.5. For example, change "GHG Emissions" weighting to 1.0 to reflect the importance of reducing emissions. This makes a small change to the overall environmental weighting (increase from 0.5 to 0.6) and value of the environmental sustainability of the assessment (Figure 28).

Figure 28: Sustainability assessment use case example – Step 7 Altering weighting of indicators





6.5 Review results

The full detail of results is presented in the “Impact” section and then summarised briefly under “Summary” (Figure 29 and Figure 30).

Figure 29: Sustainability assessment use case example – Step 8 Display results

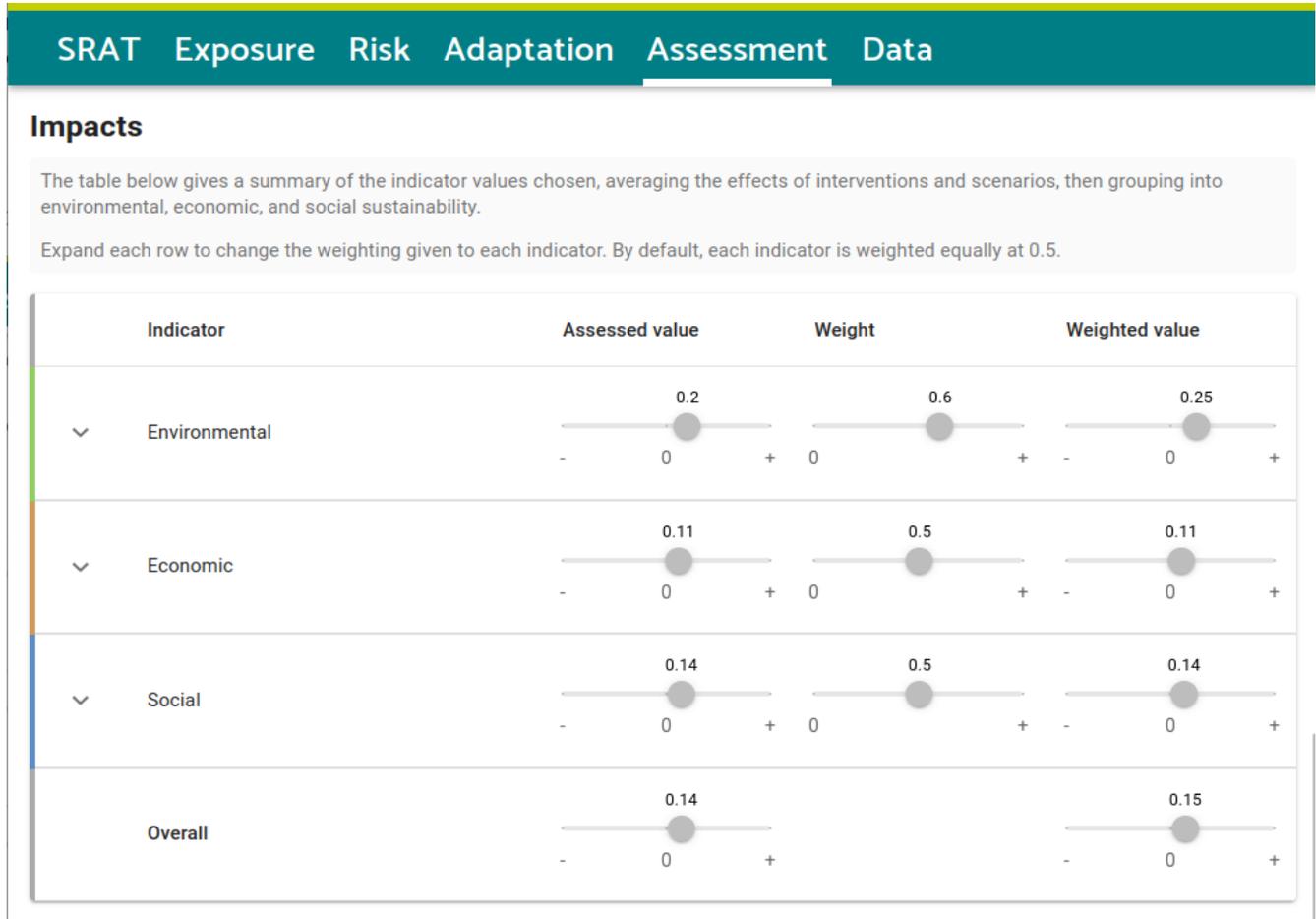


Figure 30: Sustainability assessment use case example – Step 8 Display summary

Summary

Overall, the proposed interventions are expected to have:

- a **slightly positive** effect on environmental sustainability
- a **slightly positive** effect on economic sustainability
- a **slightly positive** effect on social sustainability

Given the weights assigned, this could be considered a **slightly positive** effect overall.

SAVE DISCARD

The results suggest that maintenance is a sustainable option overall, with slightly positive effects across the board. To fill out the summary text, absolute values less or equal to 0.05 are considered neutral. Absolute values greater than 0.05 and less than 0.3 are considered “slightly” positive or negative. Absolute values greater than or equal to 0.3 are described as “strongly” positive or negative.

Click “Save” to save the assessment and run through another option for comparison, for example to test the relative sustainability of including a programme of infrastructure construction alongside the maintenance of existing assets.



6.6 Save and load assessment files

The completed assessments are shown in the main table (Figure 30). From here, click the pencil icon to edit an existing assessment. Click the bin icon to delete an assessment. Click the download icon to save an assessment to a file.

Figure 31: Saving, loading and deleting assessments

SRAT Exposure Risk Adaptation Assessment Data

Click "Start New" to start a sustainability assessment.

Assessments are stored in the current browser window and not shared or saved online. To share an assessment, save it as a file using the download icon. Load shared files using the import box below.

#	Assessment	Action
0b694f78-2...	Maintenance and drainage programme	✎ 🗑 ⬇
98270bfa-d...	Construction and maintenance	✎ 🗑 ⬇

▶ START NEW

Import from file

Drag an assessment file over this area, or click to select files

Assessment files can be shared and imported. For example, save an assessment then open another browser or private window. Drag the saved assessment file over the grey import area (or click the area then pick the file) to load it into the new window.

Assessment files are only intended to enable sharing assessments for use within this tool, though they are saved in the standard "text/json" file format, which can be viewed using any text editor (including notepad.exe) and read using most programming languages. The schema used for the file contents is not documented and not guaranteed to be stable across future releases of the tool.

7. Further Support

The tool is freely and openly available online at <https://east-africa.infrastructureresilience.org/> and will be hosted there for the duration of the project and at least until the end of March 2023. Long-term hosting options can be discussed.

The source code for the tool is developed and documented at github.com/nismod/infra-risk-vis/tree/release/east-africa. Software issues can be raised and contributions can be made through GitHub. All code is published open-source under an MIT license.

Bibliography

Hickford AJ, Blainey S, Pant R, Jaramillo D, Russell T, Preston JM, Hall JW, Young M, Glasgow G. Decision support systems for resilient strategic transport networks in low-income countries – Final Report. 2023. Available from: <https://transport-links.com/download/final-report-decision-support-systems-for-resilient-strategic-transport-networks-in-low-income-countries/>

University of Southampton

Boldrewood Campus
Burgess Road
Southampton, SO16 7QF
Email: S.P.Blainey@soton.ac.uk
Web: www.trg.soton.ac.uk

University of Oxford

Environmental Change Institute
School of Geography and Environment
South Parks Road, Oxford, OX1 3QY
Email: raghav.pant@ouce.ox.ac.uk
Web: www.eci.ox.ac.uk