

THE SUSTAINABLE WATER MANAGEMENT TEAM

OF THE AREQUIPA NEXUS INSTITUTE

Presents:

EASYINDEX-Agua

User's Manual



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Arequipa Nexus Institute

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INTRODUCCION TO TOOL

EASYINDEX-Agua is a water quality visualization tool and calculator that includes an interactive map and a calculator to provide simplified water quality information.

- Provides access to aggregated water quality information for the general population of Arequipa;
- Connects different watershed characteristics to a single index of contamination at each sampling point.
- Calculates a simplified water quality value for easy interpretation of water quality based on data that is input by the user.

TOOL DEVELOPMENT

EASYINDEX-Agua is divided into two parts – an interactive map and a calculator – which can be used individually or in combination to better understand water quality in Arequipa and to interpret users' water quality data.

The calculator and map use a water quality index, which combines data from multiple water quality parameters to provide a single value, usually between 0 and 100, to indicate the overall quality of the water. Multiple water quality indices have been developed which use different water quality input data, providing alternative perspectives on water quality. The choice of which water quality parameters are included depends on local water quality concerns, intended audience and water use and overall cost.

Currently, EASYINDEX-Agua uses the Simplified Water Quality Index (ISQA; Orozco et al. 2005), which was chosen for its simplicity and wide application for many water quality data sets in environments similar to Arequipa. The ISQA only uses five water quality parameters - temperature, biological oxygen demand, total suspended solids, dissolved oxygen, and conductivity. These parameters are generally widely available, inexpensive to sample and sensitive to a wide variety of water quality issues. The benefit of the ISQA is that it can be calculated for many datasets, and provides a good indication that water quality problems might be present, since for example a high BOD value means there is a high likelihood of bacterial contamination, but it should be noted that ISQA does not provide a direct measure of parameters that impact human health, such as heavy metals or bacteria.

Water quality parameters

This section provides a brief explanation of the five water quality parameters used in the ISQA and why they are included in this index.

Temperature (TEMP)

Fish and other organisms all have a preferred temperature range, and as temperature falls above or below this range, the number of individuals decreases. Water temperature is also important for its influence on water chemistry; warmer water can hold less dissolved oxygen. Elevated water temperature might indicate that warmer wastewater is entering upstream from irrigation return flows, wastewater treatment plant or mining effluent.

Biological oxygen demand (BOD)

Biological oxygen demand indicates how much oxygen is needed by bacteria to break down organic matter in the water. A high BOD indicates a high amount of organic pollution in water, which may be an indication of contamination by sewage or other waste and could result in high bacterial contamination.

Total suspended solids (TSS)

Total suspended solids are a measure of the mass of particles suspended in water, which can come from erosion of land surfaces and be washed in from urban areas. These particles can interfere with drinking water treatment and

irrigation infrastructure and provide evidence that other contaminants that pose a health risk may be flushed directly into the river.

Dissolved oxygen (DO)

Dissolved oxygen is a measure of oxygen available in water for fish and other organisms. Low values can kill these organisms. Low dissolved oxygen results from decomposition of organic waste or algae by bacteria.

Conductivity (COND)

Conductivity is a measure of the ability of water to conduct electricity. It is related to the amount of dissolved salts including calcium, magnesium, potassium, bicarbonate, sulfate, chloride and nitrate that is present in water. Water with a lot of dissolved salts can be dangerous to crops, and high salt concentrations are often present in agricultural runoff, so other agro-chemicals could also be present in these waters.

Calculating the ISQA

The ISQA is calculated by combining individual indices calculated for each of the five water quality parameters.

These individual index values are represented as:

I_{TEMP} = Temperature index

I_{BOD} = Biological oxygen demand index

I_{TSS} = Total suspended solids index

I_{DO} = Dissolved oxygen index

I_{COND} = Conductivity index

Where

$TEMP_i$ = temperature value (in °C)

BOD_i = biological oxygen demand value (in mg/L)

TSS_i = total suspended solids value (in mg/L)

OD_i = dissolved oxygen value (in mg/L)

$COND_i$ = conductivity value (in $\mu S/cm$)

Each of the individual indexes is calculated as follows:

For temperature,

$$\text{if } TEMP_i > 20 \text{ }^\circ\text{C}, \quad I_{TEMP} = 1 - (TEMP_i - 20);$$

$$\text{if } TEMP_i \leq 20 \text{ }^\circ\text{C}, \quad I_{TEMP} = 1$$

For BOD,

$$\text{if } BOD_i \leq 5, \quad I_{DBO} = 30 - BOD_i;$$

$$\text{if } BOD_i > 5, \quad I_{DBO} = 21 - (0.35 * BOD_i)$$

For TSS,

$$\text{if } TSS_i \leq 100, \quad I_{TSS} = 25 - (0.15 * TSS_i);$$

$$\text{if } 100 > TSS_i \geq 250, \quad I_{TSS} = 17 - (0.07 * TSS_i);$$

$$\text{If } TSS_i > 250 \quad I_{TSS} = 0$$

For DO,

$$\text{If } DO_i \geq 10 \quad I_{DO} = 25;$$

$$\text{If } DO_i < 10 \quad I_{DO} = 2.5 * DO_i$$

For conductivity,

$$\text{If } COND_i > 4000, \quad I_{COND} = 0;$$

$$\text{If } COND_i \leq 4000, \quad I_{COND} = 15.4 * (3.6021 - \log (COND_i))$$

Each of these indexes are added together as follows to compute a single ISQA value between 0 and 100:

$$ISQA = I_{TEMP} * (I_{BOD} + I_{TSS} + I_{DO} + I_{COND})$$

The ISQA value between 0 and 100 can be interpreted using the table below. Index values are broken down into five categories from *Excellent* to *Poor*. *Excellent* indicates the best water quality that can be obtained using these parameters and *Poor* indicates the worst.

Table 1: Water quality categories for the ISQA index

ISQA	Water quality
91 – 100	Excellent
71 – 91	Good
51 – 70	Average
26 – 50	Fair
0 – 25	Poor

Development of the EASYINDEX-Agua calculator

The equations explained above have been plugged into the EASYINDEX-Agua calculator. When the user inputs water quality data for the five given parameters, a final ISQA value is calculated using the equations above.

Development of the EASYINDEX-Agua interactive map

The EASYINDEX-Agua interactive map was developed as a visualization tool for historical water quality data from the National Water Authority (ANA). This map includes three types of layers – monitoring locations, watersheds (or drainage areas), and rivers and streams.

Monitoring locations and water quality

The National Water Authority has released water quality monitoring reports in the region of Arequipa since 2011. More information about these reports is available in our Water Quality Data in Arequipa factsheet (Bowling et al. 2021). Values from sampling events in 2014 were included in the EASYINDEX-Agua map. These reports provide information about sample location, parameters sampled, and date of the sampling event. The reports were digitized and underwent a quality control process that included 5-10% random checks, scanning for zeros and blank data, and double-checking extreme outliers. Values recorded as below the detectable limit were converted to ½ of the detectable limit for analysis.

Location information from each sampling point from the ANA reports in the Ocoña, Majes-Camaná, and Vitor-Chili were imported into geographic information system (GIS) software as a layer. Each point was given a name by ANA during sampling, and these names are shown next to each point in the map. Processed water quality data were used to calculate ISQA values using the equation above.

Drainage areas and characteristics

The map also shows the contributing drainage area upstream of each sampling location. These drainage areas were created using GIS software and elevation data to define areas that flowed to a single location. In cases where there are several points along a stream or river, drainage areas shown on the map only include additional contributing areas since the previous sampling location. Drainage areas were calculated in square kilometers using GIS geometry functions.

All drainage areas include characteristics of that area like land use, erosion potential, population, and annual precipitation. Table 2 shows the source of each of these characteristics. These sources were downloaded as shapefiles or raster files. All files were converted to raster files and the percent of the drainage area with each specific characteristic was calculated, with the exception of population. The sum of total population within each drainage area was calculated.

Table 2: Data sources for drainage area characteristics in EASYINDEX-Agua Map

Layer	Sublayer	Type	Source	Link
Population	-	Total	The Humanitarian Data Exchange	https://data.humdata.org/dataset/worldpop-population-counts-for-peru
Precipitation	-	Percent area	Arequipa Climate Maps - Normals	doi:10.4231/JNBK-ZK34
Land use	Agricultural	Percent area	Estimated land cover properties for hydrologic modeling in Arequipa, Peru	doi:10.4231/GYN8-W684
	Urban			
	Bare			
	Forest			
	Herbaceous			
	Water surface			
	Wetlands			
Erosive land	-	Percent area	Estimated soil physical properties for hydrologic modeling in Arequipa, Peru	doi:10.4231/N5MX-9W30
Geology	Igneous intrusive	Percent area	Geology of the Arequipa Region – Ecologic and Economic Zoning. From the Regional Government of Arequipa.	
	Metamorphic			
	Sedimentary			
	Volcanic			
Mining concessions	-	Percent area	Global Forest Watch	https://hub.arcgis.com/datasets/38d73f7882724318baf2be8bc2cd260a_8/explore?location=-17.168594%2C-70.889174%2C9.35

Rivers and streams

The map includes a layer of rivers and streams including names where available. Most water quality monitoring locations can be found along these lines, with the exception of a few locations where canals or effluent from point sources were sampled.

USING THE TOOL

Using the calculator

The EASYINDEX-Agua calculator can be accessed on-line at:

<https://www.agry.purdue.edu/hydrology/projects/nexus-swm/en/Tools/WaterQualityCalculator.php>.

Follow these steps:

1. Have your sampling data for temperature, BOD, TSS, DO, and conductivity from the desired location ready.
2. Ensure that the units for your data match the units indicated in the white boxes for each water quality parameter in the “Data Entry” column.
3. Enter your water quality data into the correct column, as shown in Figure 1.

Parameter	Data Entry	Parameter Range
Temperature (°C)	Temperature (°C)	0°C 20°C 40°C
BOD (mg/L)	Biological Oxygen Demand (mg/L)	0mg/L 12mg/L
TSS (mg/L)	Total Suspended Sediment (mg/L)	0mg/L 250mg/L
DO (mg/L)	Dissolved Oxygen (mg/L)	0mg/L 10mg/L
Conductivity (µS/cm)	Conductivity (µS/cm)	1µS 4000µS

Simple Water Quality Index:

Excellent (91-100)
Good (71-90)
Average (51-70)
Fair (26-50)
Poor (0-25)

Reset Submit

Figure 1. The data entry screen for EASYINDEX-Agua Calculator

4. Click submit.
5. The ISQA value for your data will appear in the big box in the middle of the calculator (Figure 2). The box will also change color. You can use the water quality graph on the right side of the calculator to determine water quality level for the index value calculated. The color in the output box will also match the color of the water quality category.
6. To enter new data or reset the calculator, hit the Reset button on the bottom left of the calculator.

To learn more about each of the five water quality parameters, scroll down past the calculator on the page, or click **“Click here to learn more about the ISQA and the five water quality parameters used to compute it”** on the top of the page.

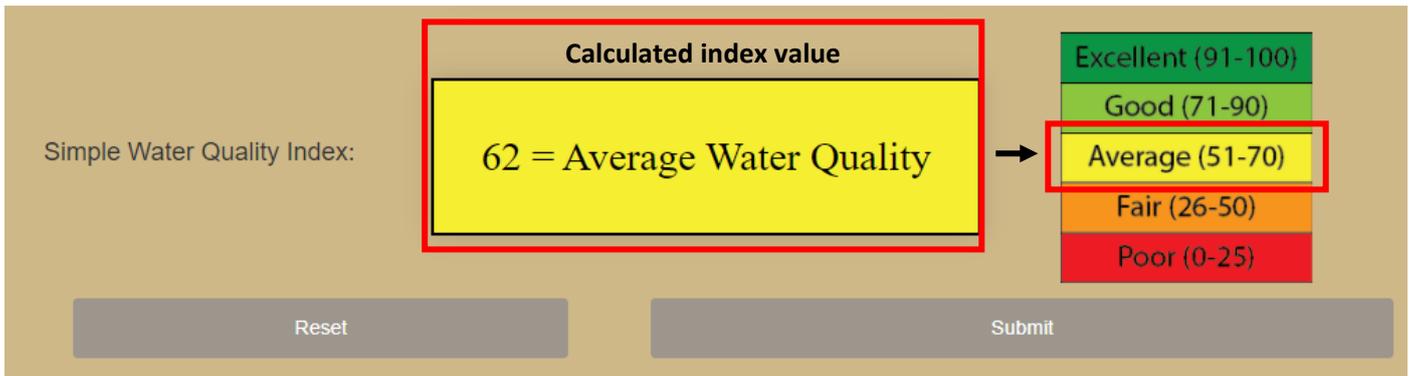


Figure 2. The results screen for EASYINDEX-Agua Calculator

Using the map

Introduction to the EASYINDEX-Agua Map

The EASYINDEX-Agua map can be accessed on-line at: <https://arcg.is/GL5n9>. It allows the user to explore the four Arequipa River basins, and it shows indices for the aggregated water quality of each available monitoring point (Figure 3).

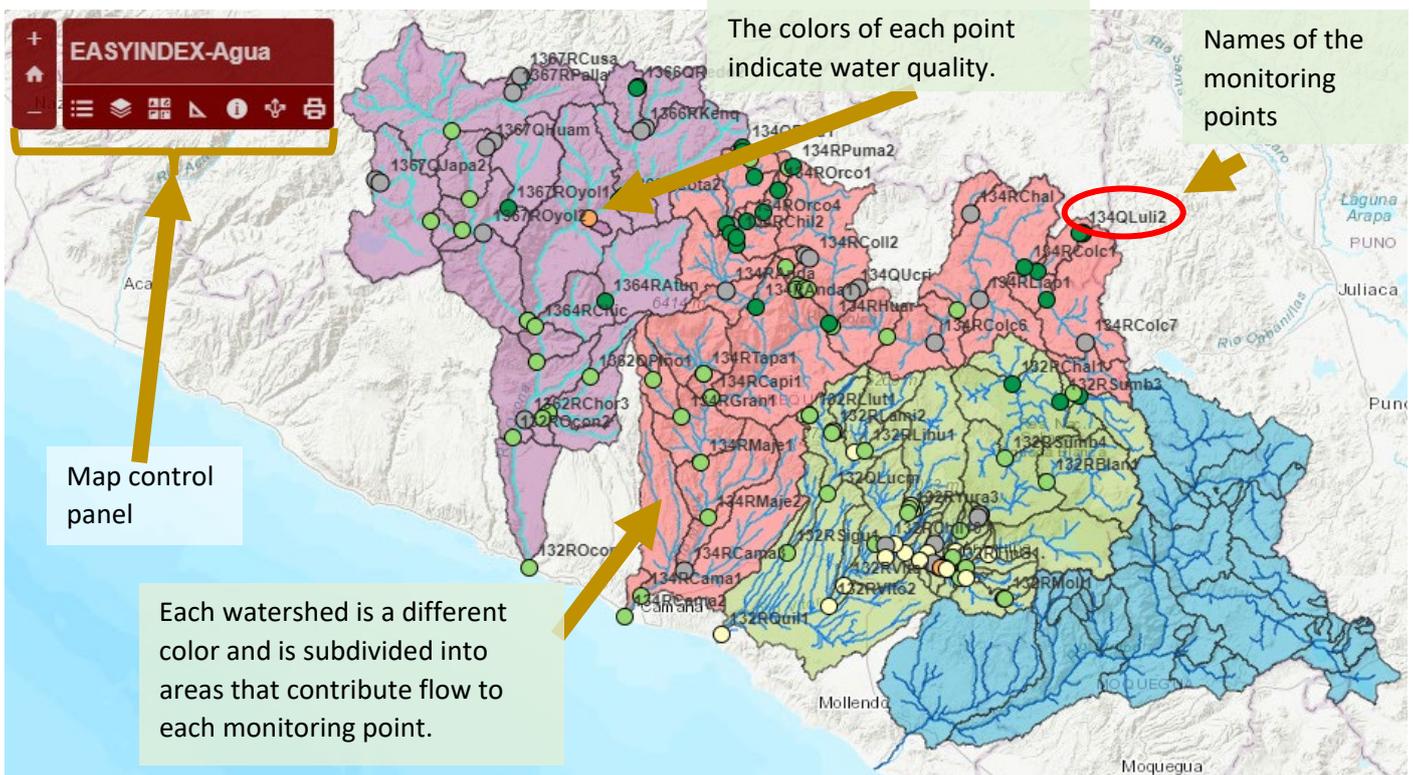


Figure 3. The primary map screen for EASYINDEX-Agua Map

The map's control panel

The control panel is located in the upper left corner of the map, and details for the function of each button can be seen in Figure 4.

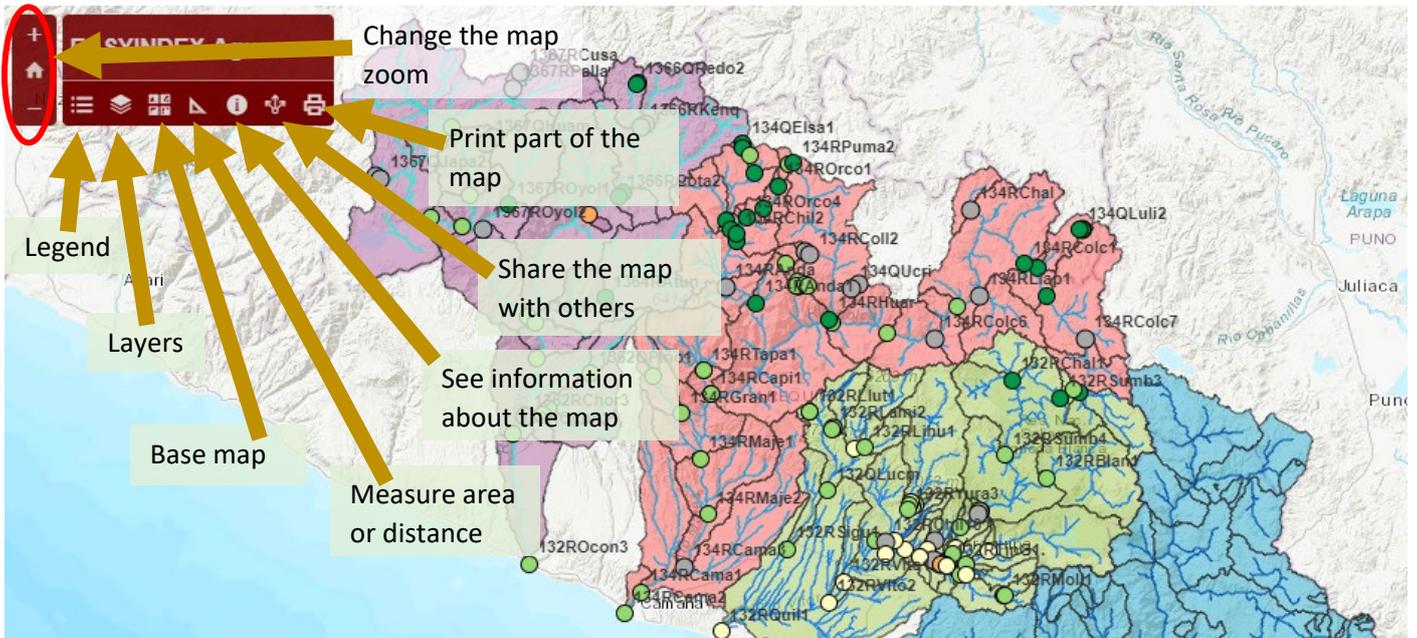


Figure 4. Explanation of the map control panel

Legend and layer panels

When you click on the buttons in the control panel, a box appears on the right side of the screen with the option that you selected. Options for Legend and Layers are shown in Figure 5.

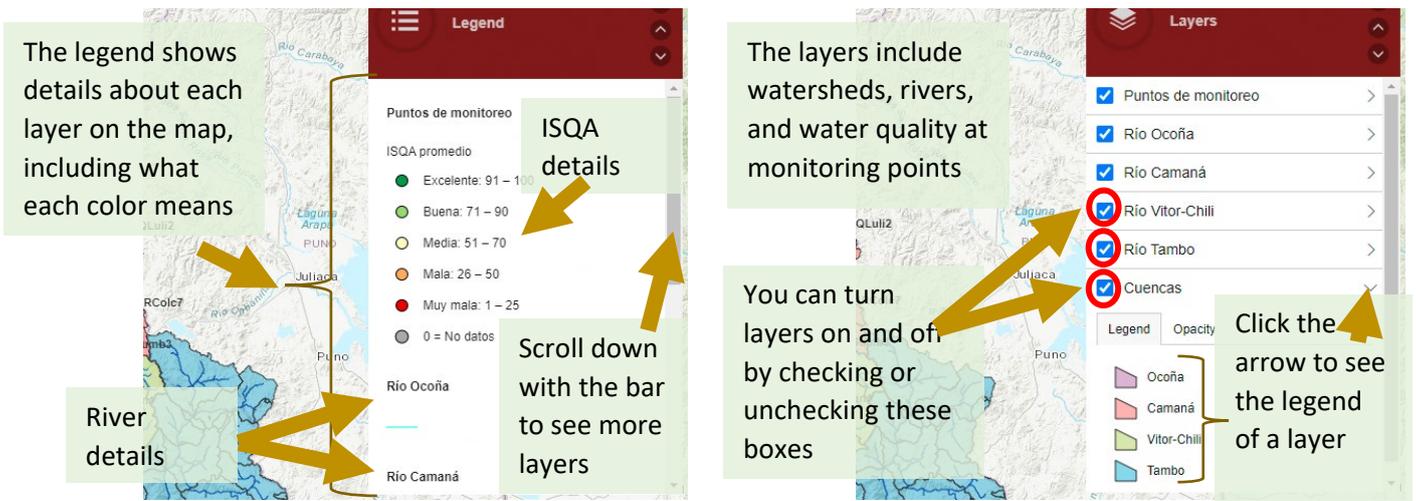


Figure 5. Explanation of a) the map control panel legend option and b) the map control panel layers option

Explore information on the map

In addition to turning different layers on and off, there are three features that can be clicked for additional details, including: ANA monitoring points, watershed contributing areas (sub-basins), and river reaches. The sub-basin boundary will turn cyan when selected and a box will appear showing the contributing area, the total population, the mean annual precipitation, land use and geology (Figure 6). In addition, the river reach name will appear if you select a stream segment. In addition, clicking on individual sampling points will provide details on all sampling dates for that location, and the individual and average ISQA values (Figure 7).



Figure 6. Example of sub-basin characteristics that appear when selecting the sub-basin boundary

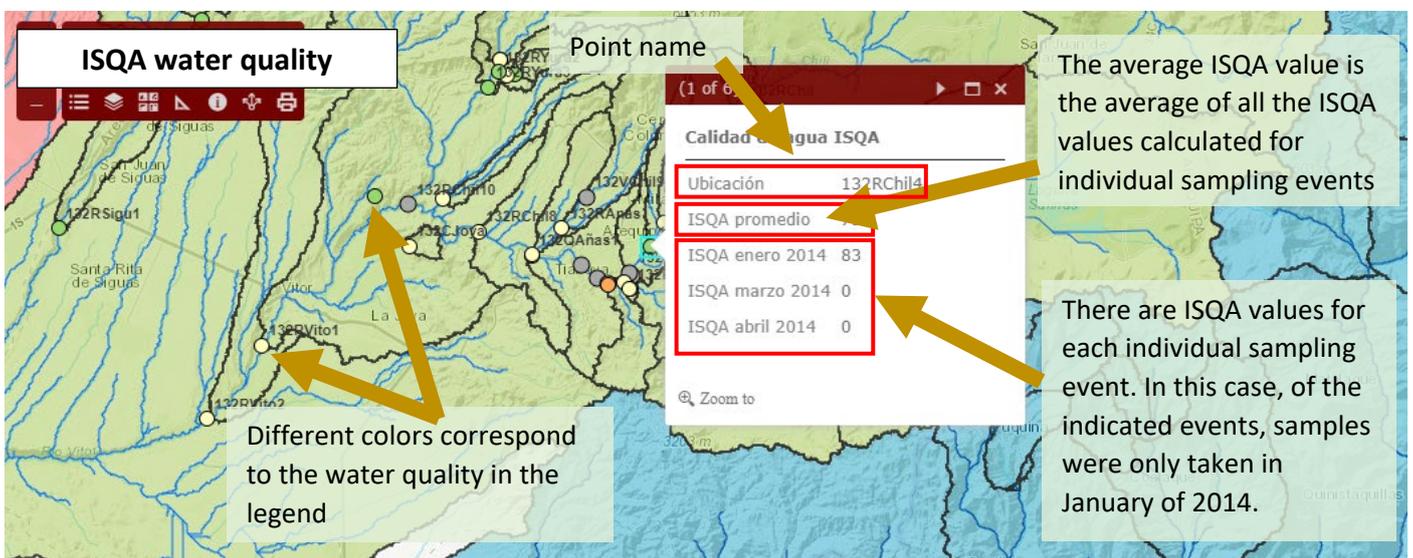


Figure 7. Example of monitoring location details and ISQA values

APPLICATIONS

Example application of the EASYINDEX-Agua Calculator

A rural community is concerned with water quality in their area. They have limited funding but would like to do some sampling to better understand their water quality. They know there are issues with wastewater discharge, so the community chooses five locations to sample water quality. With the help of the Junta de Usuarios, they decide to take samples of the five parameters used in the ISQA. They send the samples to be analyzed in an accredited lab, and they receive the results shown in Table 3.

Table 3. Theoretical sample results for five locations along a community water source

Point	Temperature °C	BOD mg/L	TSS mg/L	DO mg/L	Conductivity µS/cm
A	18	1	3	10	86
B	7	94	103	1	1376

C	14	1	137.5	7.05	92.2
D	19.5	25.5	115	7	561
E	24.7	2.8	57.2	8.27	3900

The community leaders are not familiar with how to understand water quality based on numbers. They use the EASYINDEX-Agua calculator to help them interpret the data (Figure 8).

The figure shows a digital interface for calculating the Simple Water Quality Index (ISQA). It is organized into three main columns: 'Parameter', 'Data Entry', and 'Parameter Range'.
 - **Parameter Column:** Lists five water quality parameters with corresponding icons: Temperature (°C), BOD (mg/L), TSS (mg/L), DO (mg/L), and Conductivity (µS/cm).
 - **Data Entry Column:** Contains input fields for each parameter. The values entered are: Temperature (18), BOD (1), TSS (3), DO (Dissolved Oxygen), and Conductivity (Conductivity).
 - **Parameter Range Column:** Shows color-coded arrows representing the acceptable range for each parameter: Temperature (0°C to 40°C), BOD (0mg/L to 12mg/L), TSS (0mg/L to 250mg/L), DO (0mg/L to 10mg/L), and Conductivity (1µS to 4000µS).
 - **Bottom Section:** A 'Simple Water Quality Index' box is currently empty. Below it are 'Reset' and 'Submit' buttons.

Figure 8. Example calculation of ISQA values from sample data

The results of their calculations are given in Table 4. The community leaders can use this information to choose which water would be best to use for irrigation or other activities, as well as decide on priority areas to focus on to identify potential sources of pollution into streams. Note that the ISQA does not provide a direct measure of drinking water quality, and more substantial analysis is necessary before the development of a new drinking water source.

Table 4. ISQA values for the data presented in Table 3

Point	ISQA	Water quality category
A	100	Excellent
B	19	Poor
C	79	Good
D	40	Fair
E	60	Average

Example application of the EASYINDEX-Agua Map

The same community from the previous example would like to compare their water quality to in other areas in the Arequipa Region. They go to the EASYIDEX-Agua map tool (<https://arcg.is/GL5n9>).

They see that most areas on the map have a good or excellent water quality rating based on the ISQA (Figure 9).

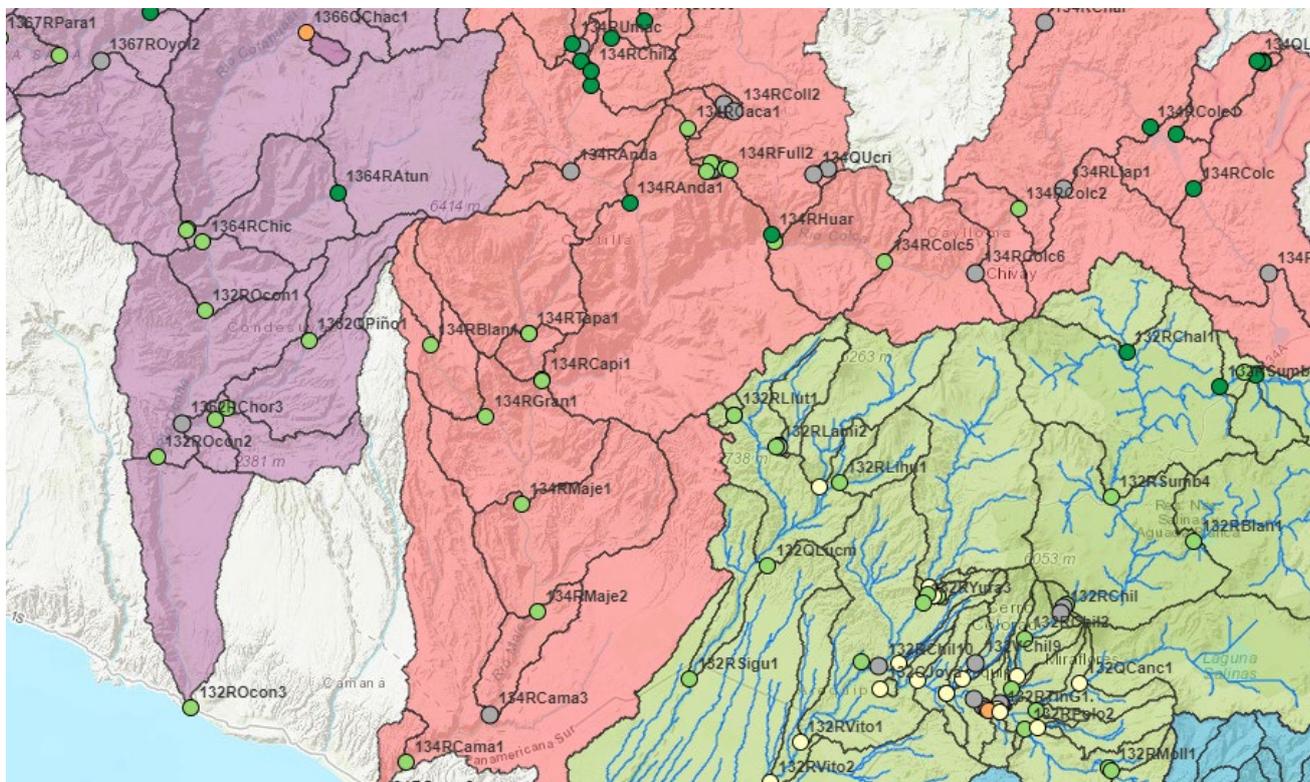


Figure 9. ISQA values for a portion of the Quilca-Vitor-Chil basin

They find one point named 1364RAtun, near the Chichas River in the Ocoña watershed, where the water quality index was shown as excellent on the map (Figure 10).



Figure 10. ISQA values for point 132QCanc in the Quilca-Vitor-Chil basin

When they click on this point, they see that the average water quality index at this point was Excellent, but there was only one event in sampled during the period of available data in April 2014, shown in Figure 11. This means that the average value shown is the same as the ISQA from that month, but other sites might have different ISQA values

over time. They can also look at characteristics of the drainage area that drains to this point. It seems to be a relatively small area, with a small population of people, and a relatively high amount of rainfall (Figure 12, left).

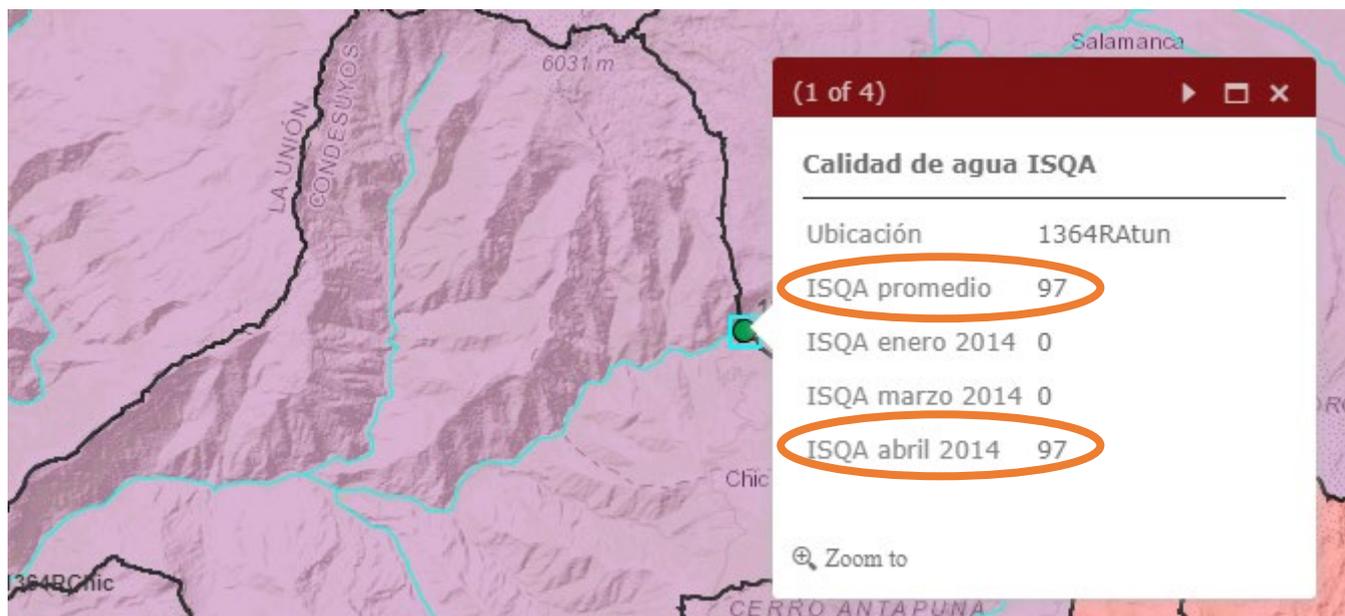


Figure 11. ISQA values for point 1364RAtun in the Ocoña basin in January 2014

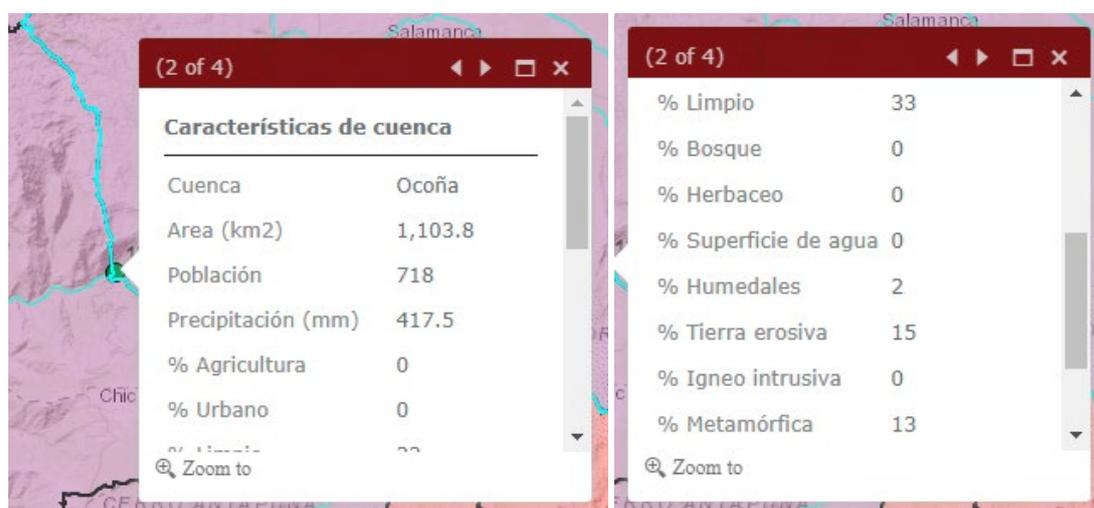


Figure 12. Watershed characteristics for point 1364RAtun in the Ocoña basin

Scrolling down in this pop-up box (Figure 12, right), they can also see the land use of this watershed and the erosion potential. It looks like 33% of this area is bare soil and 15% is highly erosive. This small percentage of erosive soil, combined with the small population and lack of agriculture help explain why the water quality is so good in this area.

FOR MORE INFORMATION

This tool was part of the Sustainable Water Management project of the Arequipa Nexus Institute. To see more of our tools and learn more about the SWM team, please visit our website at <https://www.agry.purdue.edu/hydrology/projects/nexus-swm/es/index.html>.

Together with this manual, there are three more sources (formats) of information about how to use the tool: 1) an introduction video to the tool, 2) a tool quick start guide document, and 3) a factsheet on water quality monitoring in Arequipa.

ABOUT THE TEAM

Development team

This project team was composed of several members, all with an interest in interpreting water quality data to make it accessible to the general public of Arequipa, Peru.

Katy Mazer is coordinator of the Sustainable Water Management team of The Nexus Institute at Purdue University. She engages with stakeholder groups in Arequipa, Peru to coproduce water management decision-making tools.

Edwin Bocardo is a principal professor in the Department of Biological Sciences and a graduate Environmental Science professor at the Universidad Nacional de San Agustín de Arequipa. He also works as an environmental consultant for several companies and a natural resource management specialist.

Laura Bowling is a professor of hydrology in the Department of Agronomy at Purdue University. Her research investigates the water resources impact of environmental change across multiple scales, climate regimes and ecosystems and communicates these findings to stakeholders.

Keith Cherkauer is a Professor of Agricultural and Biological Engineering at Purdue University. He works to facilitate the integration of field-based observations, remote sensing products and hydrology models to address questions and concerns related to environmental change and to further understanding of land-atmosphere interactions and the hydrologic cycle.

Georgia Scalfano was a student in the Natural Resources and Environmental Science major at Purdue. She provided assistance in digitizing data, providing quality control, and development of the tool. She has recently graduated and started working at an engineering consulting firm.

Shirley Yuxin Shi is a student in the Natural Resources and Environmental Science major at Purdue. She provided assistance in digitizing data, providing quality control, and development of the tool.

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