THE SUSTAINABLE WATER MANAGEMENT TEAM

OF THE AREQUIPA NEXUS INSTITUTE

Presents:

CultiVista

User's Manual

UNSA
UNIVERSIDAD NACIONAL DE SAN AGUSTÍN DE AREQUIPA

PURDUE UNIVERSITY
Discovery Park

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INTRODUCTION TO TOOL

In the water scarce Department of Arequipa, in Peru, complex, highly managed water systems are used to bring the water from the semiarid Andean mountains to the lower desert area, where most of the demand is located. These water systems need to balance the needs of the population of the second biggest city of Peru, Arequipa, hydropower generation, mining activities, and irrigated agriculture. Agricultural water usage represents the biggest share of the consumptive water use and measuring and understanding its variations can help water managers to make more informed decisions.

The CultiVista Web tool uses state of the art remote sensing techniques to map and quantify the main crops in the region and estimate their water demands in quasi real time. Currently, the tool provides monthly crop and water demand maps and information from September 2019 to February 2020 for the city of Arequipa and its surrounding agriculture. The tool is being developed and tested in the city of Arequipa, with planned expansion to other regions inside the department. The development of this tool represents an important step towards estimating crop area and water use at the departmental level and the information derived from it can be used in many applications such as:

- Understanding the demand for water in each region and season, depending on the crops that are planted;
- Supporting agricultural planning;
- Forecasting agricultural production; and
- Studying the effect of urbanization on the change in the area destined for agriculture.

TOOL DEVELOPMENT

The CultiVista tool uses supervised image classification methods, together with ground reference data and high-resolution satellite imagery, to identify the main crops growing in the region each month. Then, it uses local weather data and the crop growth stage to calculate water demand.

Ground reference data was collected, approximately, at the first week of every month from September 2019 to February 2020. These were collected by agronomists who recorded spatial location, crop type, crop growth stage, plant density, irrigation type, and other data. The high spatial (3.0 m) and temporal (daily return periods) resolution PlanetScope satellite images, supplied by Planet Labs inc., were used in this project. The images used for analysis were chosen to be close in time to the ground reference data collection dates.

The classification algorithms consist of many steps as follows:

- To reduce computational demand and avoid mapping of non-agricultural land (gardens, soccer fields, etc…) as agriculture, a non-farm masking map was developed using supervised classification of PlanetScope images, with manual corrections. The manual correction was made using Google Satellite images as reference, which helped identify crop field borders as reference for fine correction of agricultural polygons.
- Following classification using the Maximum Likelihood method a series of correction steps are applied to guarantee spatial and temporal consistency between the monthly maps, thus improving mapping accuracies.
- The crop growth stage is estimated for every pixel based on the growth stage data sampled during the field work.

The water demands of the crops are obtained using the estimates of the growth stage combined with the water demand by growth stage of each crop obtained from the CropWat Program developed by the United Nations Food and Agricultural Organization (FAO). The climatic data used in the simulations were obtained from the National Service of Meteorology and Hydrology of Peru (SENAMHI).

USING THE TOOL

CultiVista can be accessed on-line at: https://www.agry.purdue.edu/hydrology/projects/nexus-swm/es/instrumentos_web.html

Available data

The initial map tab allows users to zoom in and click on a location of interest. At this moment, data on crop growth and water demand are only available for the city of Arequipa. We are in the process of developing plans to expand this tool for use in other districts!

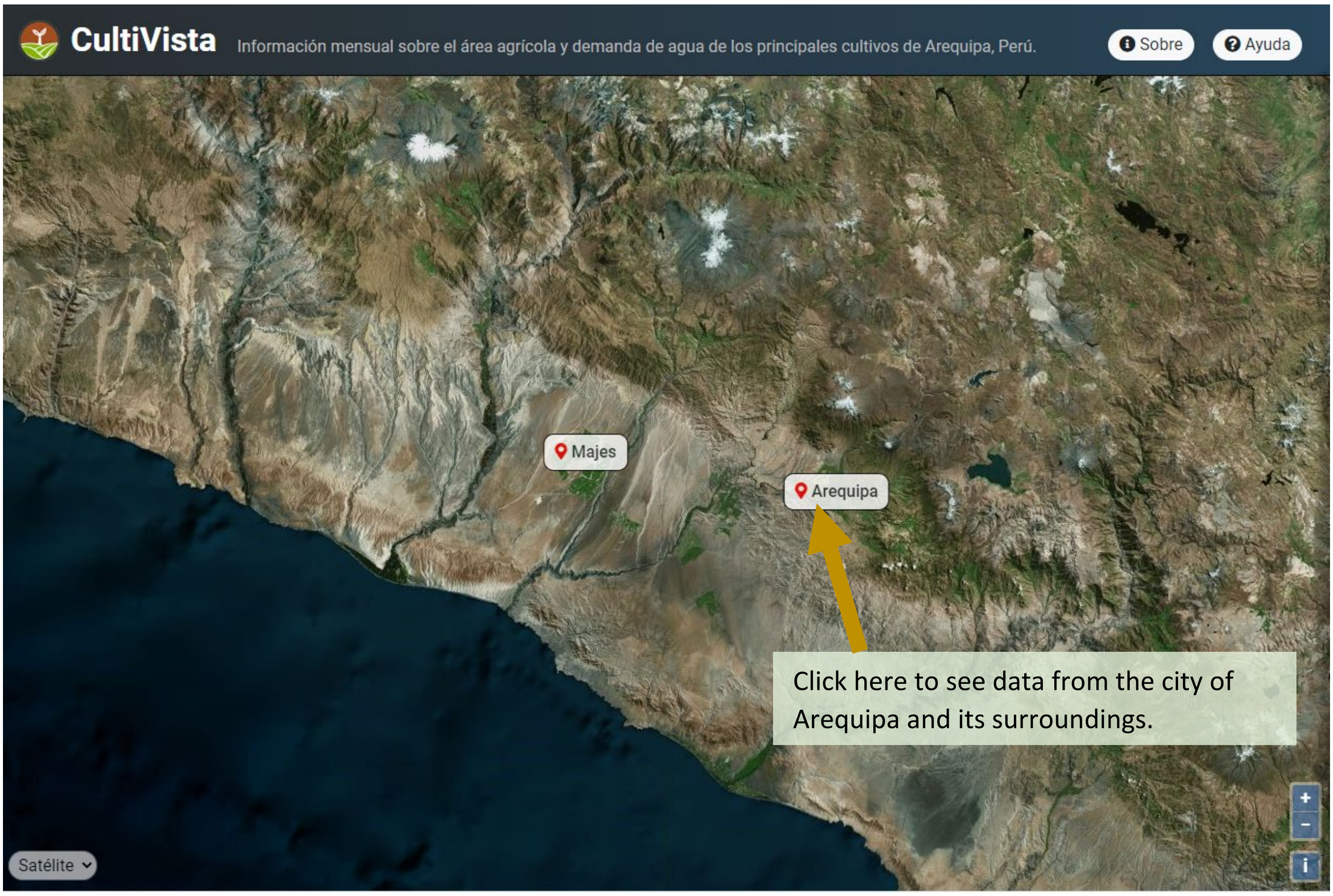


Figure 1. Opening screen of CultiVista where users can select a point of interest.

Spatial distribution of data

Once the user selects Arequipa, they are taken to the default results for the entire city (Figure 2). The map on the left identifies different crops by colors, while the table on the right provides summary statistics for the region. Los datos se pueden visualizar para toda la ciudad de Arequipa o por sus distritos. Click on the slider bar in the upper left to show the district boundaries, and then click on the district of interest to see statistics for just this district. One can also change the district or month of interest using the drop down menus in the upper right (Figure 2).

Data by Month

Whether summarized for one district or the entire city, en la herramienta se presentan tres tipos de datos: área e porcentaje de área de cultivo y demanda de agua mensual. The data table shown in Figure 3 contains the name of each crop, the area of the district currently growing each crop (in hectares), the percentage of the area growing each crop, and the water needed to grow that crop per month (1000 m^3/month). Please note that this is the actual amount of water that the crop will use under typical weather conditions for this growth stage, but does not reflect losses within the irrigation distribution system or during application of irrigation.

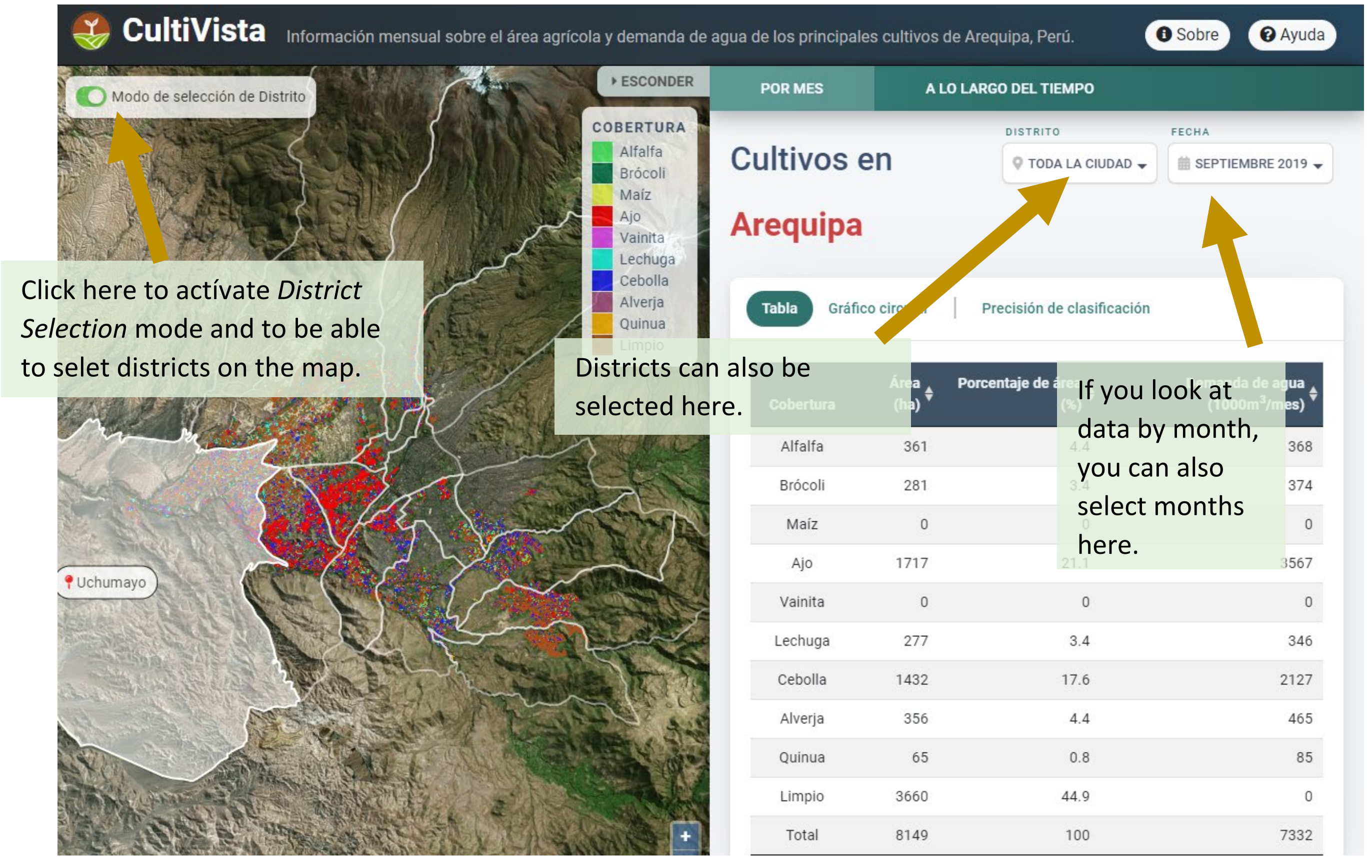


Figure 2. The default data screen, showing how to select individual districts or months for analysis.

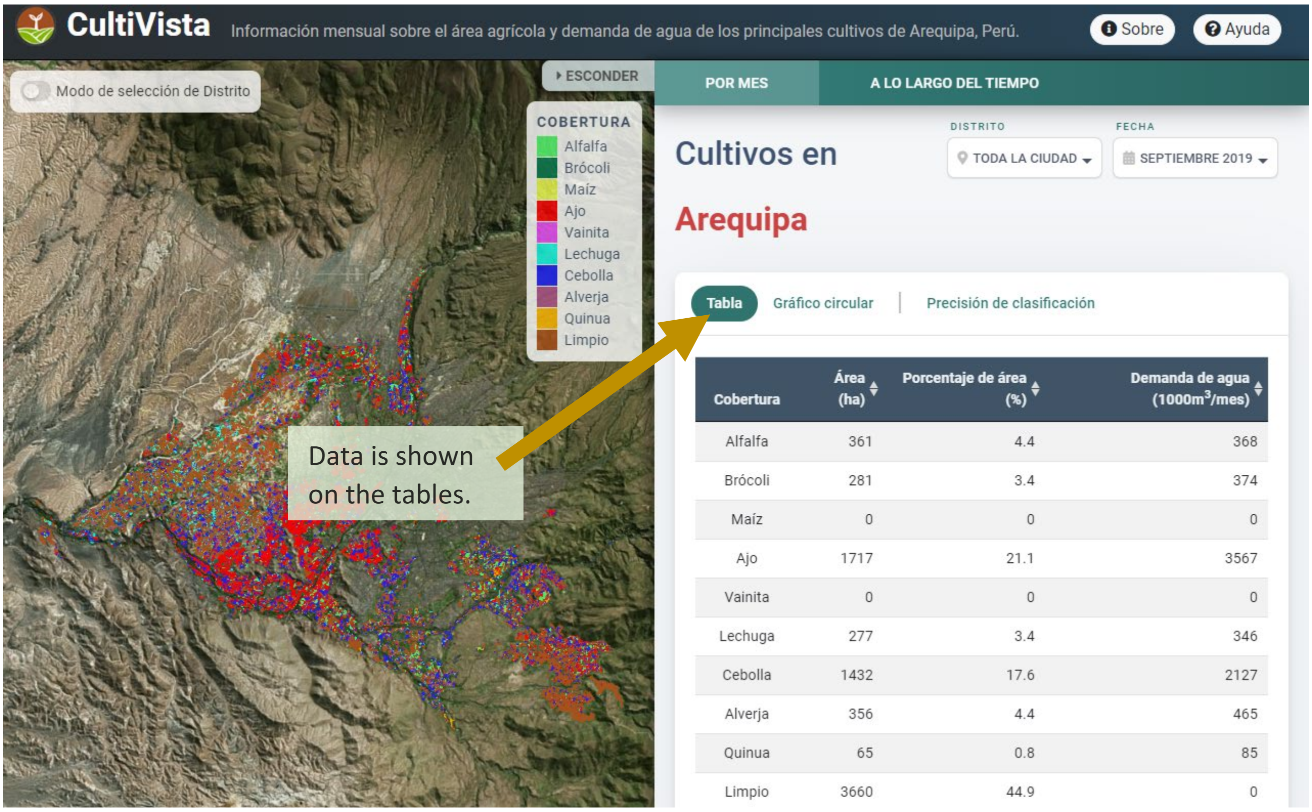


Figure 3. Data tabs: selecting the first tab shows the data in a table.

The data graph shown in Figure 4 shows the proportion of the total agricultural area in the district (or city) growing each crop, as well as the portion of total water demand that is needed by each crop. For example, in Figure 4, garlic is being grown in about 25% of the area, but requires about 50% of the water.

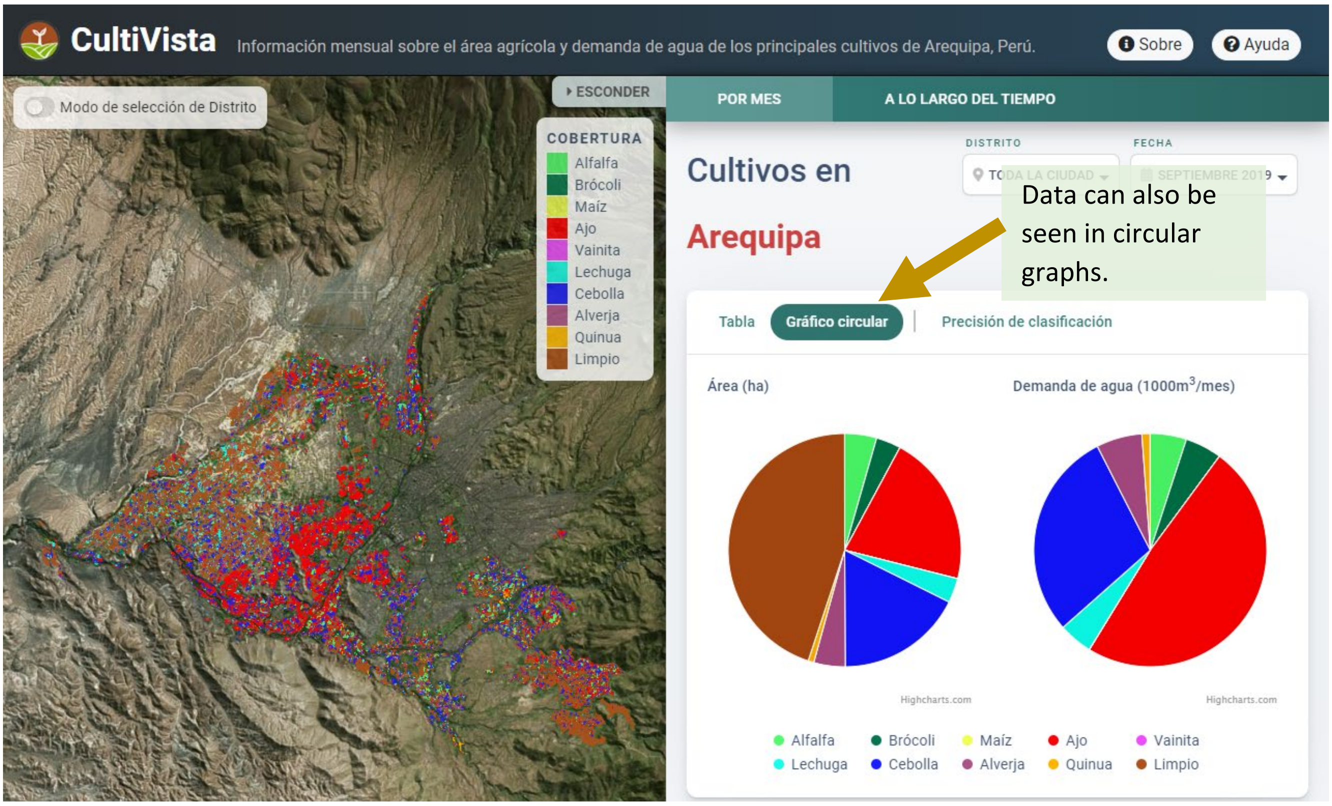


Figure 4. Data tabs: selecting the second tab shows the data in a circular graph.

Precisión de clasificación

The information on which crop is growing where comes from classification of satellite images, so there is always uncertainty in the accuracy of the classification. The accuracy will be different each month, depending on the weather conditions, what crops are present and how mature they are. La herramienta presenta la precisión de la clasificación promedio y de cada cultivo para cada mes, by selecting the third tab, shown in Figure 5.

Datos a lo largo del tiempo

Finally, instead of viewing the data for a single month, the data can be viewed for the most recent six months that have been classified by selecting the green bar at the top of the screen (Figure 6).

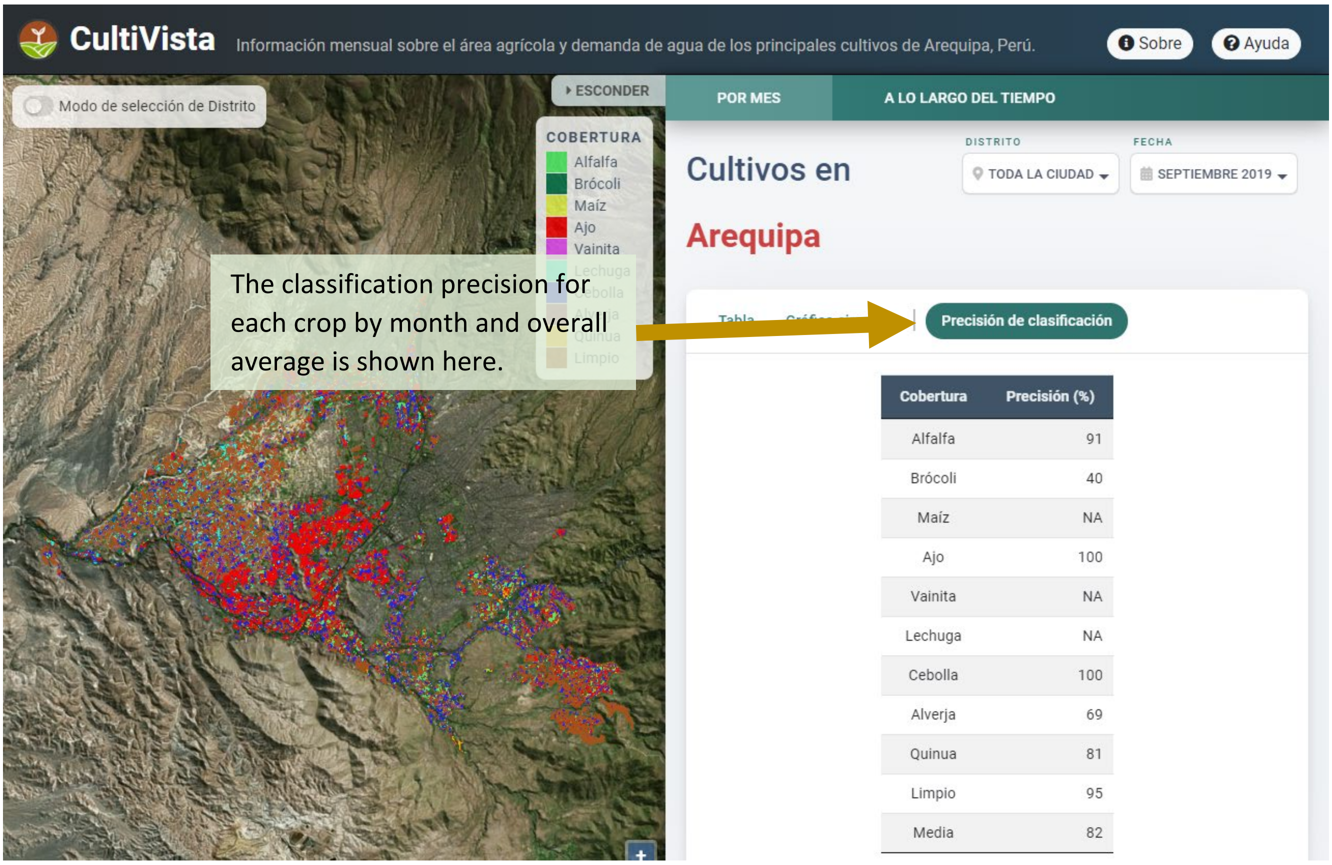


Figure 5. Data tabs: selecting the third tab shows the classification accuracy.

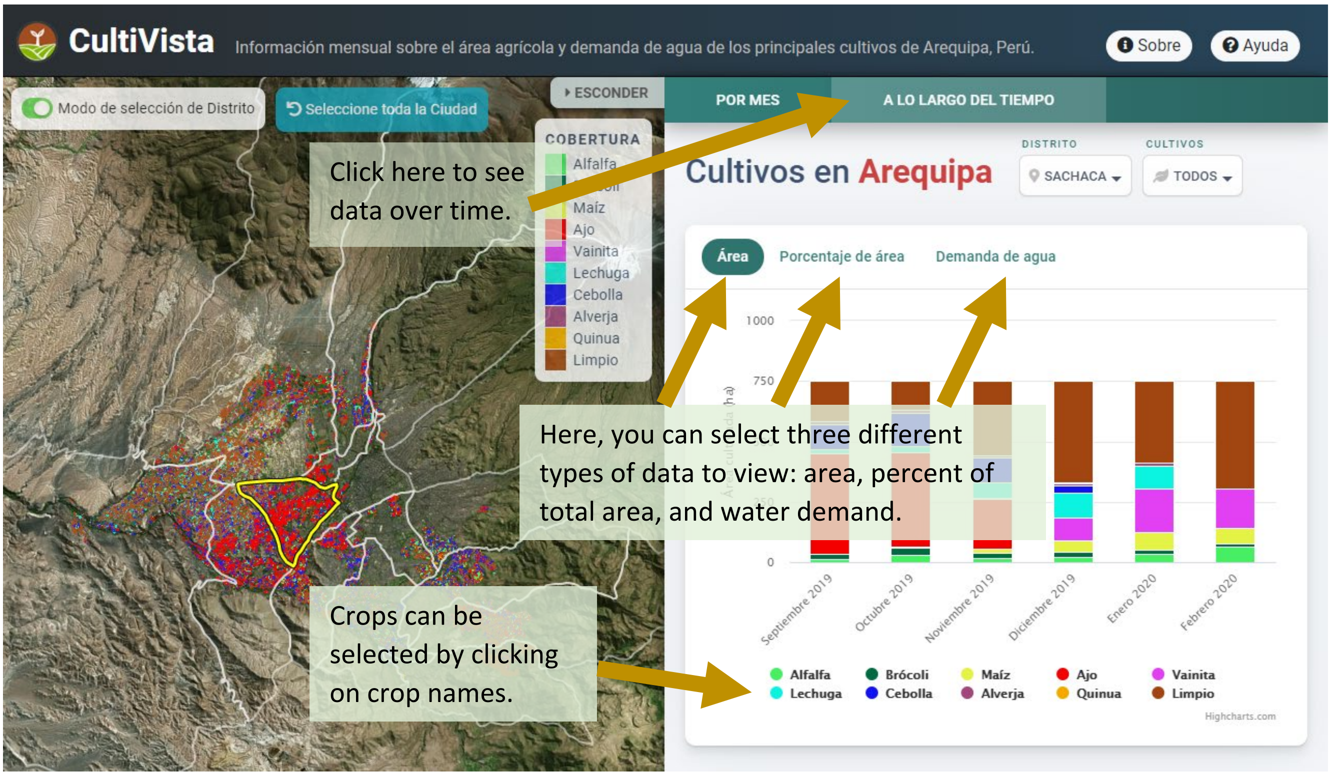


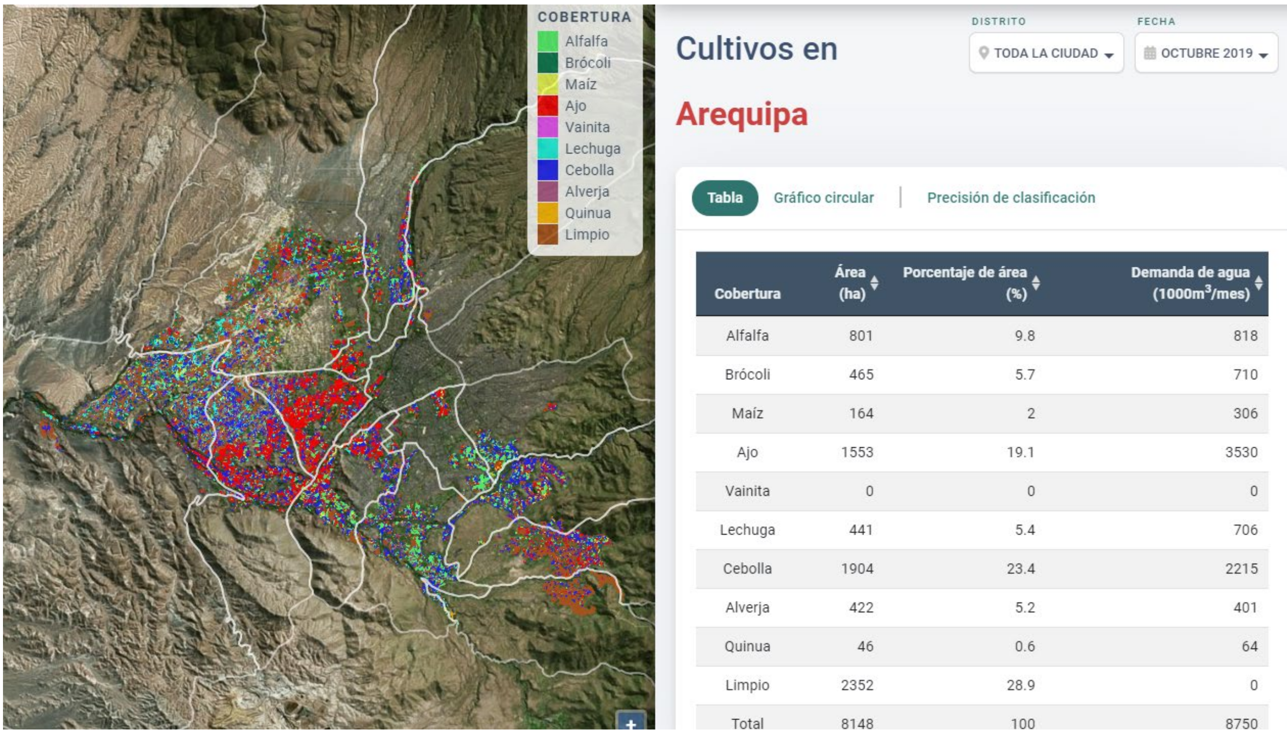
Figure 6. Time series data: each of the lower buttons will show a graph for a different variable, crop area, crop percentage and crop water demand.

APPLICATIONS

This section will present some application examples to demonstrate how CultiVista can be used to support crop and water management decisions by learning about local spatial and temporal crop patterns and crop water demand. For a better learning experience, open the CultiVista tool in your browser and try to replicate what is demonstrated here.

Spatial distribution of crops

Figure 7 shows the distribution of crops being grown in all of Arequipa in October 2019. Garlic and onions together occupied more than 40% of Arequipa's agricultural area. Garlic crops were concentrated in the Chile valley, especially in Yanahuara, Sachaca, and Tibaya Districts, while other crops, including onion, were more evenly distributed in the remaining districts. The district of Sachaca had 51.8 % of its agricultural area occupied by garlic and 18.7 % of agricultural area occupied by onions. A farmer in Sachaca making planting decisions for November may want to avoid garlic and onions, because the market is soon to be flooded with these crops. A water manager considering how to allocate water to different irrigation districts in November may see that garlic is currently requiring the most water, so Yanahuara, Sachaca, and Tibaya Districts may requore a greater water allocation in this month.



Cobertura	Área (ha)	Porcentaje de área (%)	Demanda de agua (1000m³/mes)
Alfalfa	801	9.8	818
Brócoli	465	5.7	710
Maíz	164	2	306
Ajo	1553	19.1	3530
Vainita	0	0	0
Lechuga	441	5.4	706
Cebolla	1904	23.4	2215
Alverja	422	5.2	401
Quinua	46	0.6	64
Limpio	2352	28.9	0
Total	8148	100	8750

Figure 7: Crop distribution for all of Arequipa in October 2019

Temporal distribution of crops

Although Arequipa presents a very stable climate throughout the year, there is still a seasonality in the distribution of crops by month. In Figure 9, we can see that garlic and onion crop seasons ended in November and December, respectively. These crops were mostly replaced by corn (starting in October) and vainita (starting in November). Other crops are planted all year round and so present somewhat constant areas throughout the year as is the case of Broccoli, Lechuga, Alverja, and Alfalfa. Among other things, these kinds of information can help stakeholders better understanding cropping cycles and their effect on market supply and demand.

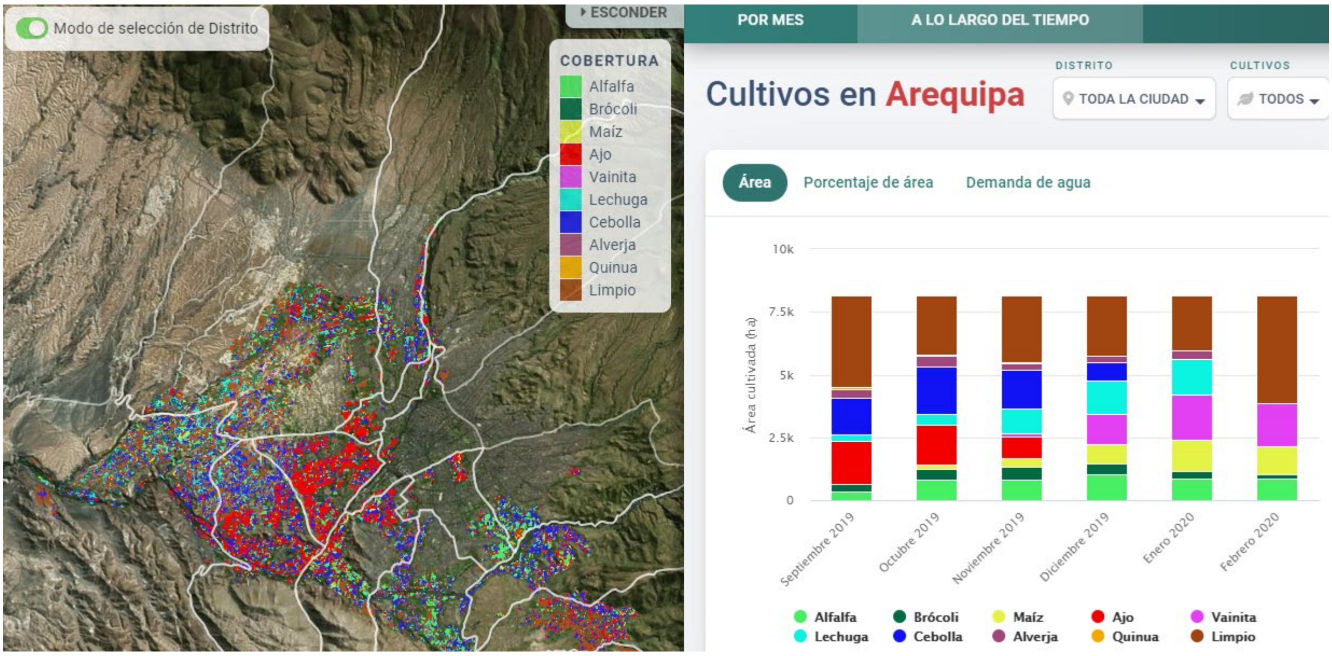
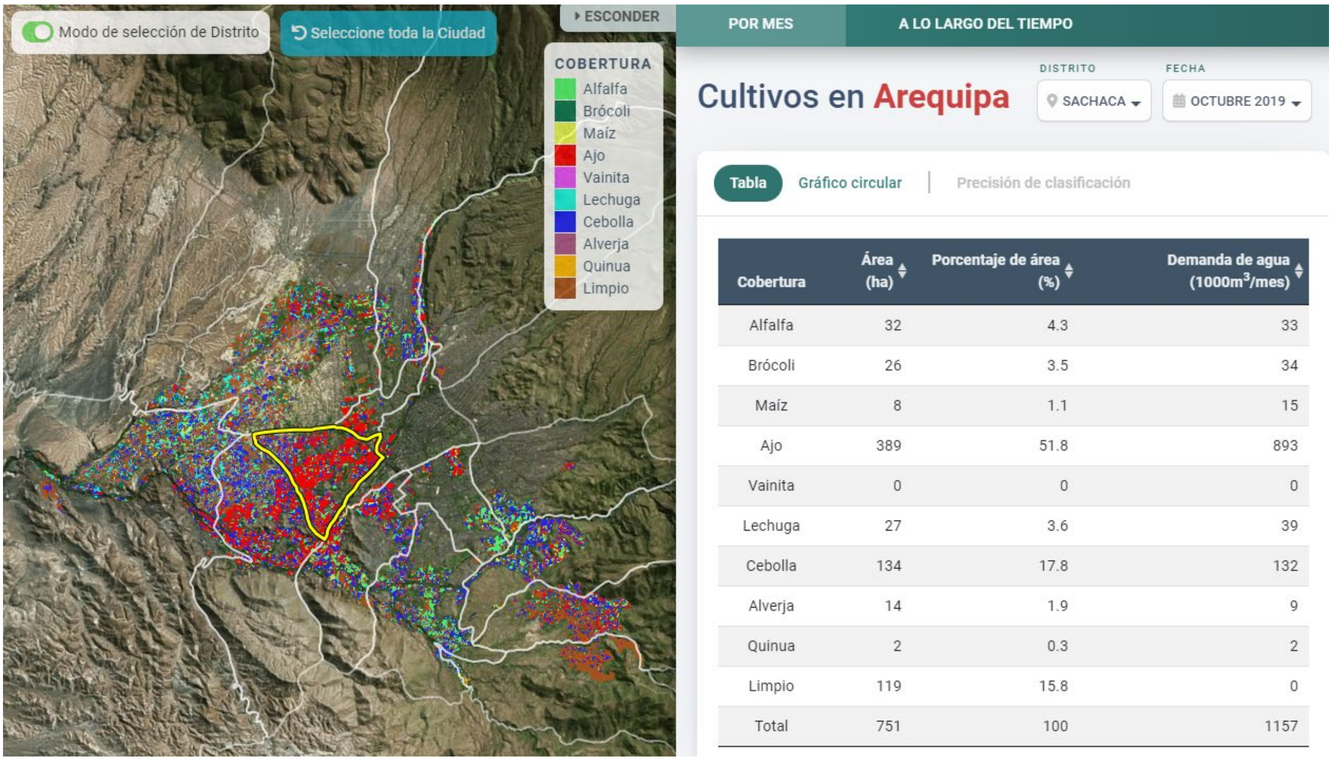


Figure 8: Distribution of crops in Arequipa by month for September 2019 – February 2020.

Water demand vs water supply

Understanding water usage can be very useful for water managers. Figure 9 shows a rough estimate of the water needed by crops in the district Sachaca in the month of October 2019 . Table 1 illustrates a comparison with the average flow rate of the Chile River in the same month.



Cobertura	Área (ha)	Porcentaje de área (%)	Demanda de agua ($1000m^3$/mes)
Alfalfa	32	4.3	33
Brócoli	26	3.5	34
Maíz	8	1.1	15
Ajo	389	51.8	893
Vainita	0	0	0
Lechuga	27	3.6	39
Cebolla	134	17.8	132
Alverja	14	1.9	9
Quinua	2	0.3	2
Limpio	119	15.8	0
Total	751	100	1157

Figure 9: Crop distribution for Sachaca District in October 2019

Table 1: Evaluation of agricultural water demand in Sachacha District

Estimated crop water demand in Sachaca (WD) =	1157000 m^3/month
Gravity irrigation efficiency (IE) =	40%
Water use = WD/IE =	1157000 m^3/month /0.5 = 2314000 m^3/month = 0.07 m^3/s
Water flow in the Chili river at Charcani in October=	13 m^3/s
Water used in Sachaca in October relative to the flow at Charcani =	= 0.07 m^3/s /13 m^3/s = 0.0052 = 0.52%

Based on these calculations, Irrigated agriculture in the district of Sachaca used **0.52 %** of the Chili River's water in October 2019. Note that this is a didactic example that makes use of some assumptions like the 50% irrigation efficiency, and it also does not consider several factors like water loss in the distribution system. However, it still demonstrates how the tool can provide data to help water managers to better understand water usage in the region and improve their decision-making process.

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) the guided tour imbedded in the tool web site. Below we demonstrate most important tool features.

ABOUT THE TEAM

Development team

Alec Watkins is a graduate student of Agricultural and Biological Engineering at Purdue University. His work is focused on the mapping of agriculture in the Arequipa department of Peru using remote sensing and pattern recognition

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Jose Pinto is a professor in the Department of Agronomy at the Universidad Nacional de San Agustín de Arequipa. He conducts agricultural research and connects with interested associations to improve natural resource management.

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