How climate change affects water resources in Costa Rica

By Laura Gil

Scientists prepare samples of spring water for the analysis of noble gases in Heredia, Costa Rica.
(Photo: L. Castro/ESPH)

"While we have always had regulations in place to protect our water, the difference is that now we can be more precise, more efficient."

— Ricardo Sánchez-Murillo, Coordinator, Stable Isotopes Research Group, National University of Costa Rica, Heredia

Sitting on the thin stretch of land that separates the Pacific from the Caribbean, Costa Rica has in recent years experienced above-average ocean temperatures and the first hurricane ever recorded. With the help of the IAEA, its scientists are now turning to isotopic techniques to monitor these extreme weather events and protect the country's water and population, in a region that has been identified as an area that could be particularly affected by climate change.

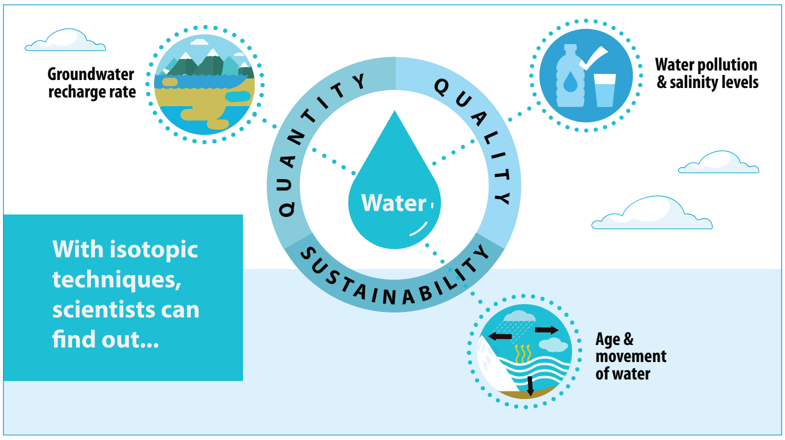
"Water has memory," said Ricardo Sánchez-Murillo, coordinator of the Stable Isotopes Research Group at the National University of Costa Rica in Heredia. "With isotopes, we can record this memory and use the current information we gather in precipitation to understand past climate events and improve Costa Rica's planning to face future meteorological events, including hurricanes." In 2015, after a severe drought period, Central America saw one of the strongest El Niño Southern Oscillations — a warming of the ocean surface that has been happening in the region for centuries. One year later, Costa Rica faced the first hurricane recorded to date in the southernmost region of Central America.

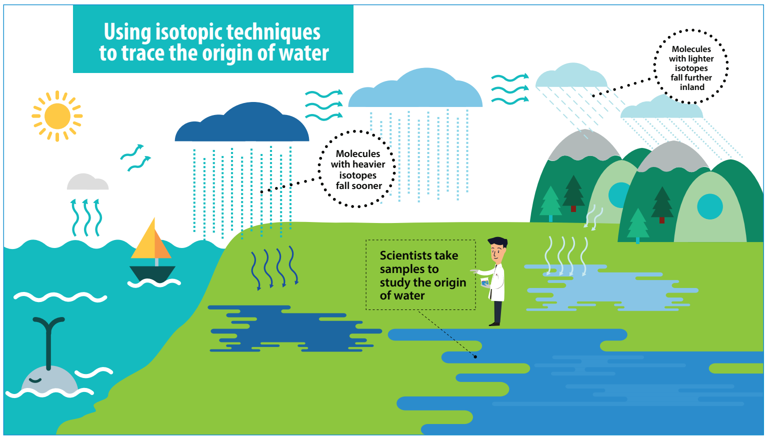
"We didn't have any historical records of hurricanes impacting Costa Rica," Sánchez-Murillo said. "So we were susceptible and suffered the consequences, because we didn't know how to respond."

Such phenomena carry with them a collection of isotopic fingerprints that scientists like Sánchez-Murillo can capture using special nuclear-derived techniques. Once recorded, they use the isotope data, coupled with climatic models and past climatic records, to predict the frequency, magnitude and intensity of future meteorological events and inform authorities, who in turn can be better prepared. The science behind this is called isotope hydrology (see box below).

"We now have the tracers, which act as a sentinel," Sánchez-Murillo said. "These techniques give us the capacity to see what conventional instruments cannot reach. Where conventional methods cannot see, isotopes can."

Using isotopic techniques to study poorly understood water systems, experts are also finding solutions to water challenges related to climate change that are affecting even the wettest regions, including Costa Rica. With these techniques, scientists can determine the quantity and quality of water supplies. They use naturally occurring isotopes as tracers to find out where groundwater comes from, if it is recent or old, if it is being recharged or polluted, and how it travels.





(Infographic: F. Nassif/IAEA)

Through the IAEA's technical cooperation programme, hydrologists in Costa Rica have received support and training to develop a monitoring network that traces precipitation and underground water processes.

Understanding rainfall patterns helps hydrologists know where, when and how water is recharged — information that is key to devising land and water management plans. With isotopes, they have studied water in the Central Valley, a biological corridor between the Pacific and Caribbean slopes that supplies drinking water to approximately a fifth of Costa Rica's population, around one million people. And today, they know the exact height and zones from which aquifers get new water.

"Understanding the key factors controlling rainfall patterns and their relationship with groundwater recharge is essential for government and environmental agencies to prioritize resources and efforts," Sánchez-Murillo said. "Now that we know the critical recharge areas and how groundwater travels, we can prioritize the conservation of these areas over commercial activities."

Impacting policy

The work by Sánchez-Murillo and his team is intended to enable the government to target conservation measures at the most critical areas of recharge. This would, in turn, allow residents, farmers, or businesses to continue developing activities without having a negative impact on the sources of water.

"While we have always had regulations in place to protect our water, the difference is that now we can be more precise, more efficient," Sánchez-Murillo said. "We know exactly which areas need special attention, and we know how to protect them to ensure water supply for now and the coming decades."

THE SCIENCE

Isotope hydrology

Every water molecule has hydrogen and oxygen atoms, but these are not all the same: some atoms are lighter and some are heavier.

"All natural waters have a different hydrogen and oxygen isotopic composition," said IAEA isotope hydrologist Lucía Ortega. "We use this isotopic composition as the fingerprints of water."

As water evaporates from the sea, molecules with lighter isotopes tend to preferentially rise. As rain falls, molecules with heavier isotopes fall sooner. The further the cloud moves inland, the higher the proportion of molecules with light isotopes in rain.

When water falls to the earth, it fills lakes, rivers and aquifers, Ortega said. "By measuring the difference in the proportions between the light and heavy isotopes, we can estimate the origin of different waters."

In addition, the abundance of naturally occurring radioactive isotopes present in water, such as tritium and noble gas isotopes dissolved in the water, can be used to estimate groundwater age — from a few days to one millennia. "And this is key to help us assess the quality, quantity and sustainability of water," she said.