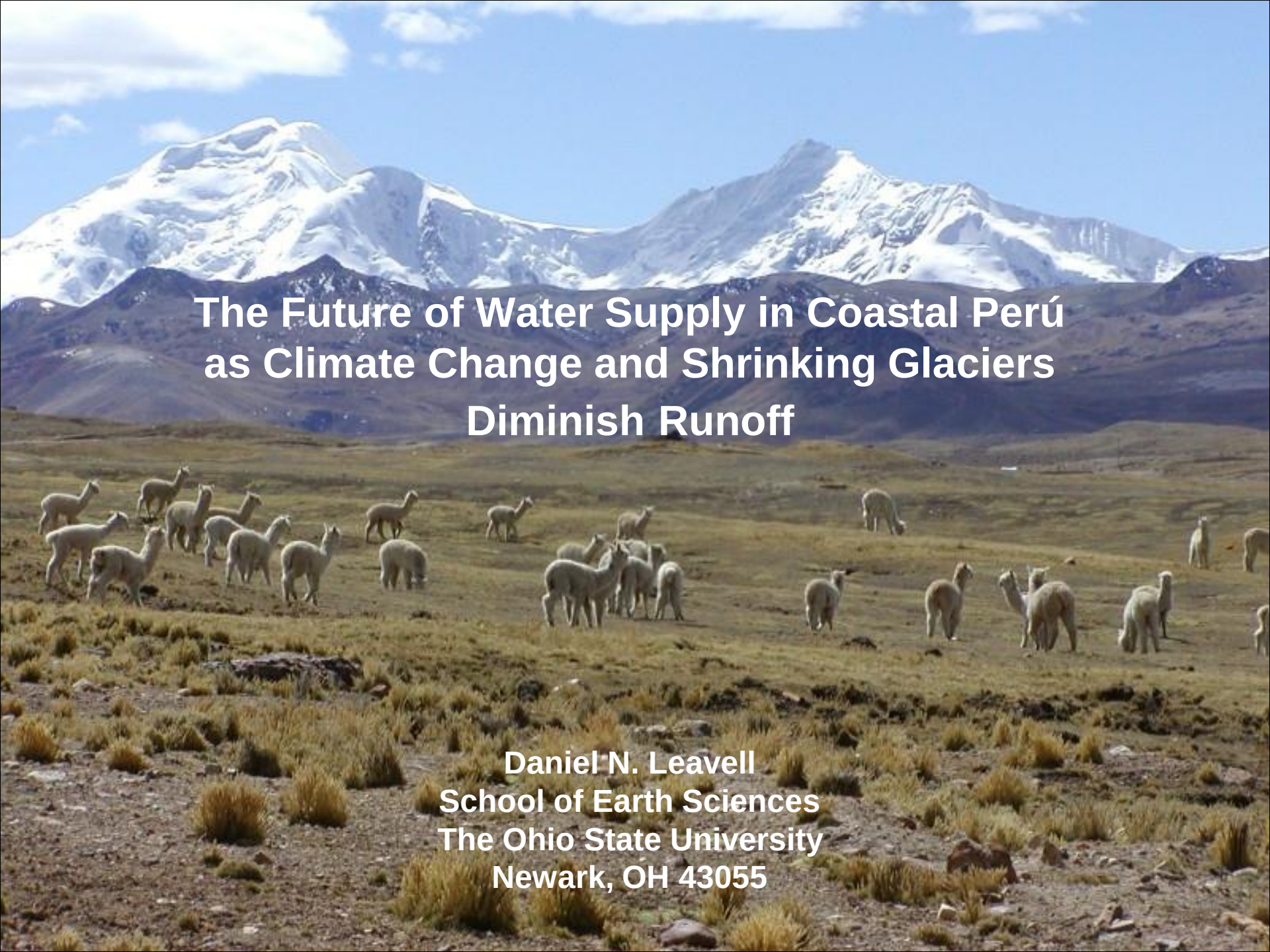


A scenic landscape of the Andes in Peru. In the foreground, a herd of white alpacas is grazing on a dry, grassy plain. The middle ground shows rolling hills and valleys. In the background, two large, rugged mountains with significant snow cover rise against a clear blue sky with a few wispy clouds. The overall scene is bright and sunny.

The Future of Water Supply in Coastal Perú as Climate Change and Shrinking Glaciers Diminish Runoff

**Daniel N. Leavell
School of Earth Sciences
The Ohio State University
Newark, OH 43055**



Image by: Stoddell, Nelson, Hasler
Laboratory for Atmospheres
Goddard Space Flight Center
<http://rsd.gsfc.nasa.gov/rsd>



Hurricane Linda west of Mexico
September 9, 1997 17:45 UTC
Data from: NASA, NOAA, USGS





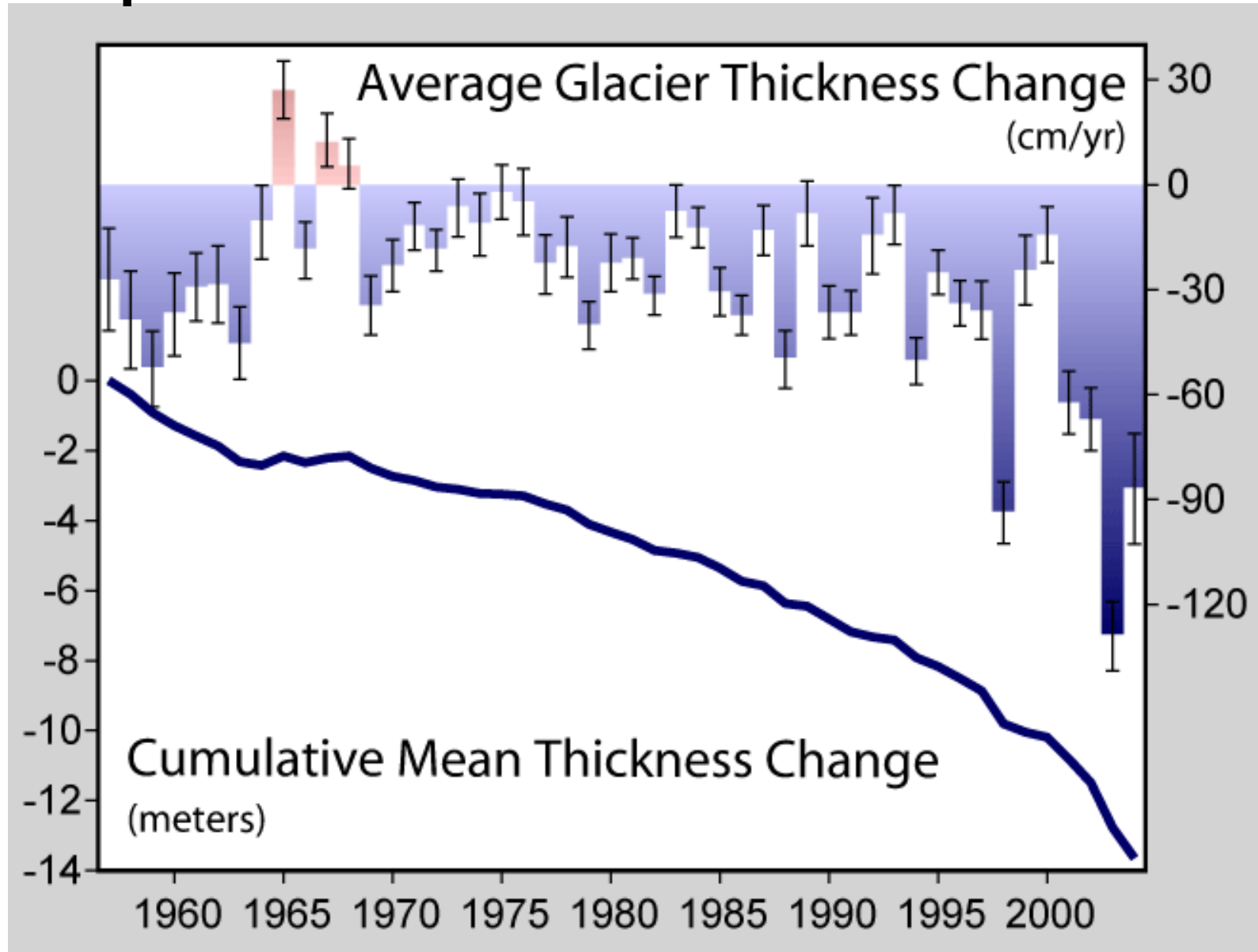
Principal Cordilleras of the Andes Mountains in Perú



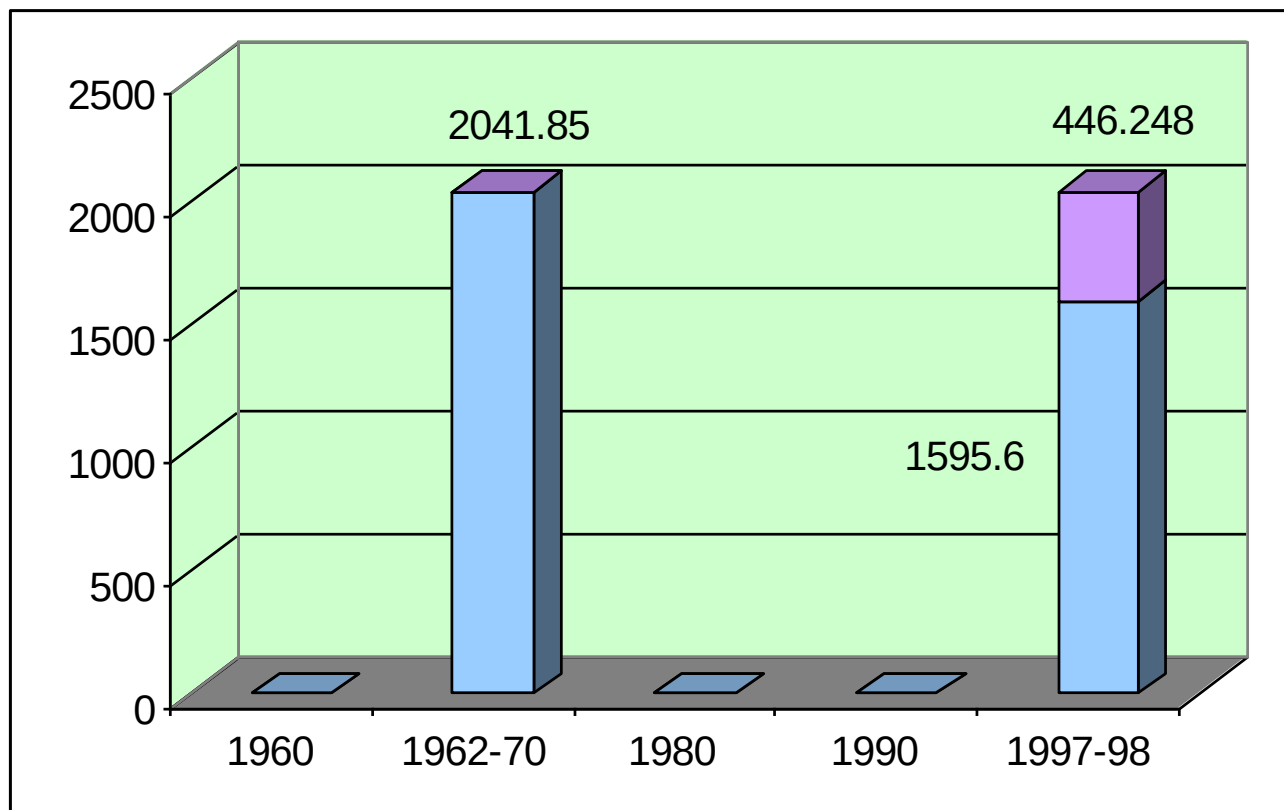




Alpine Glacier Mass Balance

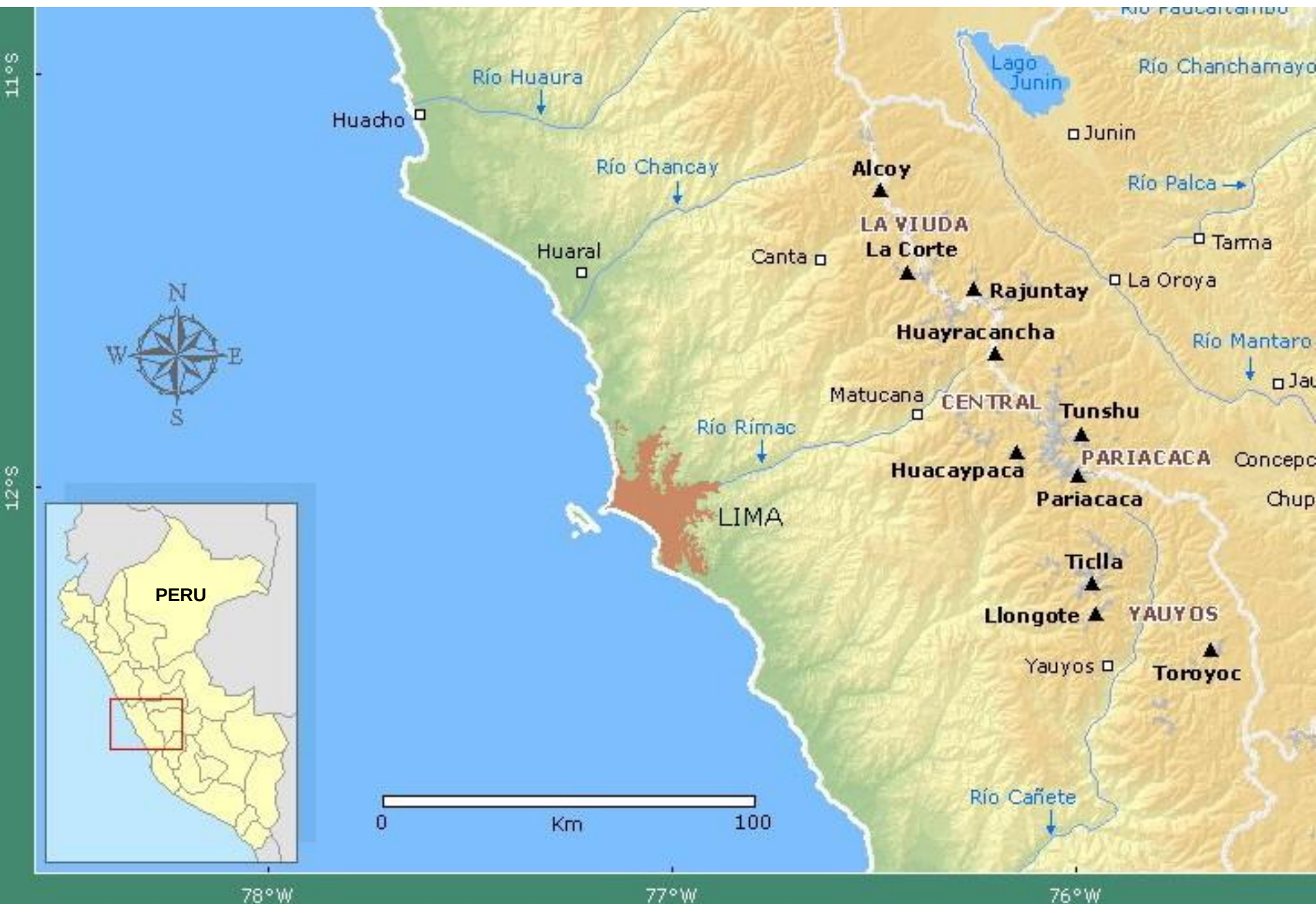


REDUCCION EN AREA 18 CORDILLERAS EN 27 AÑOS REDUCCION EN 21.85 %

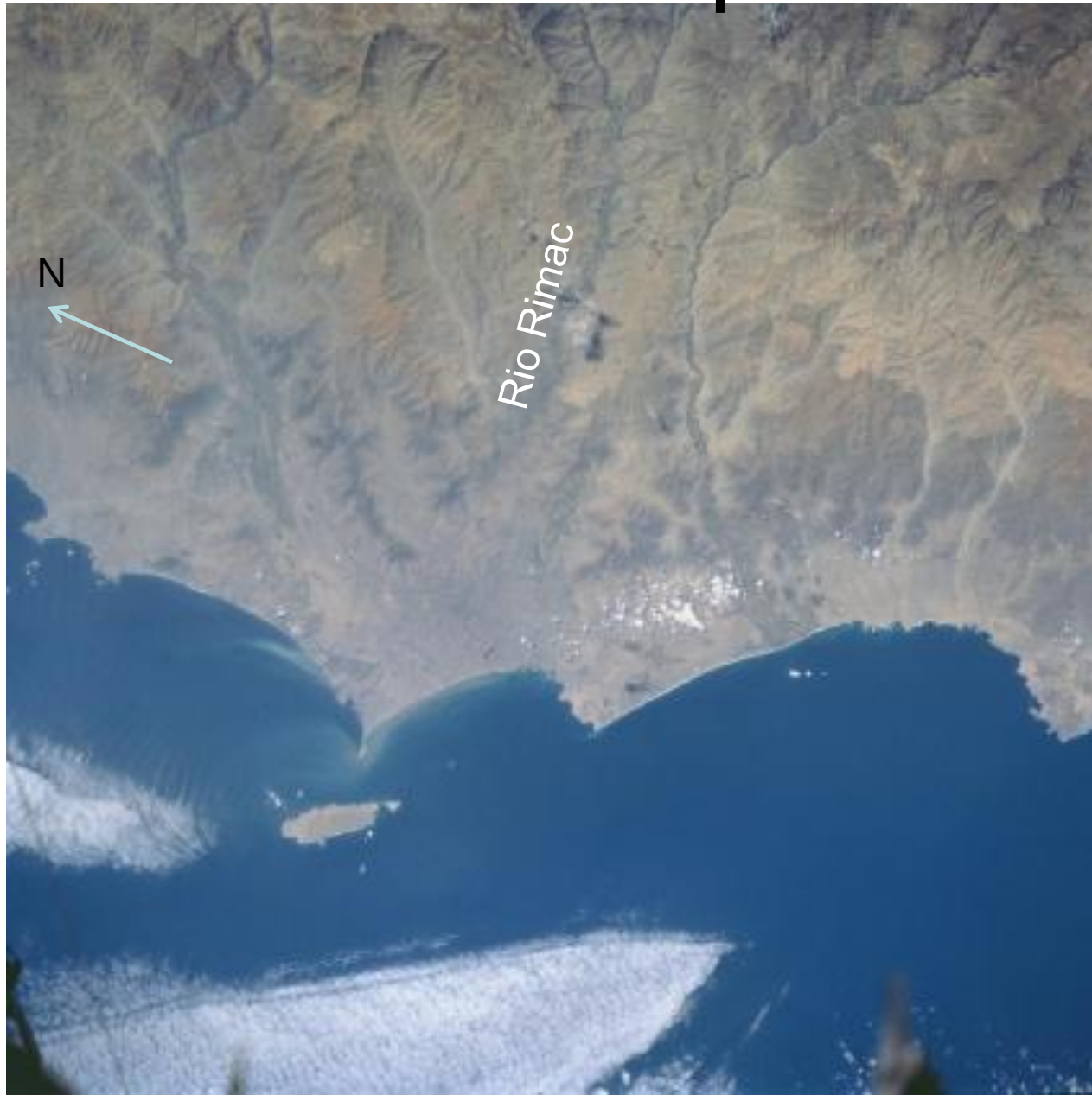


Area Reduccion Km2					446.248
Area Km2		2041.85			1595.6

Fuente: UGRH- INAGGA



Lima from Space







INCA KOLA

INCA KOLA

Coca-Cola







Lima is a rapidly growing city, outgrowing its resource base



8.8 million population
2% growth rate
9 mm/yr precipitation

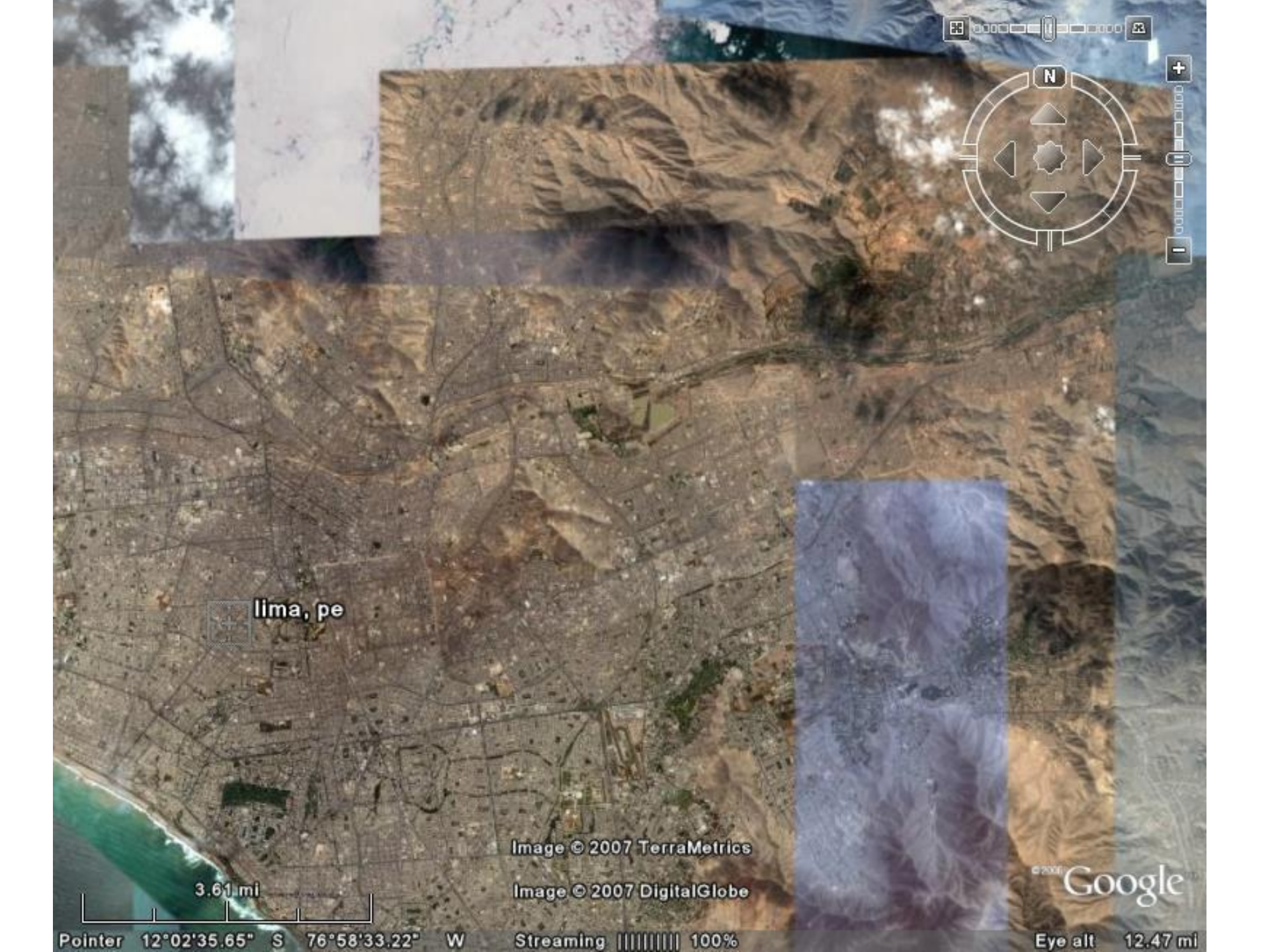
Surface water supply

Dry season flow

Río Chillón: 0 m³/s

Río Rímac: 20 m³/s

Río Lurín: 0 m³/s



lima, pe

Image © 2007 TerraMetrics

Image © 2007 DigitalGlobe

© 2007 Google

3.61 mi

Pointer 12°02'35.65" S 76°58'33.22" W

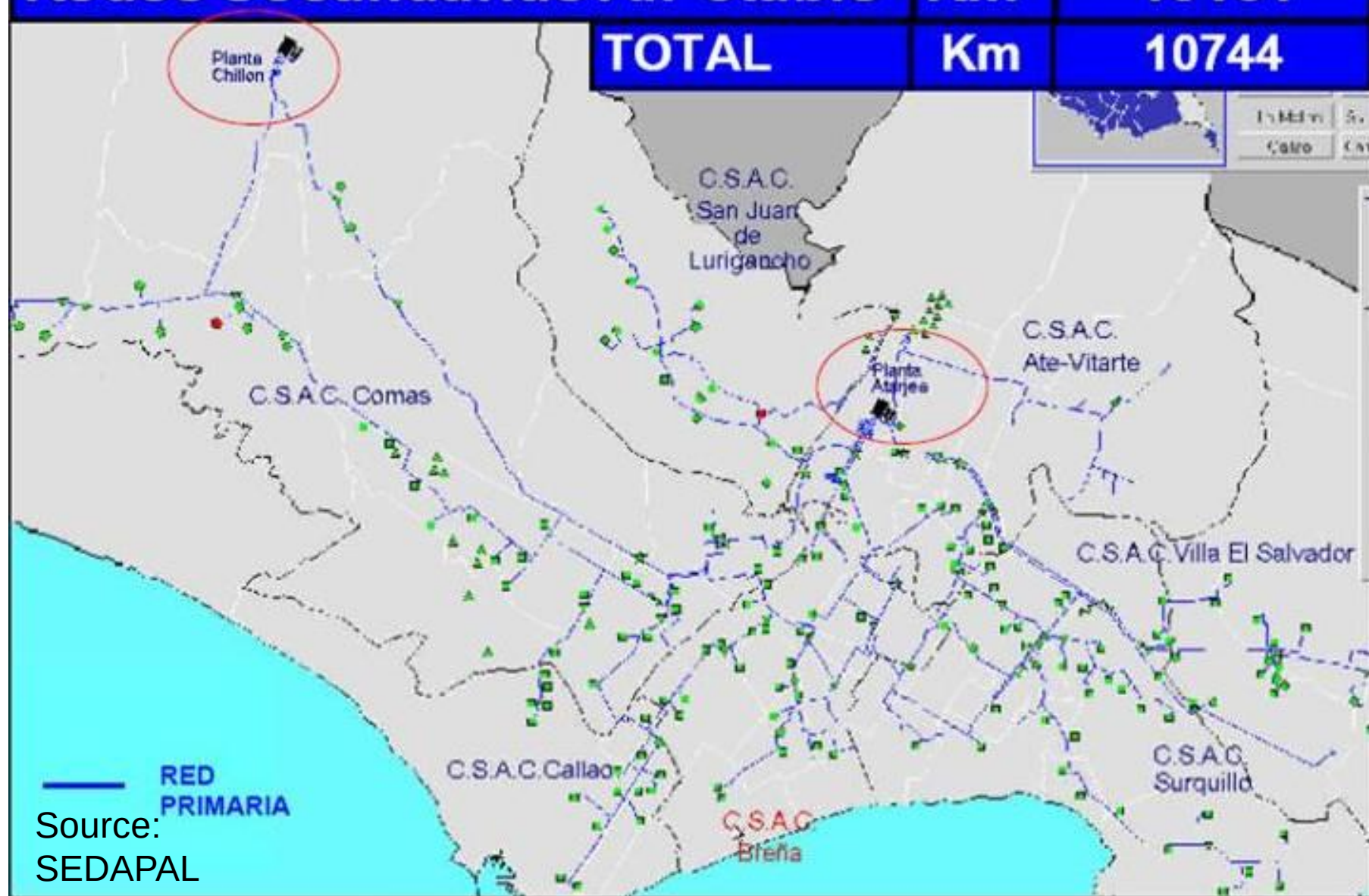
Streaming ||||| 100%

Eye alt 12.47 mi

Atarjea Water Treatment Plant

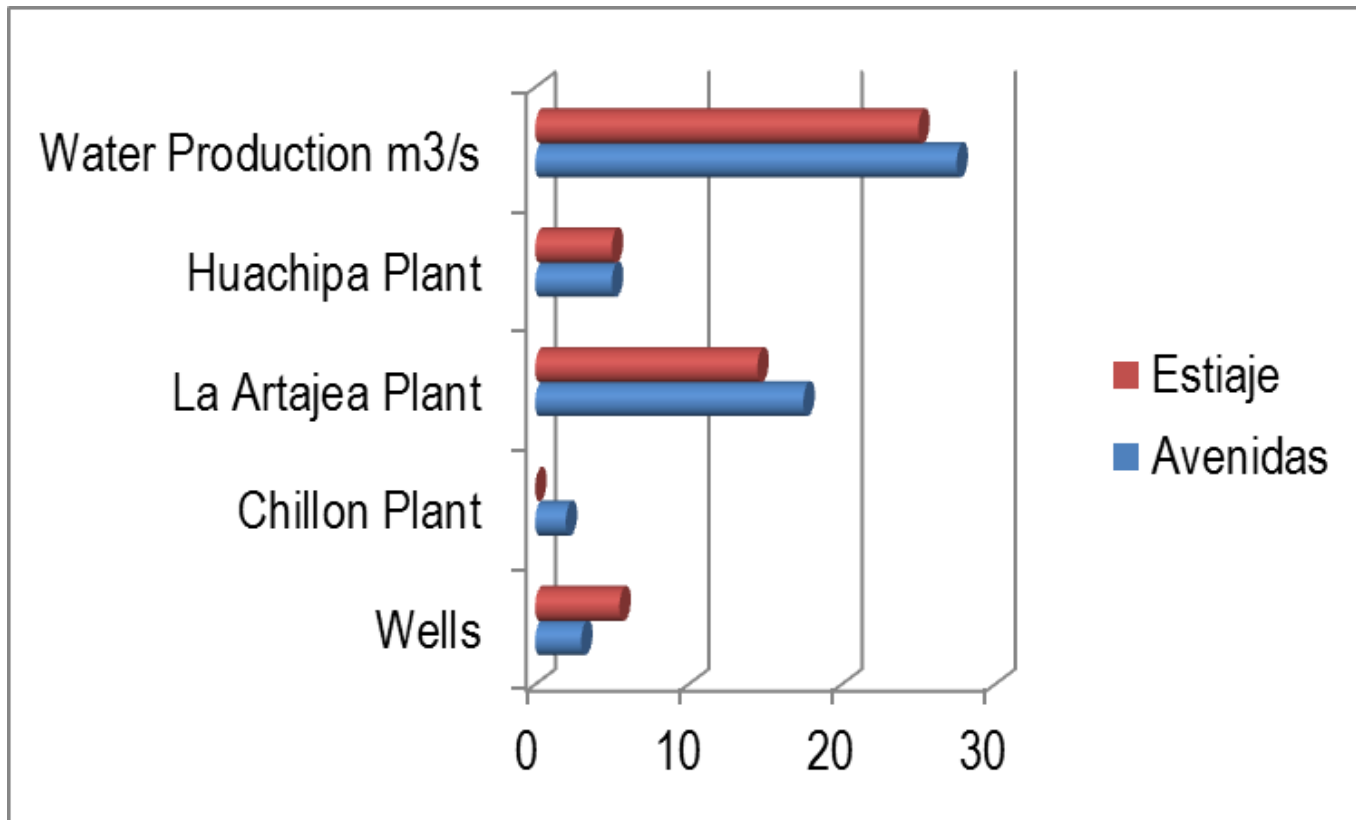


Redes Primarias A.Potable	Km	583
Redes Secundarias A.Potable	Km	10161
TOTAL	Km	10744



Source:
SEDAPAL

Lima's Water Supply



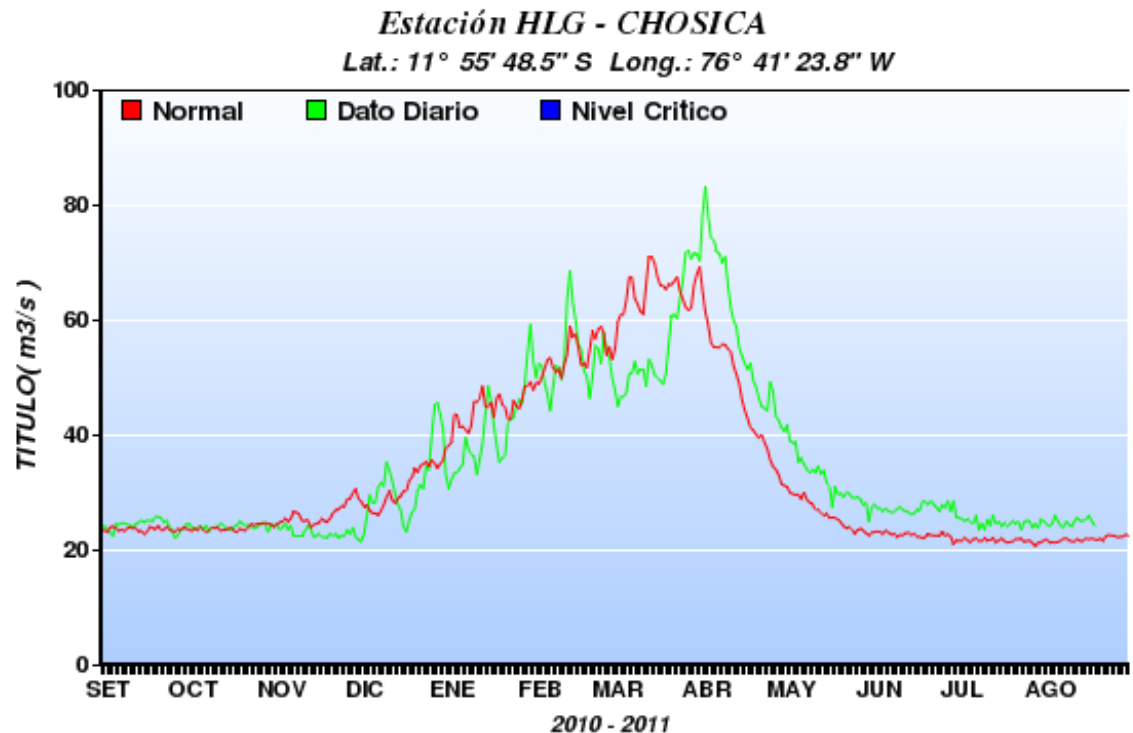
78 % Surface Water

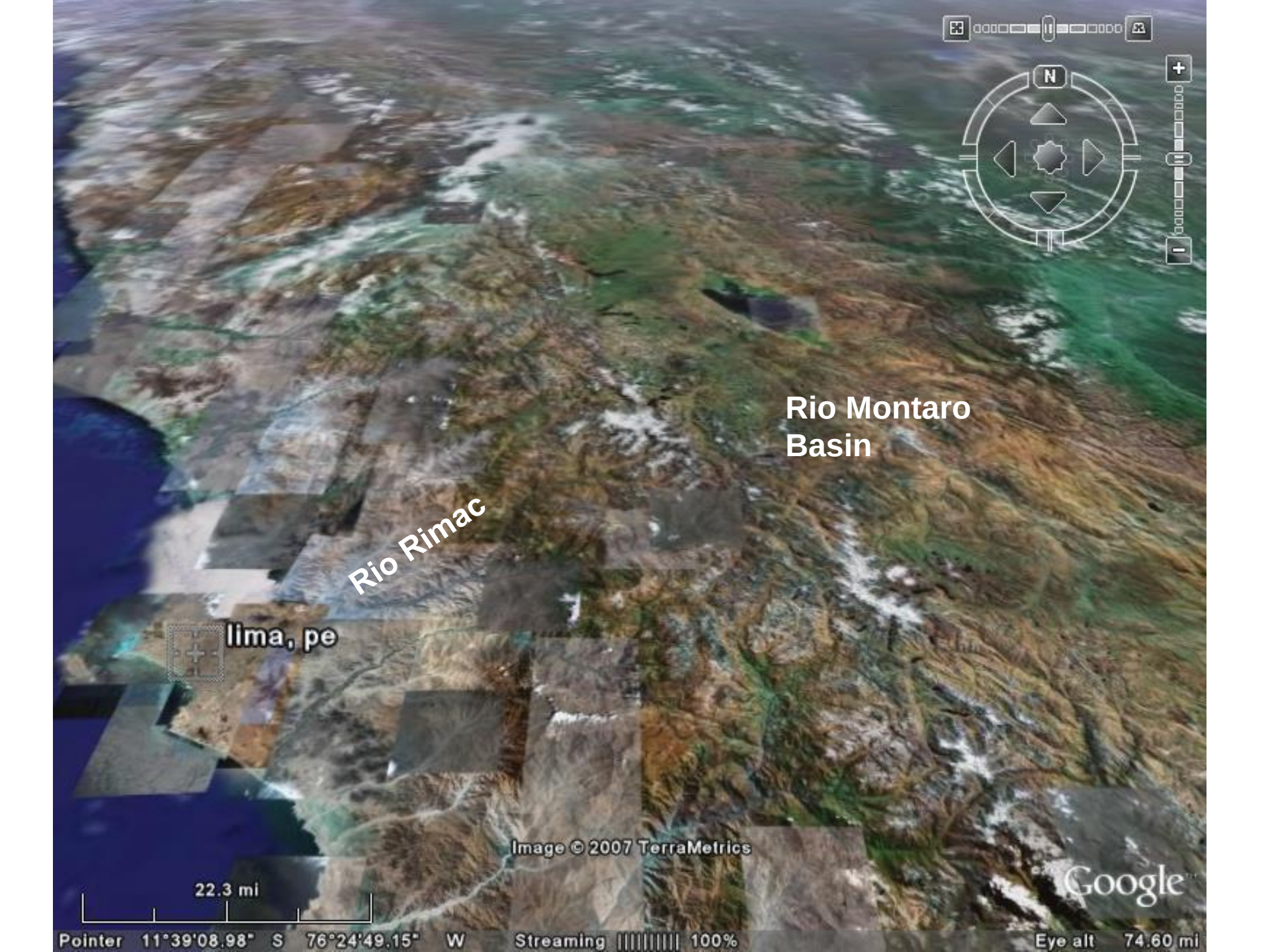
22 % Ground Water

Source - SEDAPAL



Rio Rimac above Lima at Chosica





Rio Montaro
Basin

Rio Rimac

lima, pe

Image © 2007 TerraMetrics

Google

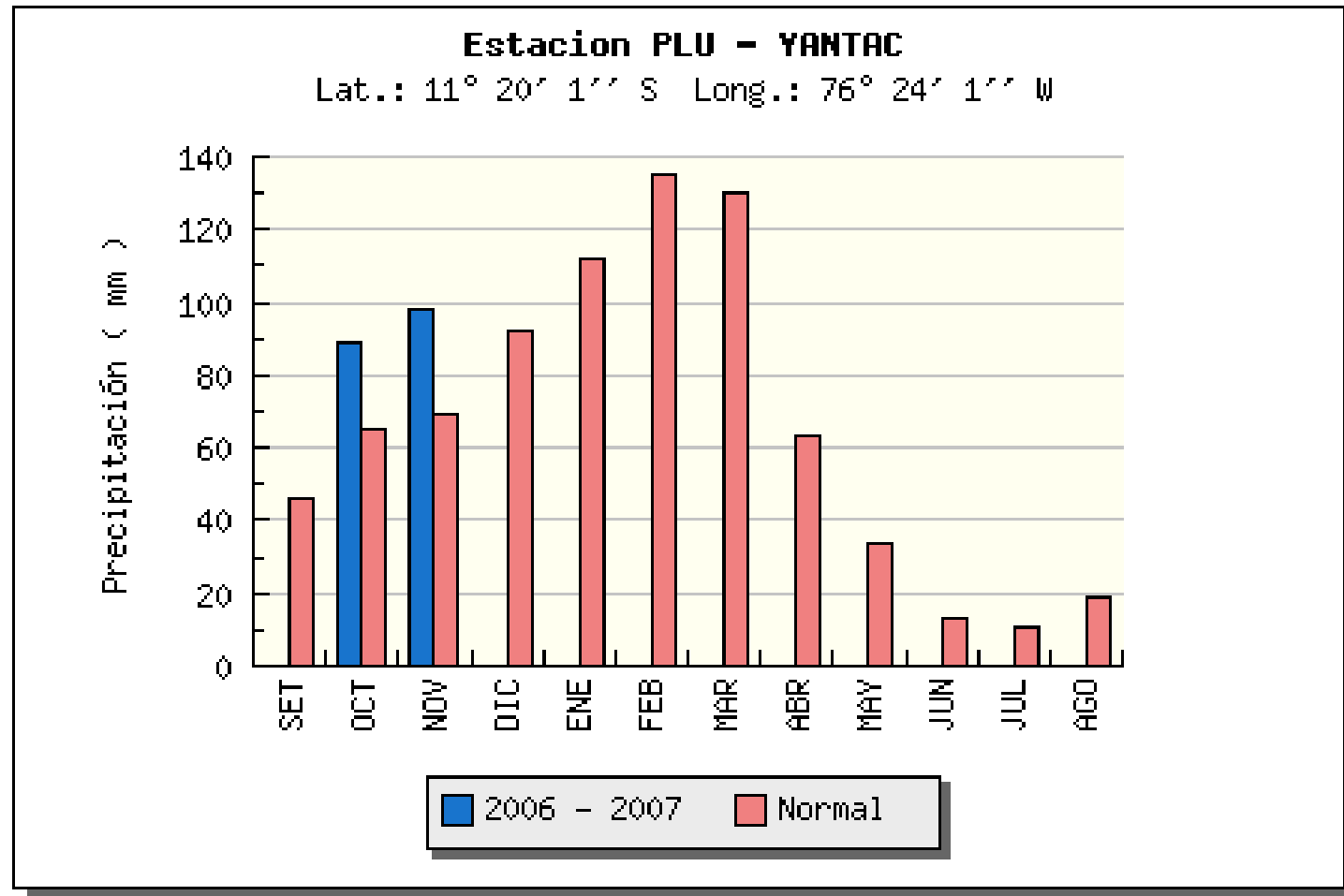
22.3 mi

Pointer 11°39'08.98" S 76°24'49.15" W

Streaming 100%

Eye alt 74.60 mi

Precipitation - Junin Highlands



Fault locations are approximate

Plate
Boundaries

Divergent

Transform

Convergent

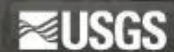
Undefined



Rio Santa Eulalia

Rio Rimac

© 2007 Europa Technologies
Image © 2007 DigitalGlobe



© 2007 Google™

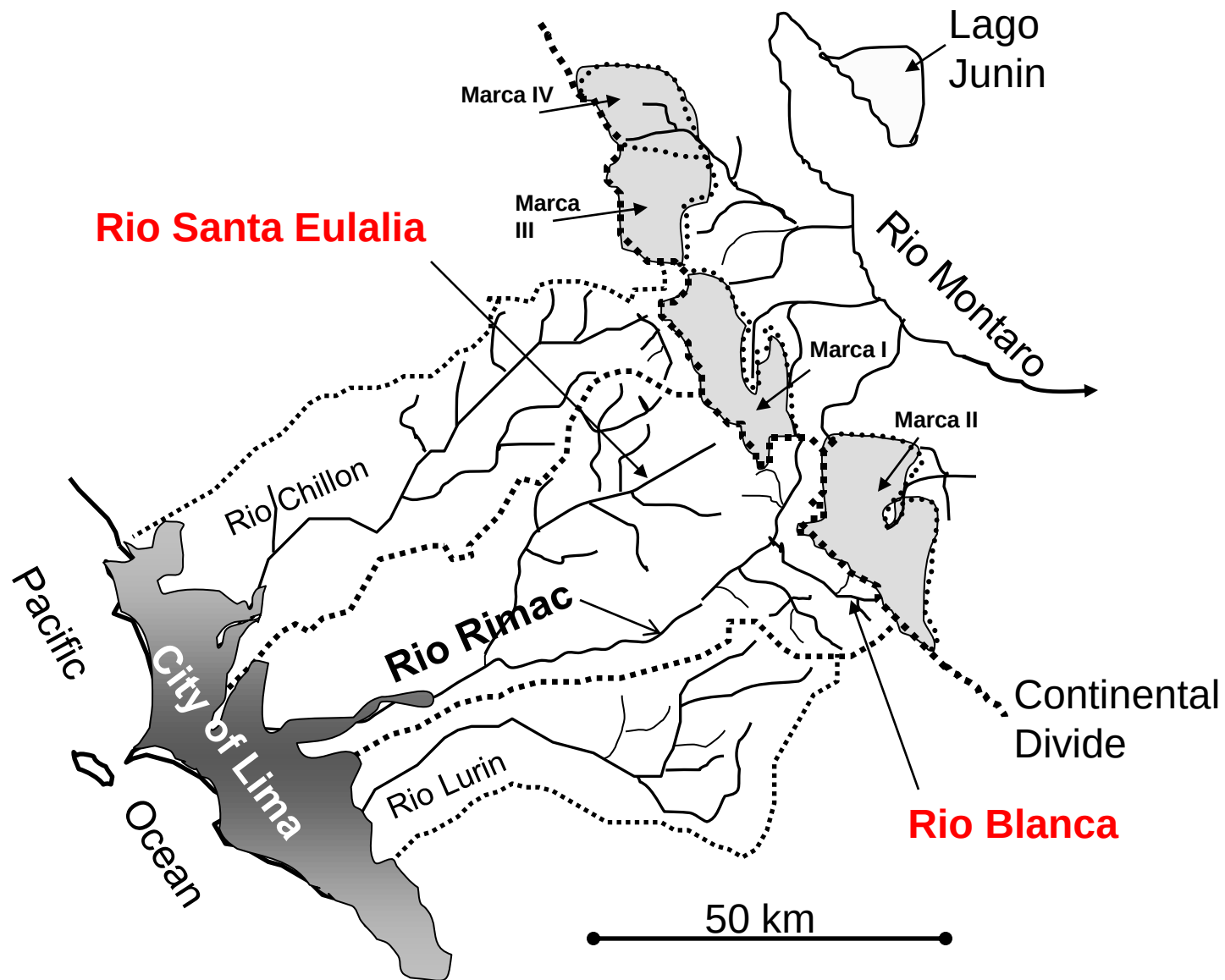
3.77 km

Pointer 11°54'58.04" S 76°39'23.59" W

Streaming ||||| 100%

Eye alt 13.11 km

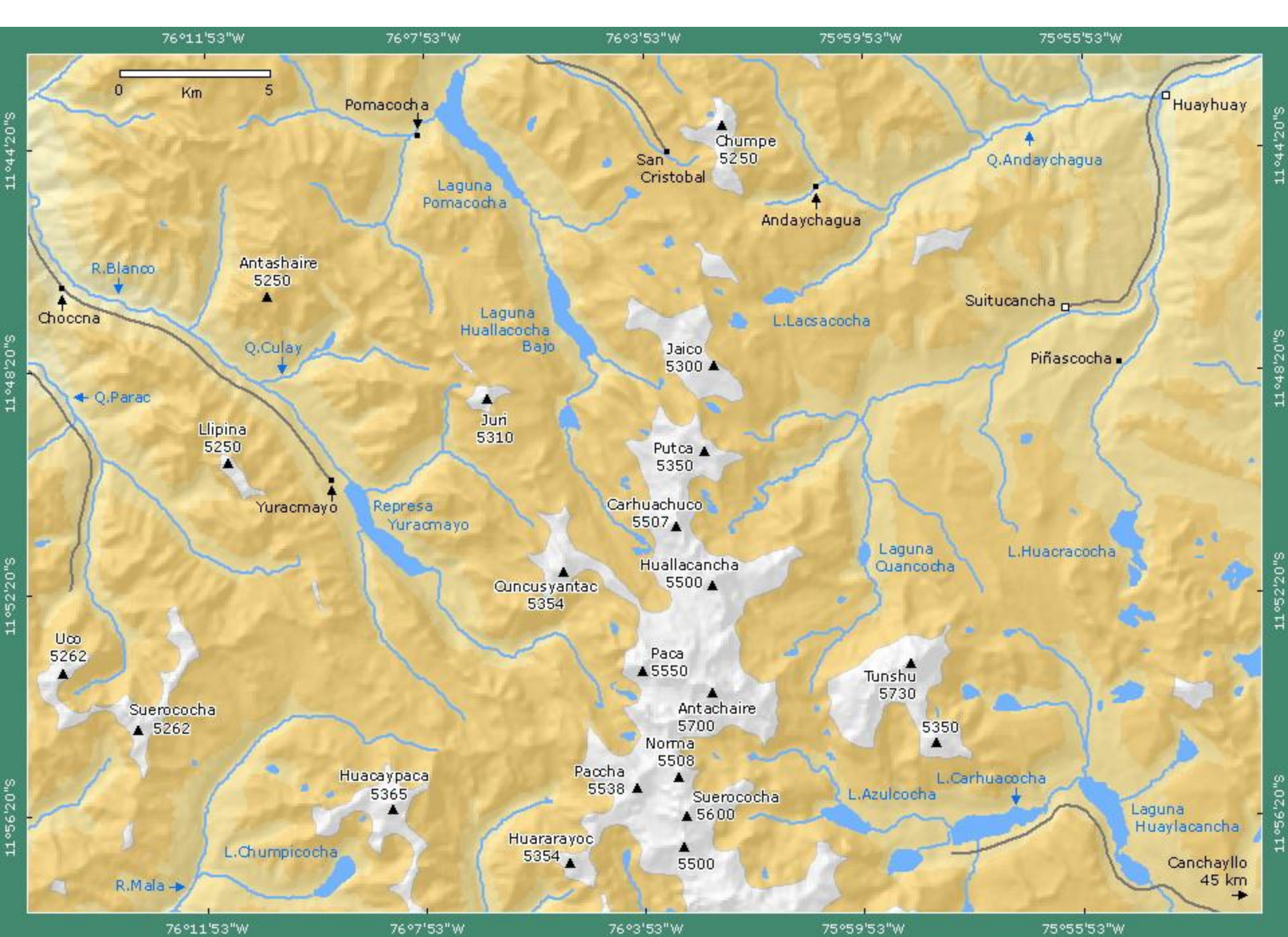






Cordillera Central and Nevado Sullcon







Yuracmayo Reservoir

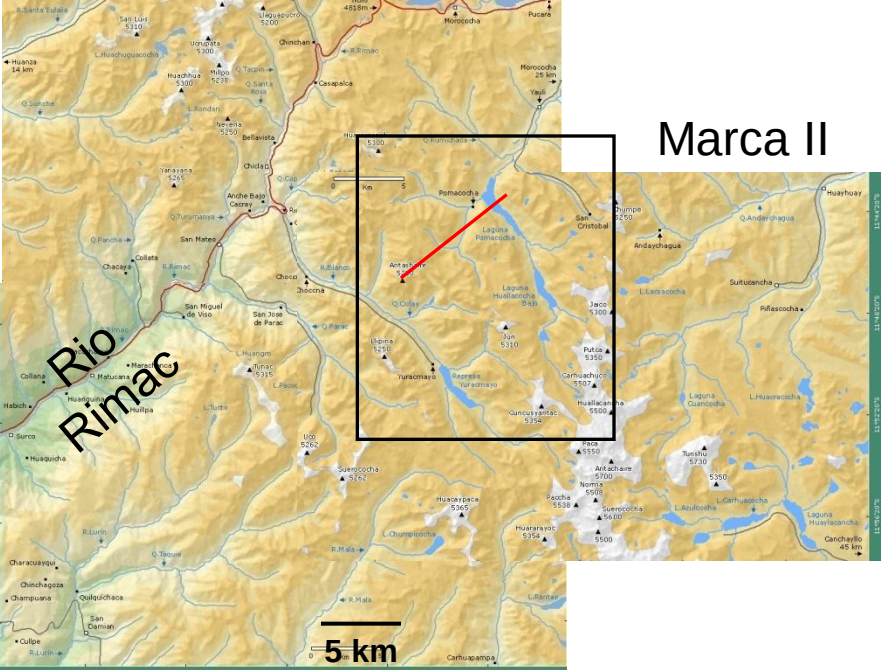
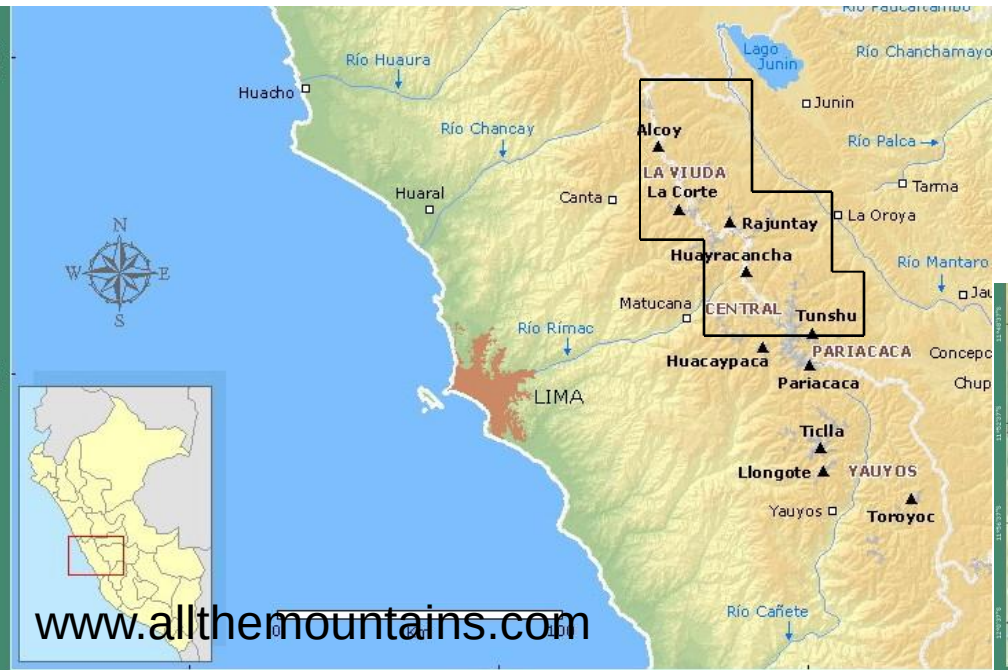
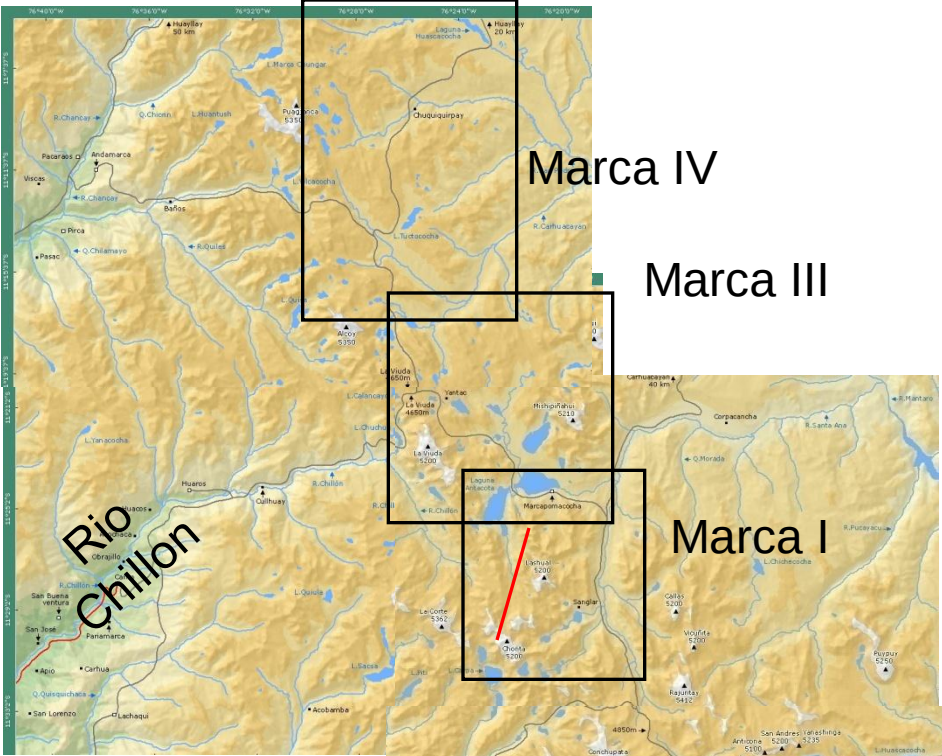
48Mm³

Rio Blanca

Tributary to
Rio Rimac



Lima's Water Supply Enhancements: Existing and Proposed



Marca I, III and IV



Marca IV - Huascacocha



Completed 2011

78 Mm³ storage

2.8 m³/s supply

Storage basins of Marcapomacocha

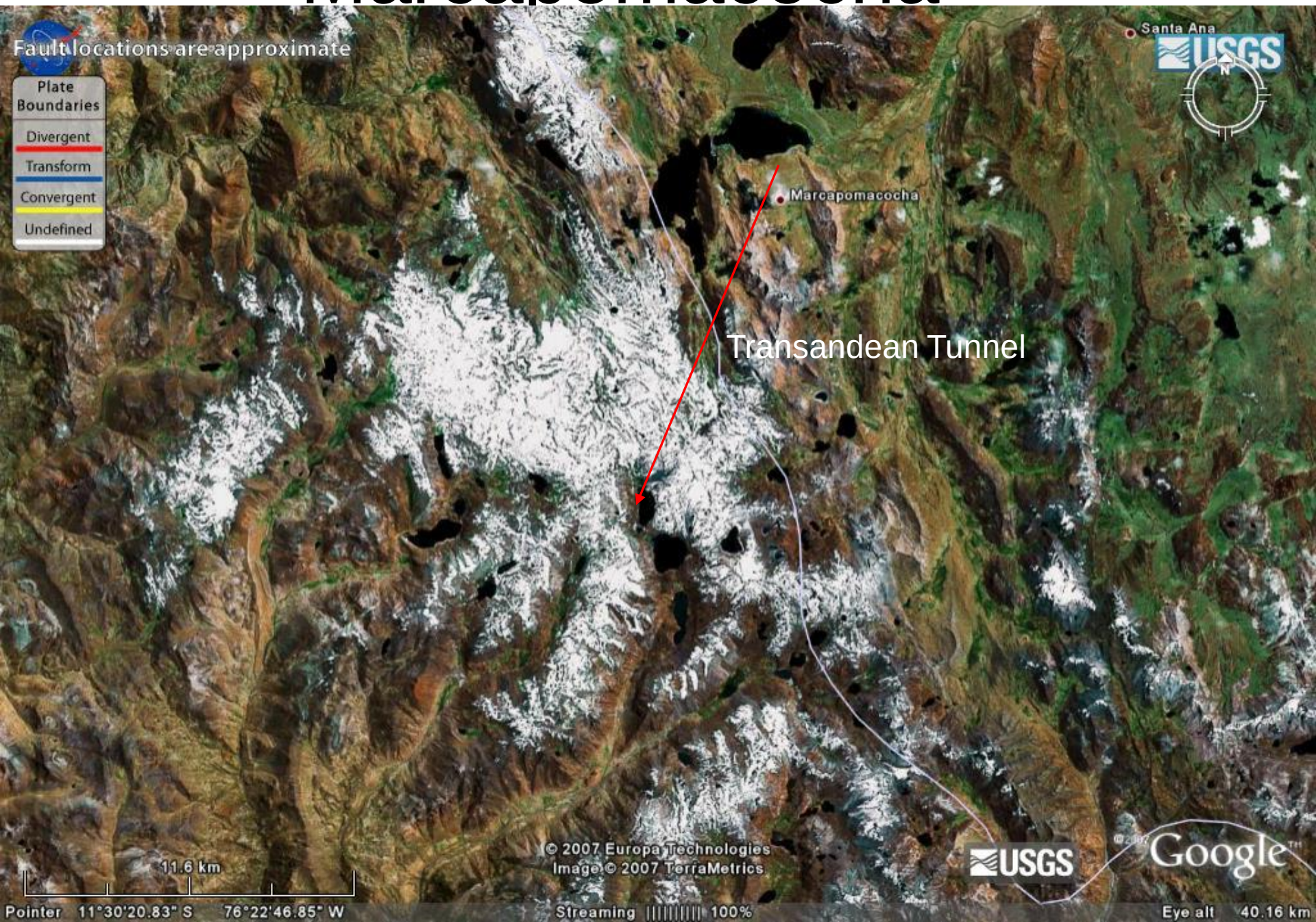


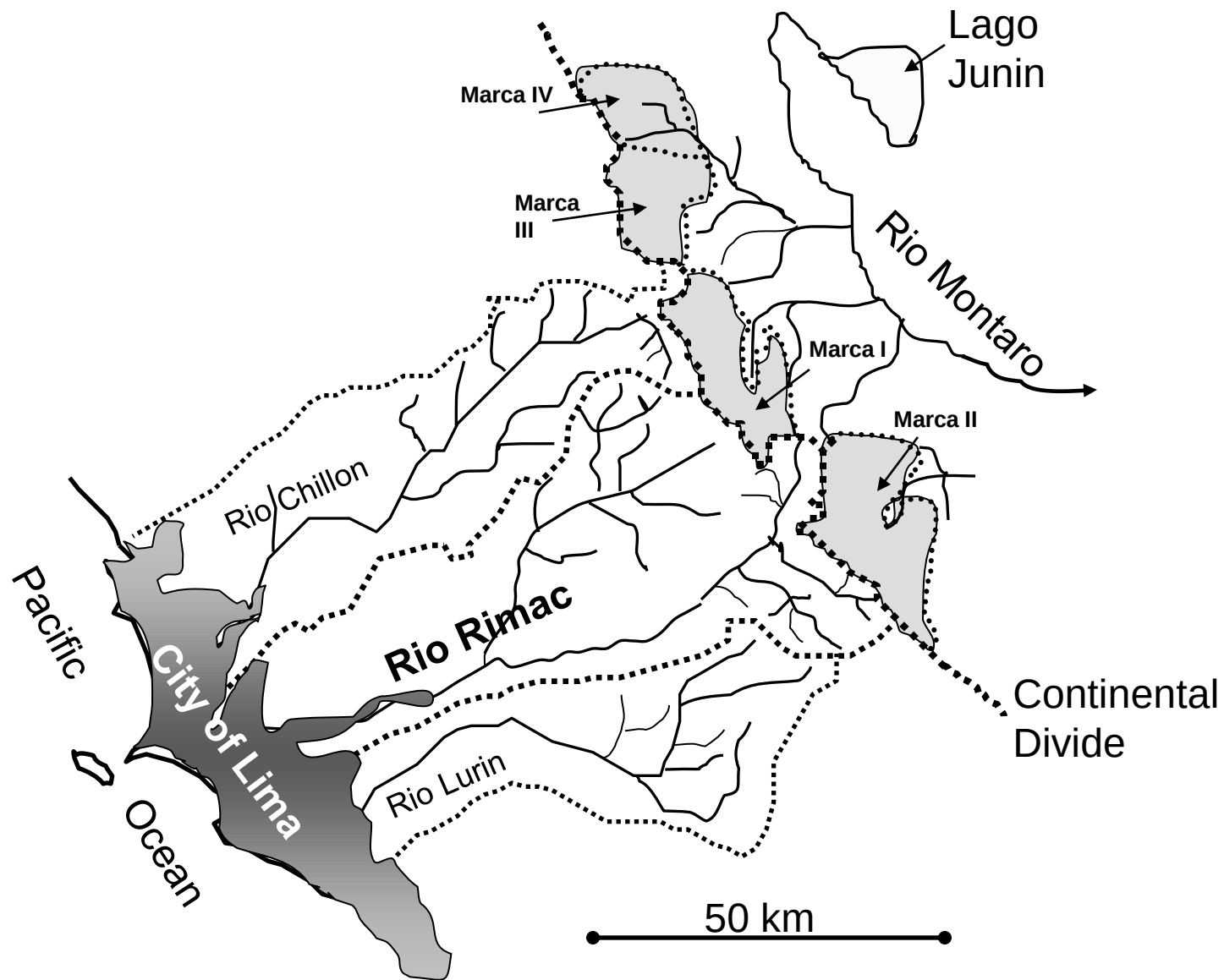
235 Mm³ storage
in the Rio Montaro
Headwaters

Transferred by Tunnel
To the Santa Eulalia Basin
77 Mm³ storage



Marcapomacocha



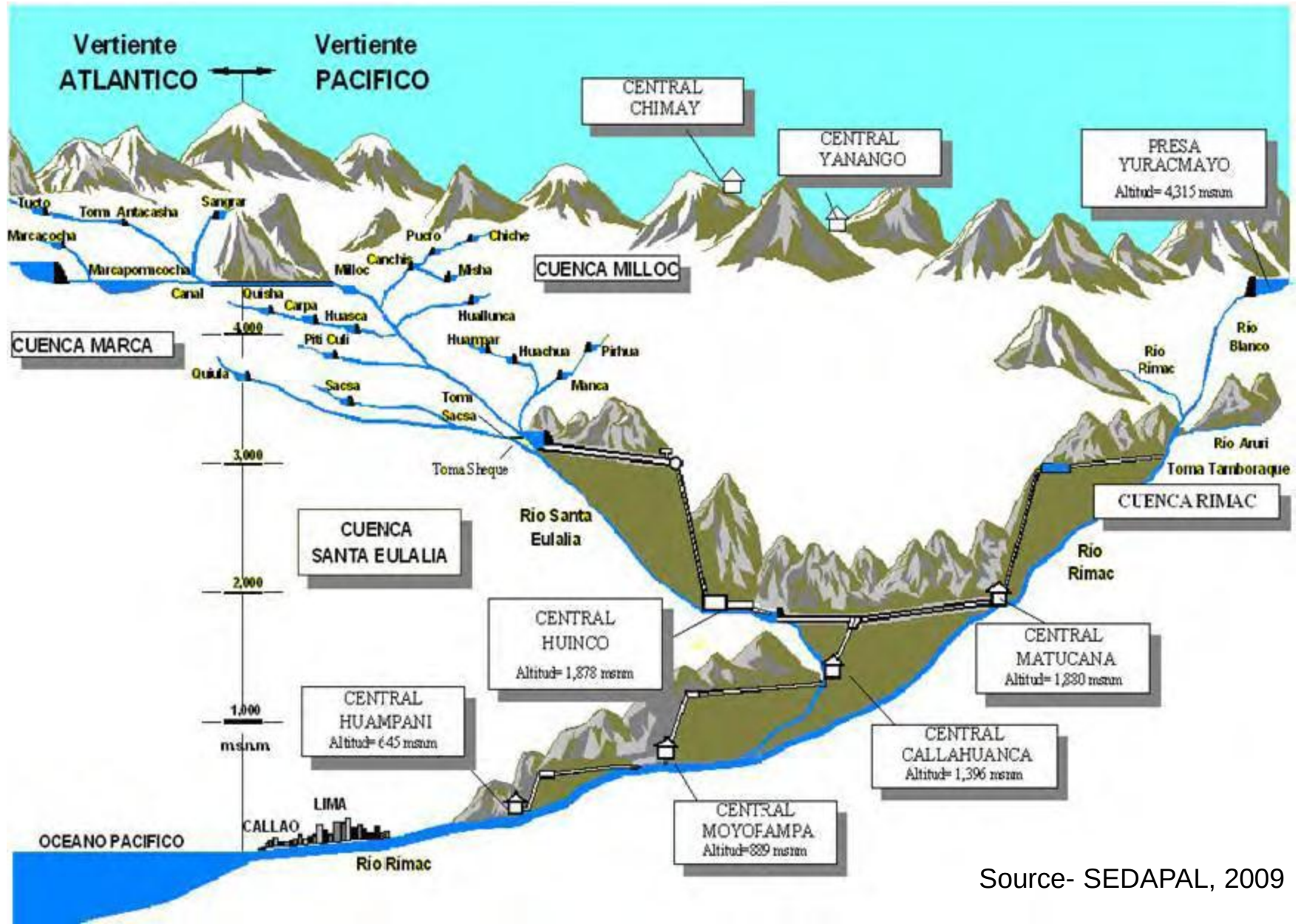


CIUDAD	Población (Mill. Hab.)	Capacidad de producción (m3/s)	Reservas (Mill. M3)	Reservas por habitante (M3/hab)	Precipitación (mm/año)	ANF (%)
Río de Janeiro	9	52	(*)	0	1170	57
Sao Paulo	25	90	2073	83	1500	38
Santiago	5.9	24	900	153	384	29
Bogotá	6.5	25	800	123	800	35
Lima	8.0	20	282	35	9	38

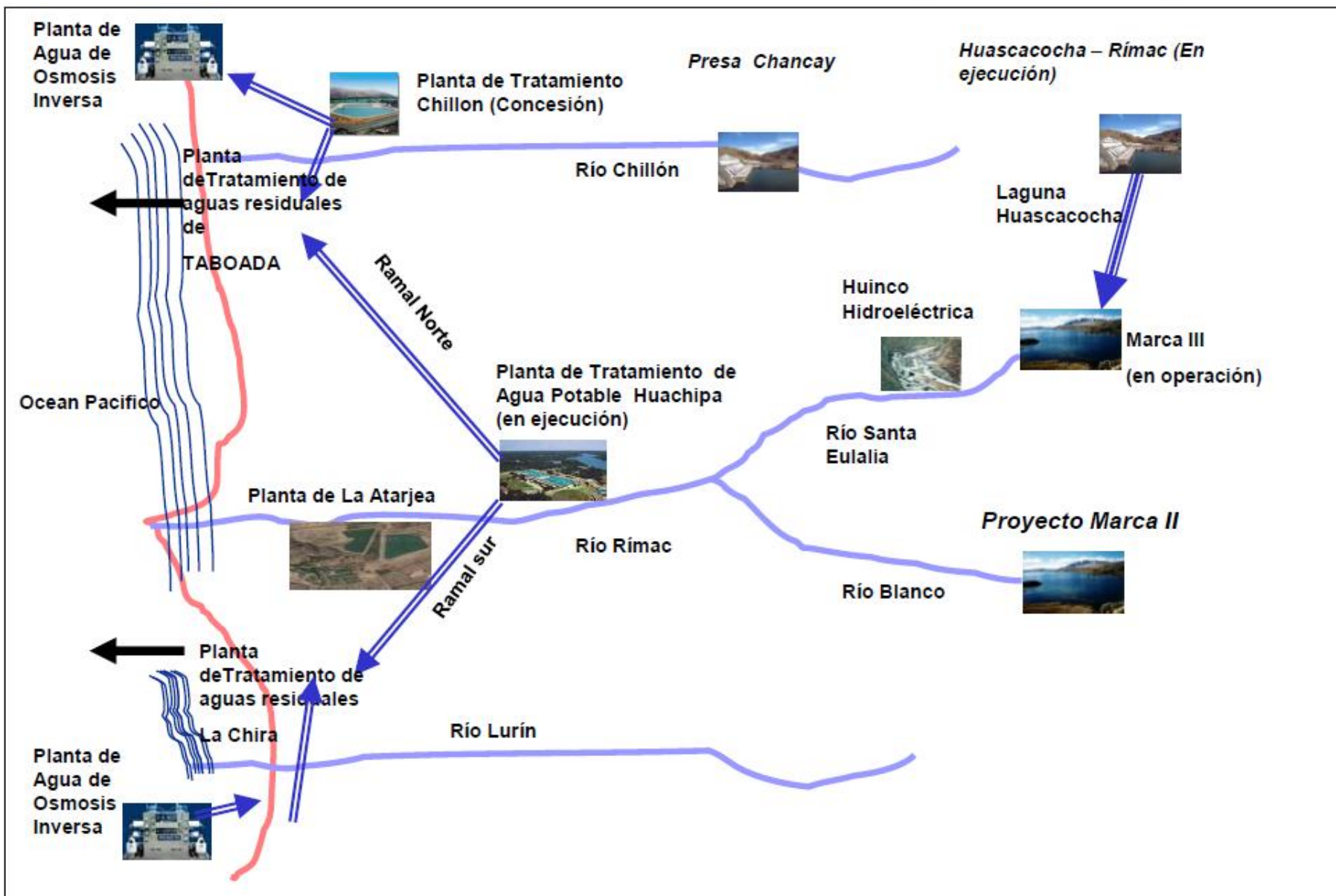
* No tiene problemas de fuente por el gran caudal del río que abastece la ciudad y por el alto nivel de precipitaciones

Fuente: Memorias Anuales Principales Empresas de Saneamiento de Sudamérica

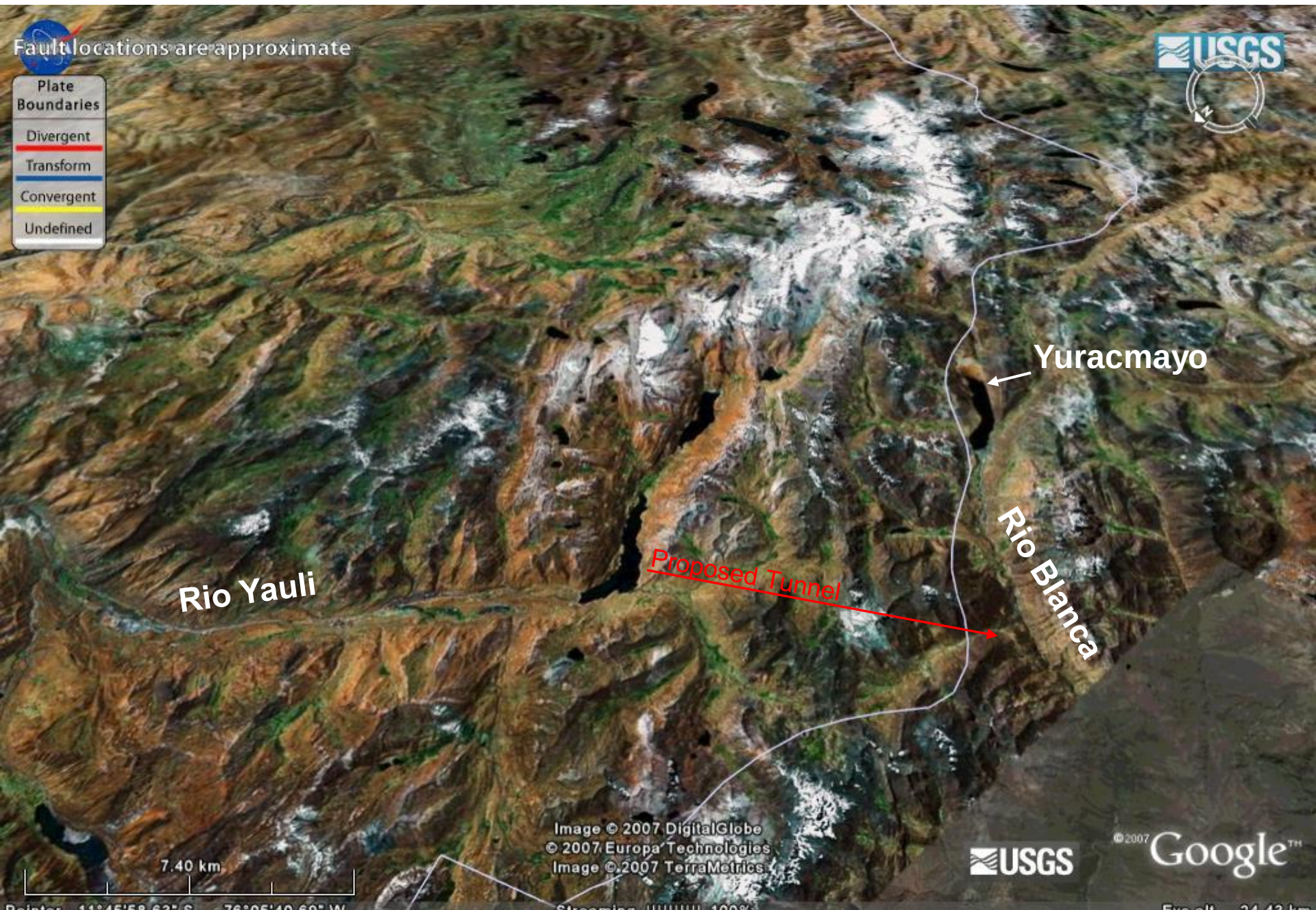
Disminución de los Caudales Naturales de los Ríos por el Calentamiento Global

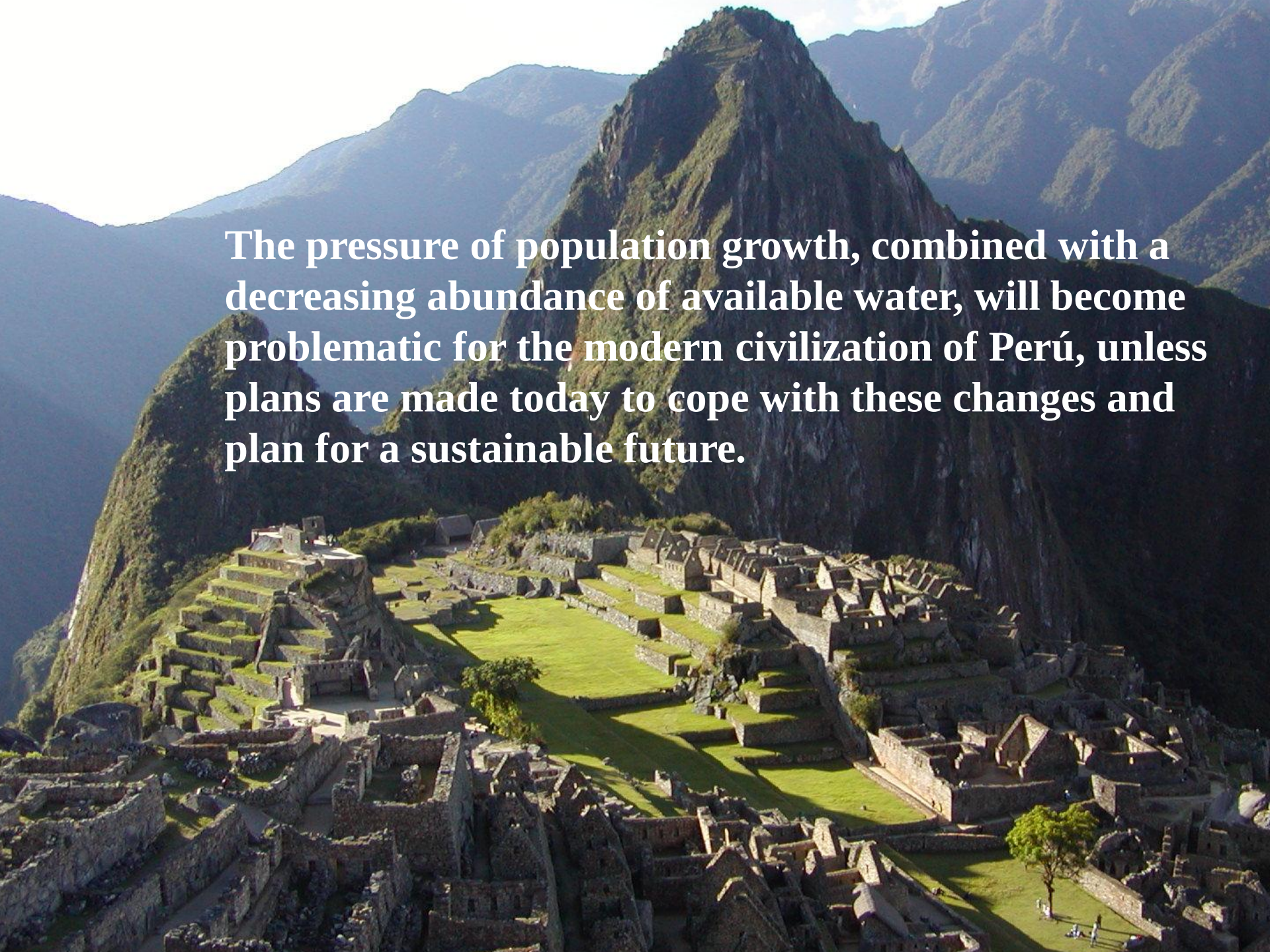


Source- SEDAPAL, 2009



Marca II and the Cordillera Central



An aerial photograph of the ancient Inca city of Machu Picchu, showing the stone ruins and terraces built into the mountain. The city is surrounded by steep, forested mountains, with a prominent peak rising directly behind it. The text is overlaid on the upper half of the image.

The pressure of population growth, combined with a decreasing abundance of available water, will become problematic for the modern civilization of Perú, unless plans are made today to cope with these changes and plan for a sustainable future.

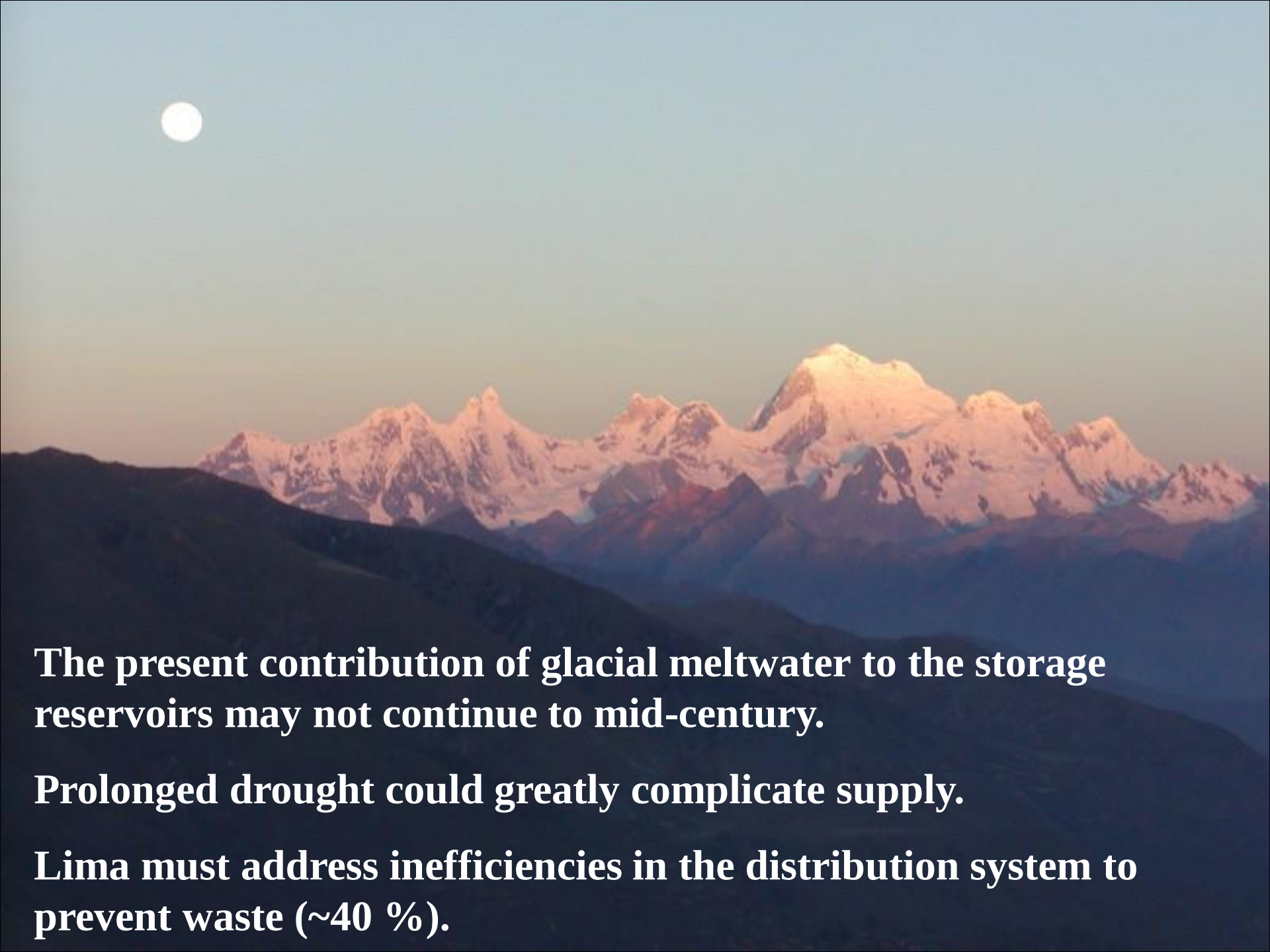
The Rios Rimac and Montaro are marginally adequate to meet today's needs for agriculture, industry, power generation and domestic supply.

Present climate trends suggest that demand for water in both river basins will exceed supply in the near future.

The Marca IV and Marca II projects will supply a total of $7.2 \text{ m}^3/\text{s}$ additional volume.

Currently Marca II is on hold and discussions in Perú suggest that it may be replaced with desalination supply.

Increasingly, Lima and coastal Peru will have to rely on water from the sea.



The present contribution of glacial meltwater to the storage reservoirs may not continue to mid-century.

Prolonged drought could greatly complicate supply.

Lima must address inefficiencies in the distribution system to prevent waste (~40 %).

Muchas Gracias
Thank You

