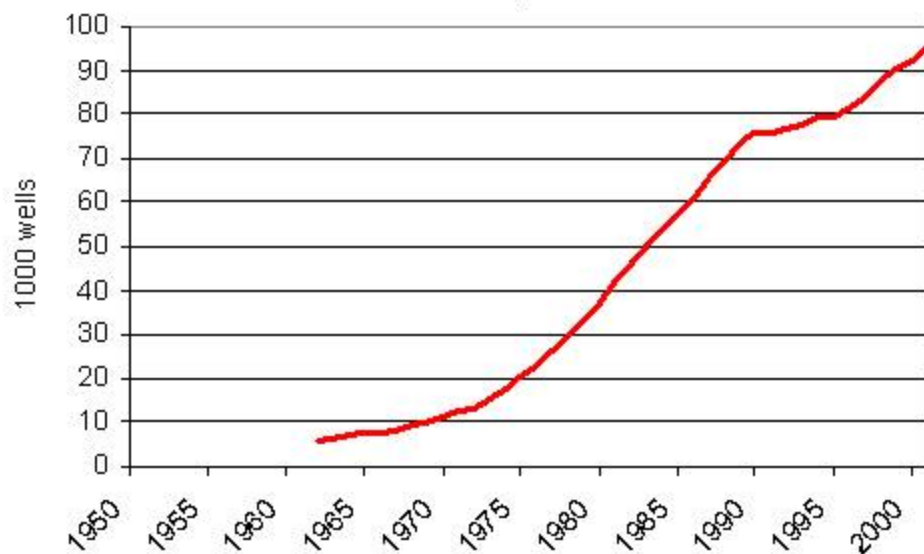


... Leading to Groundwater Bust

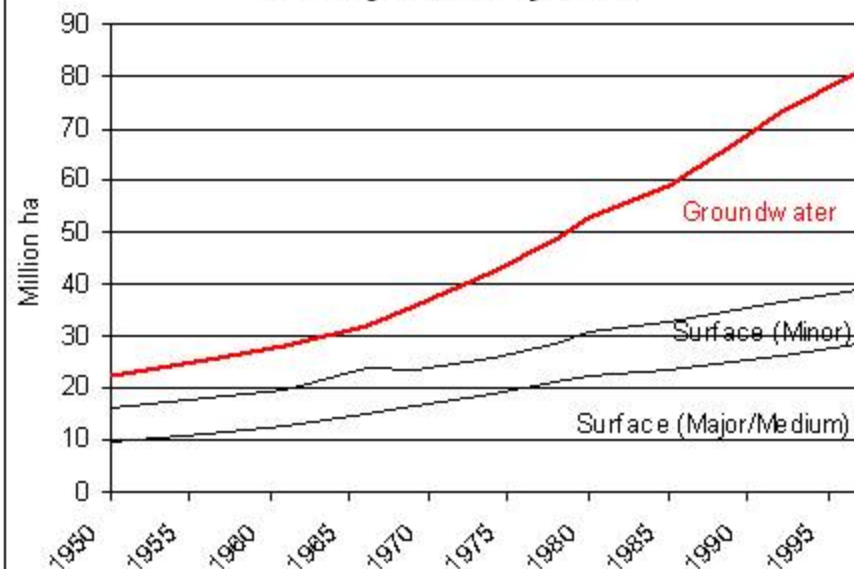
Number of Wells in Mexico

Mexico, Number of Agricultural Wells



GW Irrigation in India

India, Irrigated Area by Source

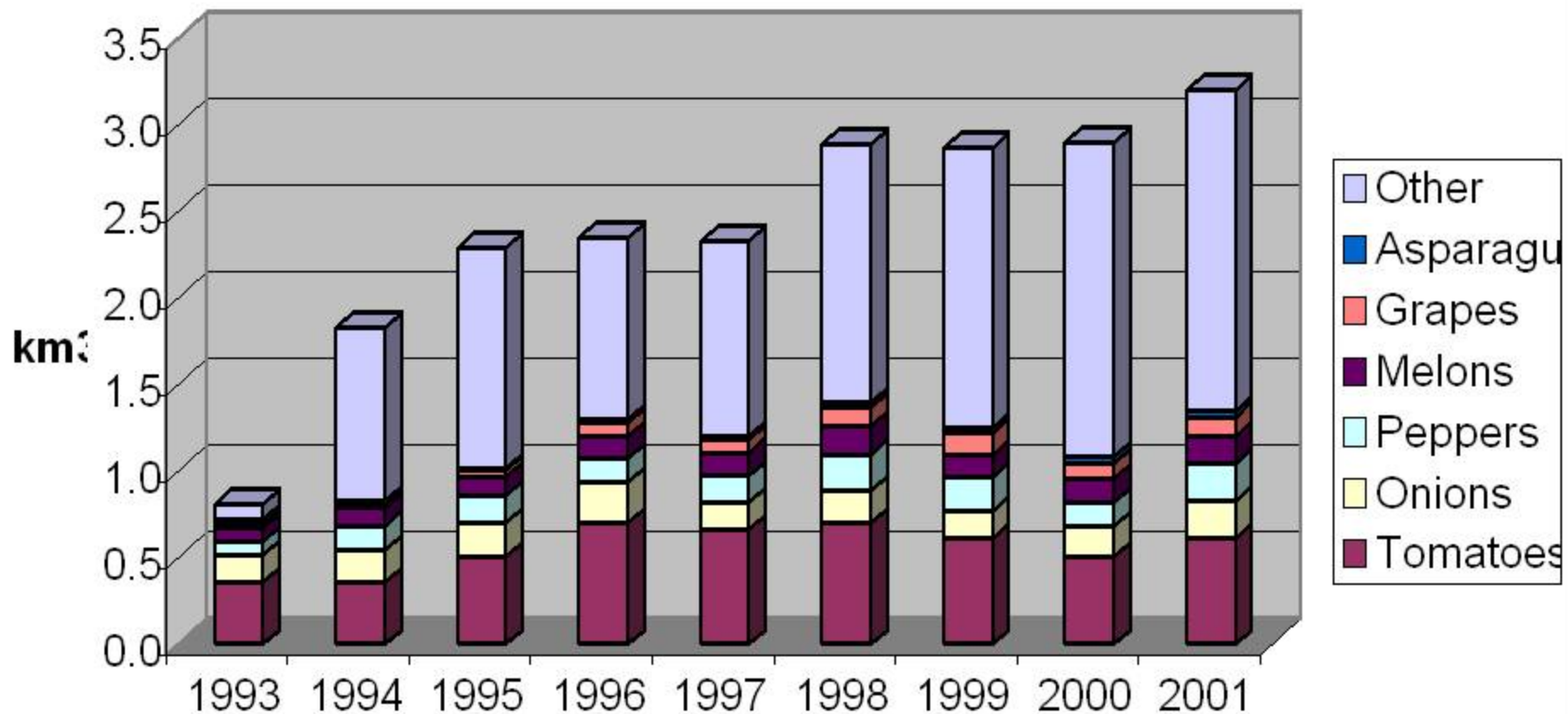


Mexico's Virtual Water Imports are Rainwater (w supplemental irrigation)

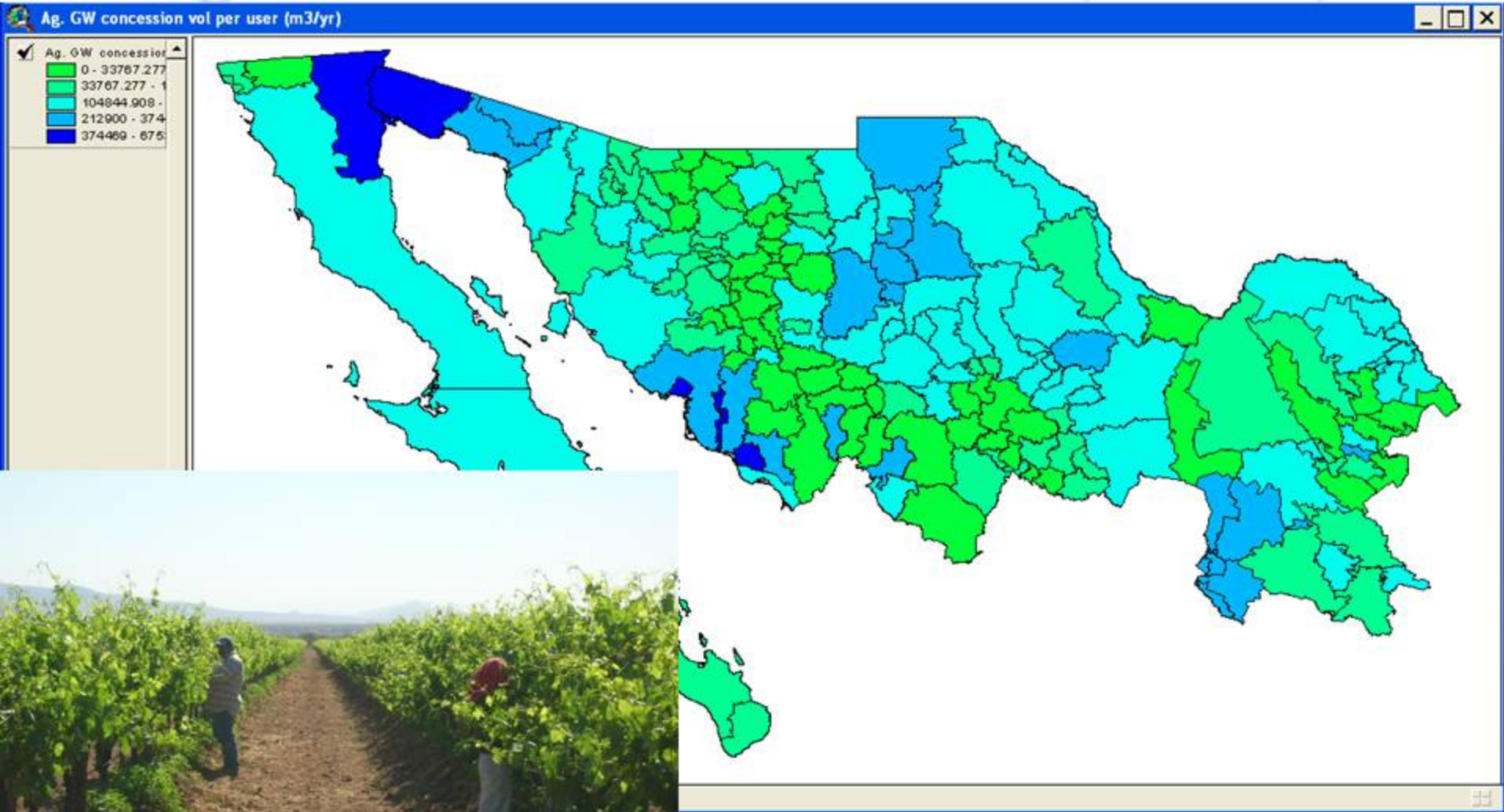
- Corn... despite the ethanol-tortilla debacle
 - Wheat
 - Grain-fed beef
 - Other animal products
 - Deciduous fruit
-

Mexico's Virtual Water Exports to the U.S. are Groundwater

Mexico's Virtual Water Exports to the U.S.



High Per-User Volumes (Titled)

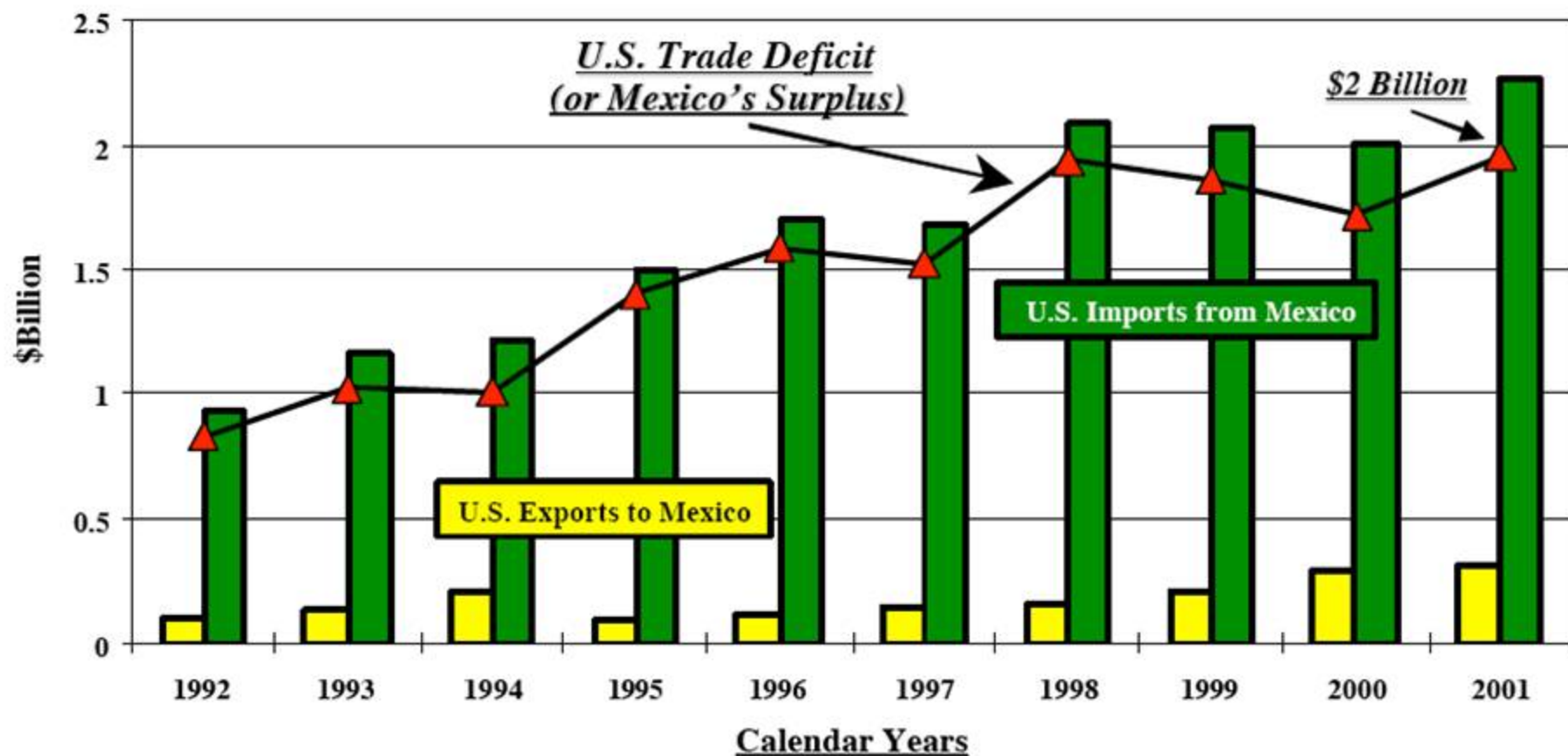


GW-Based Intensive Ag. Production

- Exports to U.S., Canada, Pacific rim
 - Expanding Mexican domestic market
 - Costa de Hermosillo (Sonora) grapes
 - Cuauhtemoc (Chihuahua) apples
 - Low water productivity in basic grains (wheat, corn) competing with high productivity horticulture
-

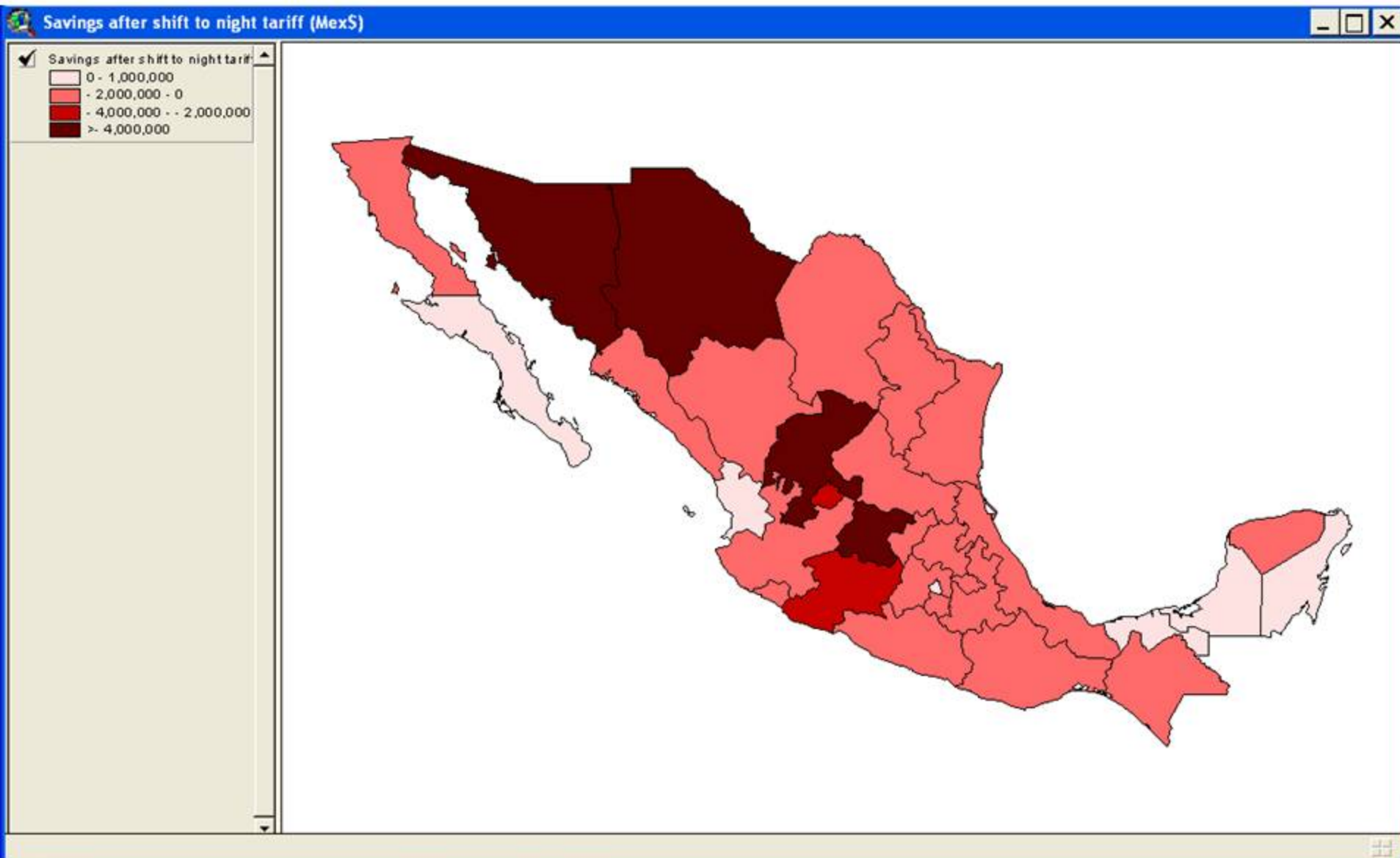
... But Overall Profits High

U.S./Mexico Fresh Fruit and Vegetable Trade



Source: U.S. Bureau of the Census

Financially, A Losing Proposition?



Shift to Night-time Irrigation



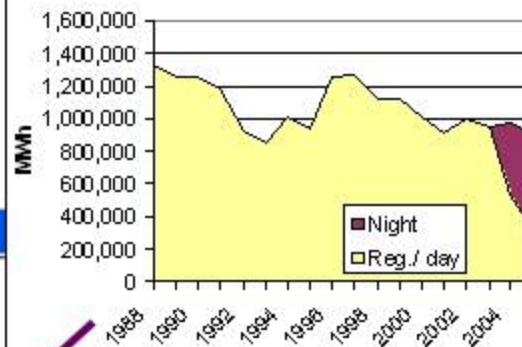
Growth, night ag. power consumption

Growth, night-time ag. power tariff (- 2005), %/yr

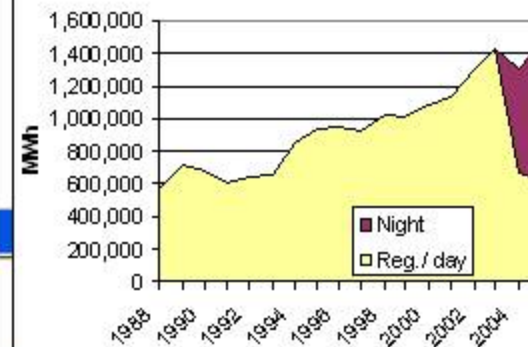
✓ Growth, night-time ag. power

- 0 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- 801 - 1500

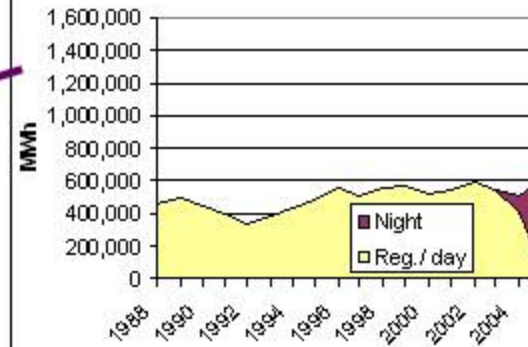
Sonora Ag. Power Consumption



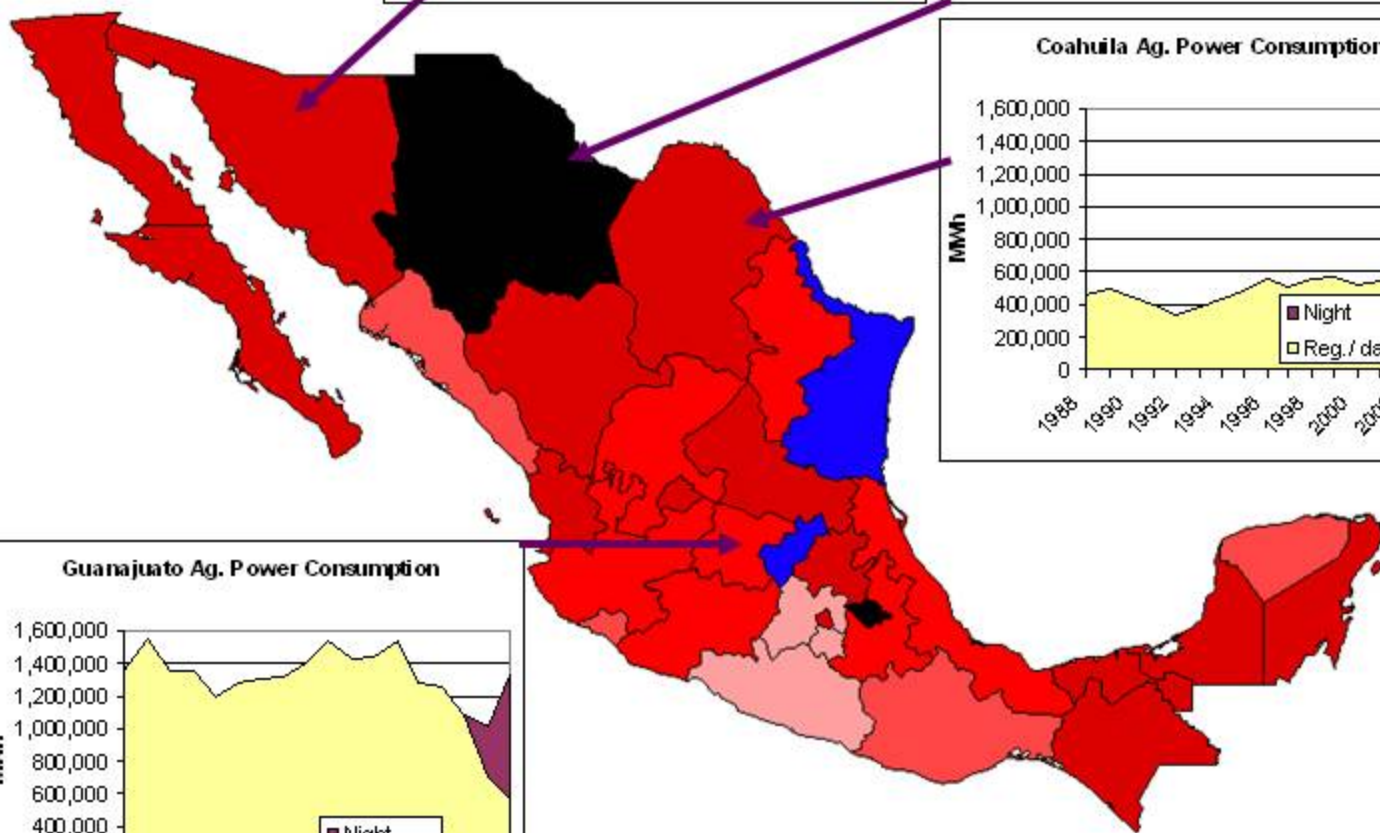
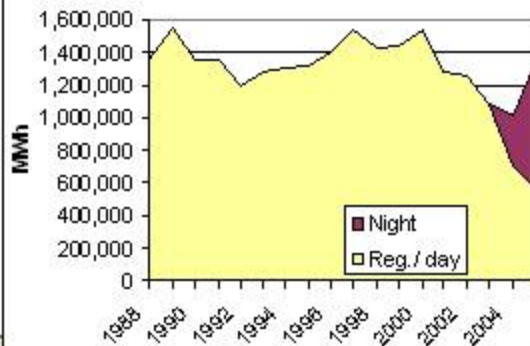
Chihuahua Ag. Power Consumption



Coahuila Ag. Power Consumption



Guanajuato Ag. Power Consumption



2003 – lost the thread? ... with lower night-time ag. tariff, but ineffective controls on volume or area irrigated

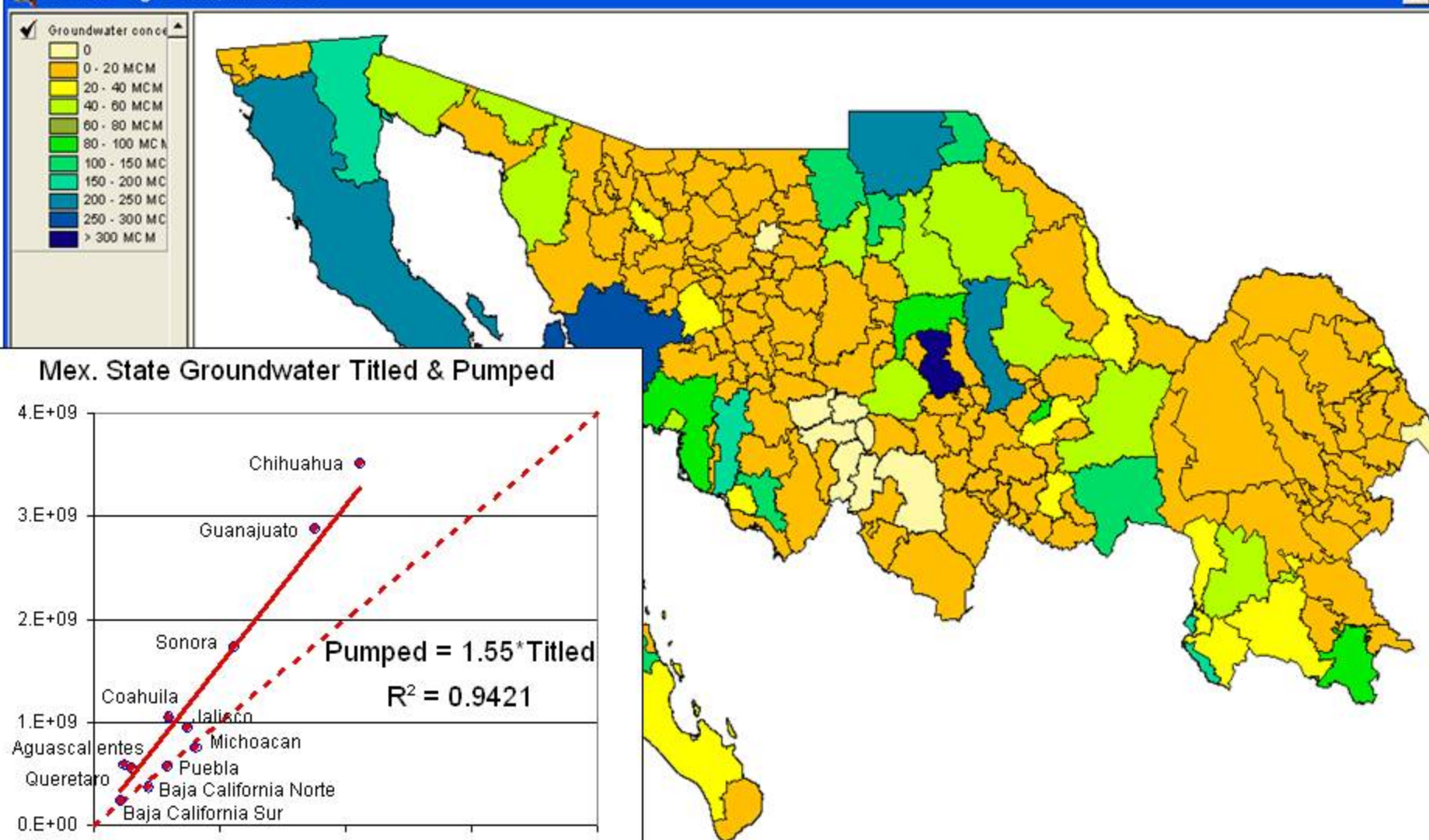
Tarifas (\$/kWh)	2003	2004	2005
1. Doméstica	0.7496	0.793	0.8356
Dom. alto consumo	1.728	2.0443	2.1236
5A. Servicios públicos	1.3353	1.4186	1.4915
6. Agua Negras y Potables	0.9727	1.041	1.0982
9. Agrícola baja tension	0.3805	0.4211	0.5357
9M. Agrícola media tension	0.3933	0.4816	0.6051
9CU. Agrícola costo unitario	0.3156	0.3928	0.435
9N. Agrícola nocturna	0.281	0.3409	0.3657

- Example: Chihuahua tariffs
- US\$ 1.00 = Mex\$ 10.80

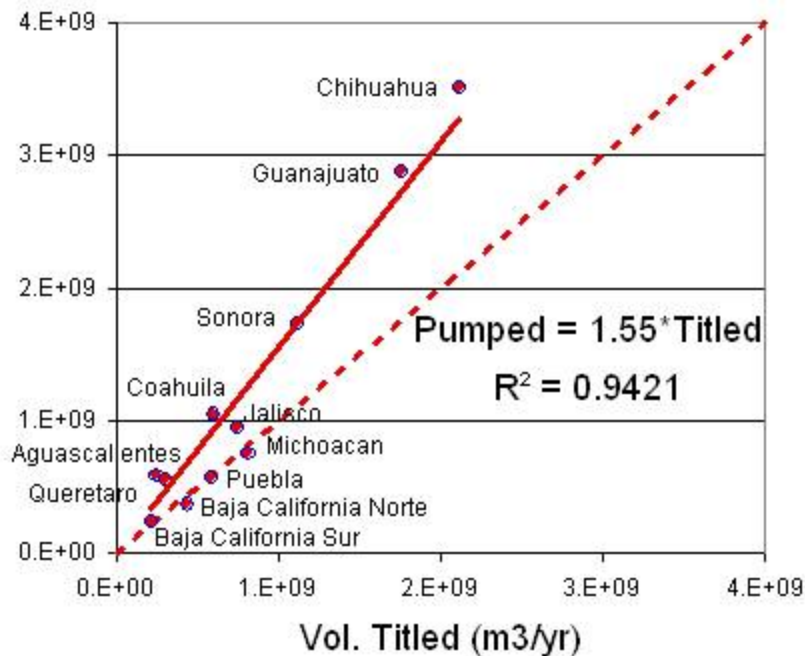
**32%
difference**

GW Titled \neq GW Pumped

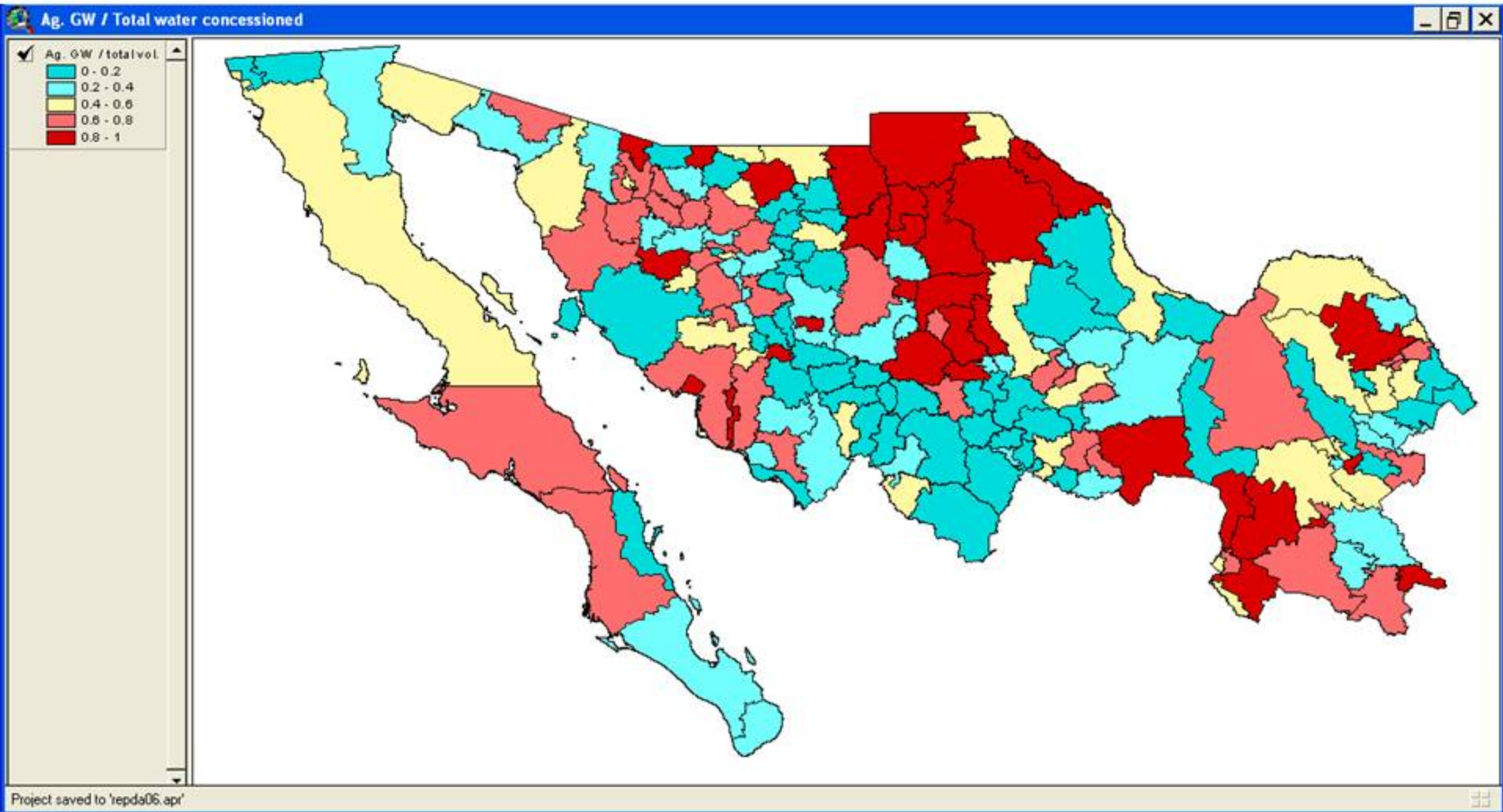
GW Titles - Ag. & Stock, REPGA 2006



Mex. State Groundwater Titled & Pumped



Ag. GW Share of Total Water Titled

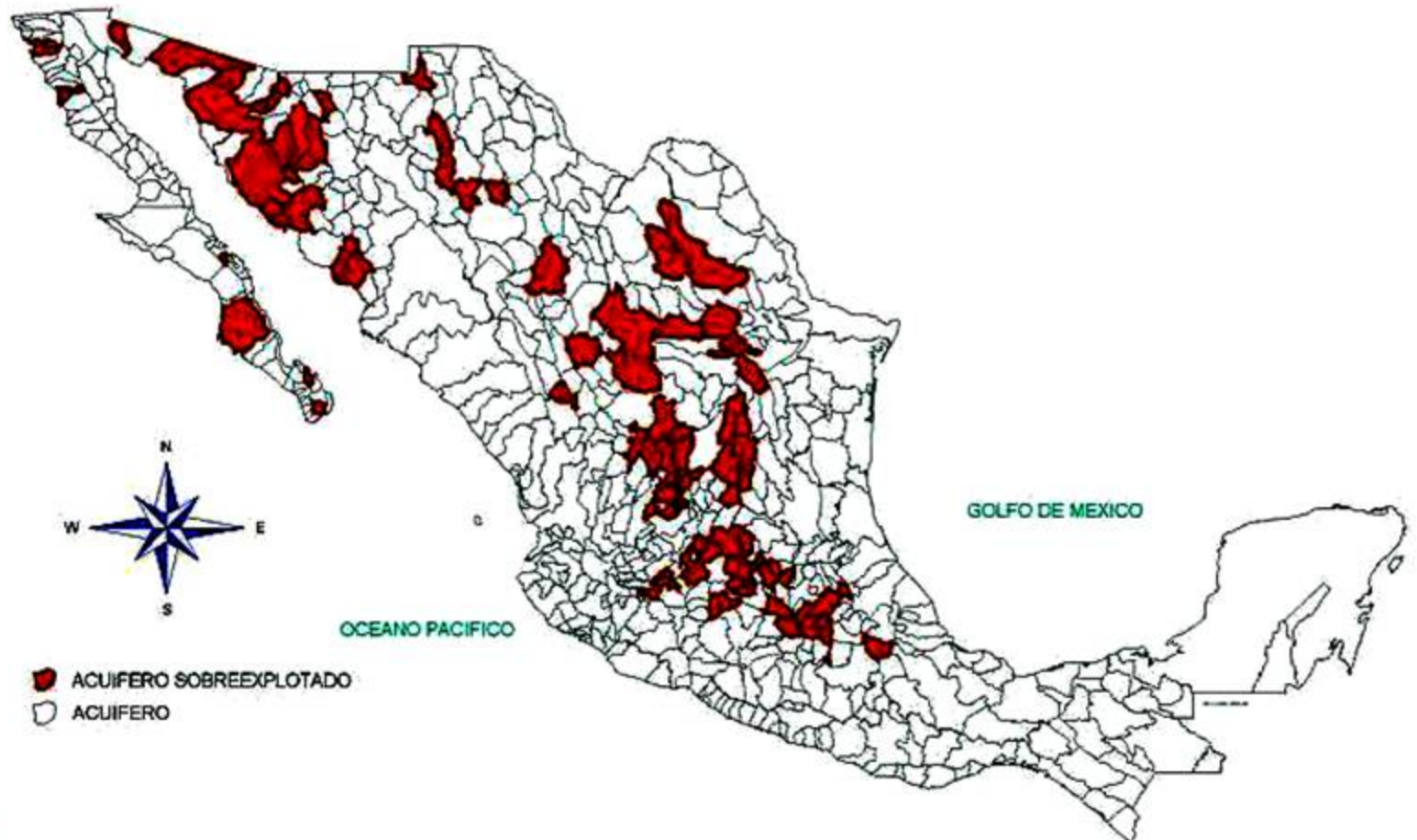


GW Sustainability Initiatives

- 1992 - water rights, titling wells
 - ❑ Registro Público de Derechos de Agua (REPDA)
 - ❑ annual concessioned volume
 - ❑ water meters, but monitoring or compliance inadequate
- Water resource (river basin) master plans
 - ❑ bans on new wells in overdrafted aquifers
 - ❑ recharge programs (controversial, runoff impacts)
 - ❑ groundwater user committees

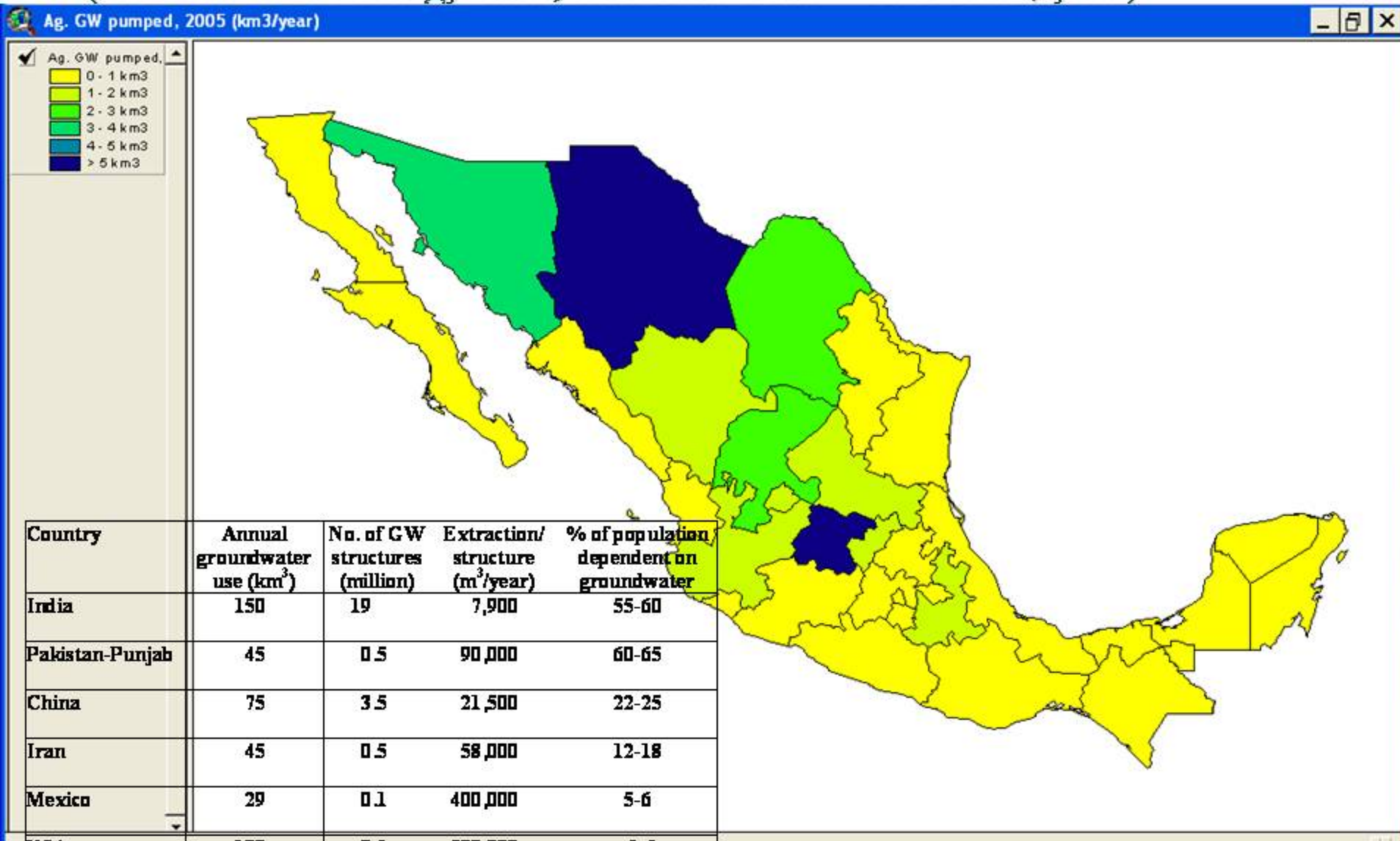


Aquifer Overdraft

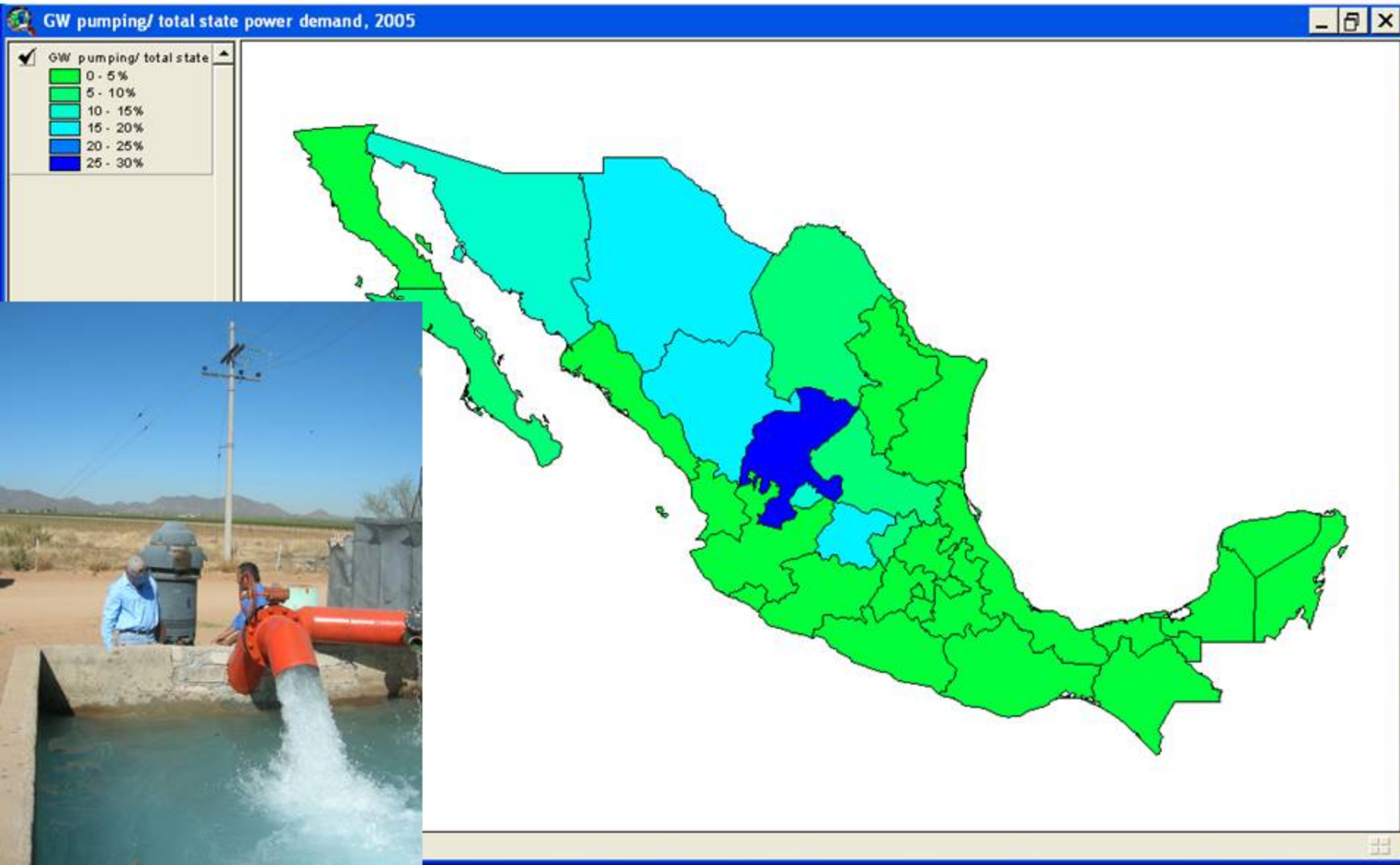


Ag. Groundwater Pumped, 2005

(derived from energy data; national total $\approx 17.6 \text{ km}^3/\text{year}$)

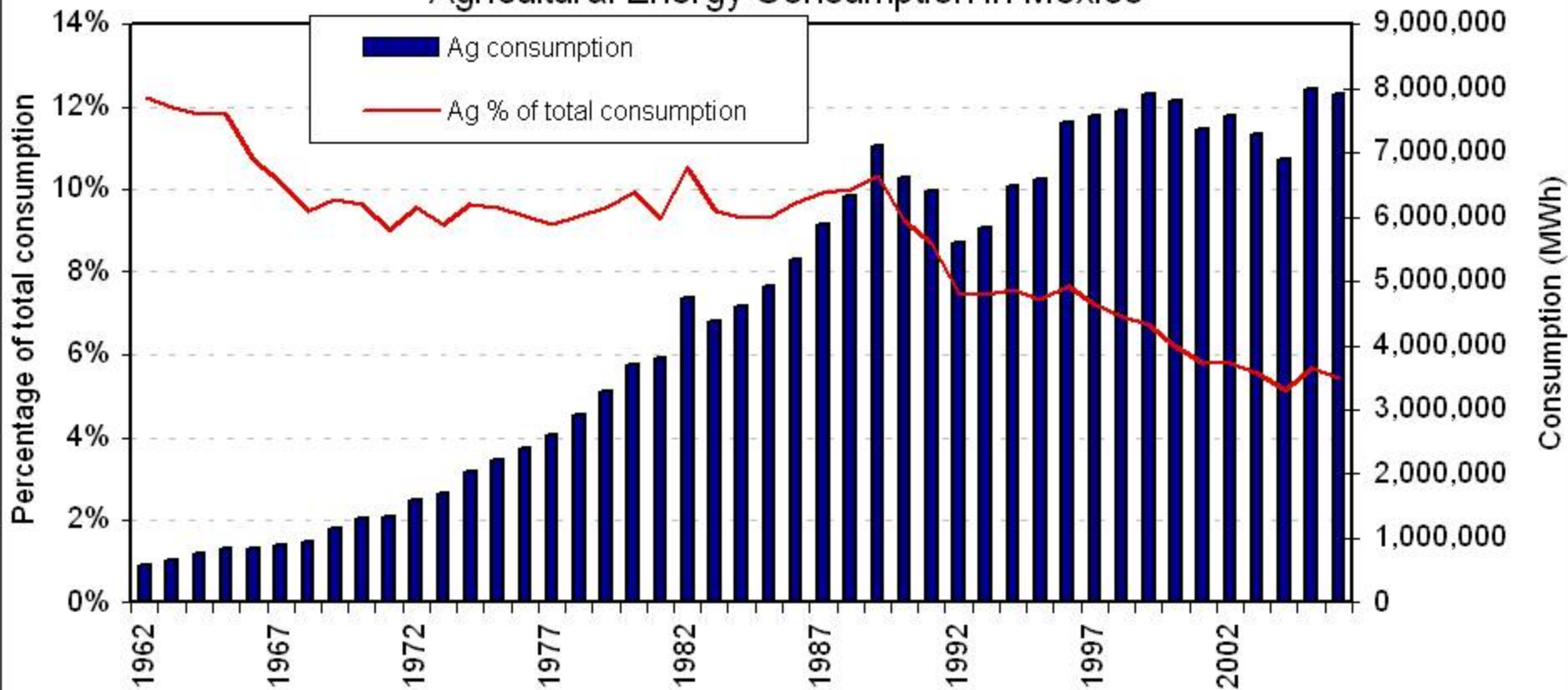


High Energy % for GW Pumping



Increasing Volume, Declining Share

Agricultural Energy Consumption in Mexico



Source: CFE, 2005.

Groundwater-Energy Supply Nexus

- Groundwater overdraft and multiple impacts are driven by electricity supply and pricing



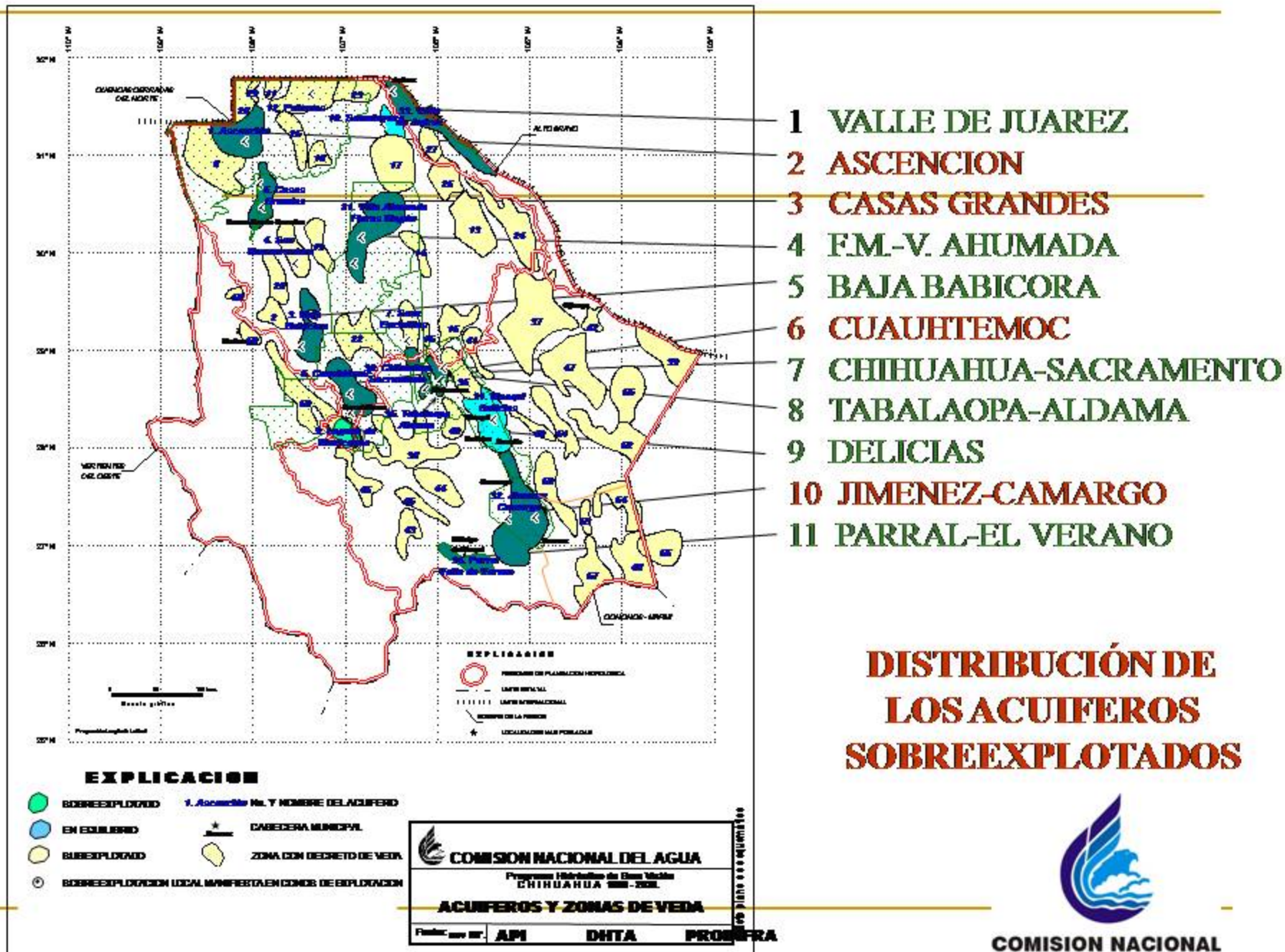


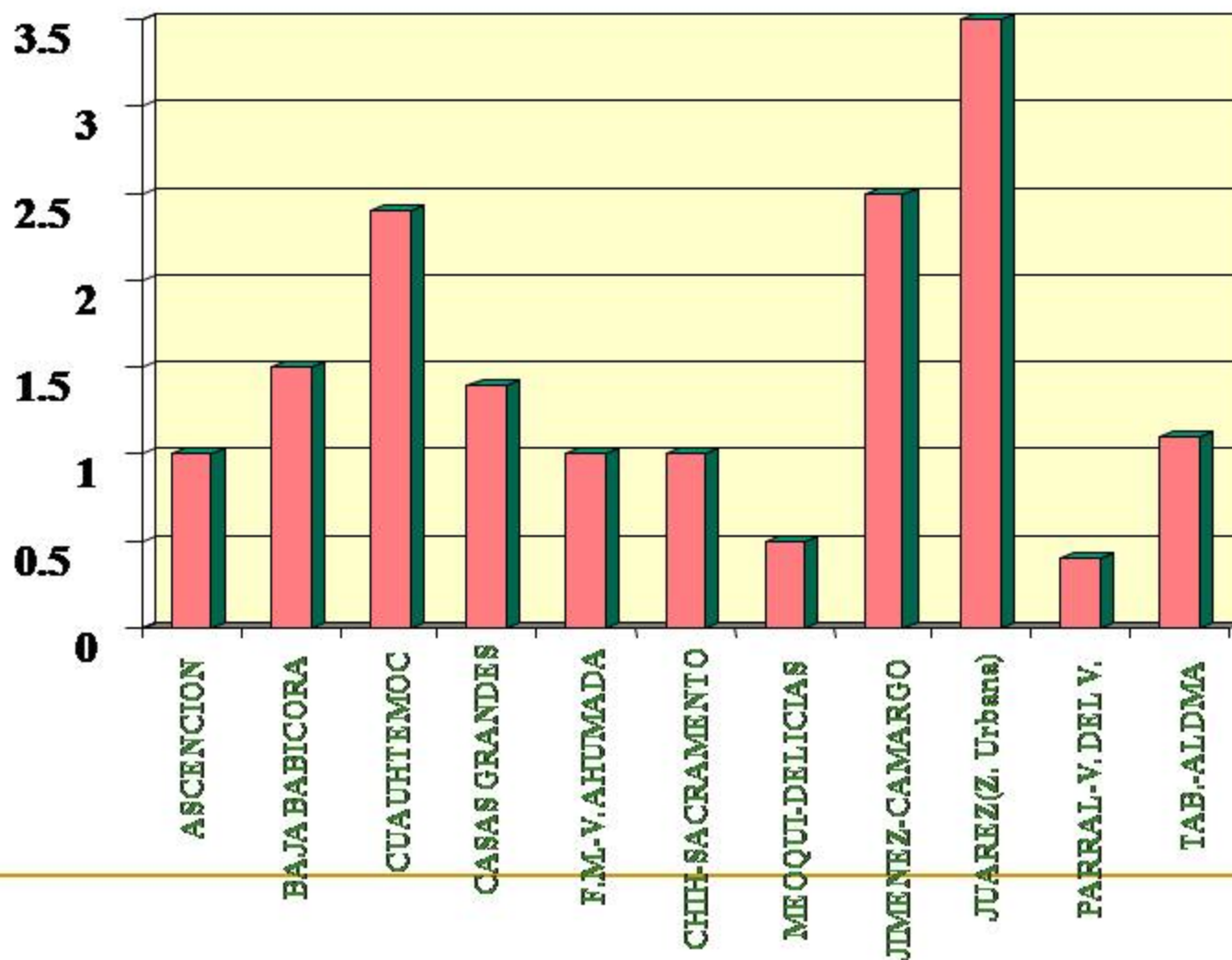
Figura 8-2



COMISION NACIONAL
DEL AGUA

ACUIFEROS SOBREEXPLOTADOS

ABATIMIENTO MEDIO EN m/año



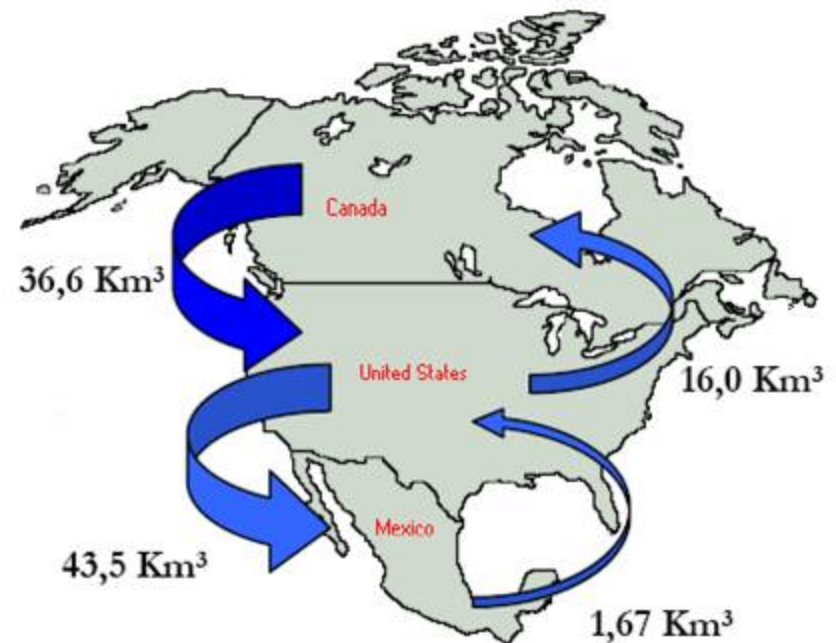
Virtual Water

Figure 3.2: Trade in embodied water in agricultural products / livestock before and after NAFTA

The Virtual Waterfall of NAFTA

Before NAFTA
1993-1994

After NAFTA
2001-2002



Failure of the Virtual Water Argument: possible explanations using the case study of Mexico and NAFTA – manuscript by Jorge Ramirez-Vallejo and Peter Rogers