29.2 Petroleum And Interactions In Mexico’s South-Central Region

A Framework to Quantify Water Availability in Shale Gas Regions of Mexico: Baseline and Development Scenarios

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1. Introduction: Mexico’s water-energy (shale oil and gas) nexus

Mexico is the sixth country with highest shale oil/gas resources and it is one of the three countries with the highest water stress (EIA, 2013)

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1. Introduction: Mexico’s water availability

Fifty percent of Mexico is considered as an arid/semiarid region with scarce physical water availability (IWMI, 2007).
1. Introduction: Water balance in ungauged basins

Water budget of a region is an easy task to compute, except when information is sparse or null, as it is common in several regions of Mexico.

\[ \Delta TWS = \Delta SW + \Delta SM + \Delta GW \]
\[ \Delta SW = P + Q_{GW} - ET - R - F \]
\[ \Delta SM = F - B \]
\[ \Delta GW = B + R_A + Q_{bi} - Q_{bo} - Q_{GW} \]

<table>
<thead>
<tr>
<th>In-situ and model based source</th>
<th>Variable</th>
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<td>P, R</td>
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<td>Empirical equations</td>
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<td>Water commissions</td>
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<th>Remote sensing and data assimilation</th>
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<td>Space borne</td>
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<td>Land models</td>
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<td>Derived from Remote Sensing</td>
<td>Q_{GW}</td>
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2. Development of shale oil/gas in Mexico

Mexico has important unconventional resources contained in 4 basins: 1) Burgos 2) Tampico-Misantla 3) Sabinas 4) Veracruz
2. Development of shale oil/gas in Mexico

Some challenges are expected in the shale oil/gas development in Mexico: lack of infrastructure, security and water scarcity.
3. Datasets and methods

Main water budget components are derived from satellites and global hydrological models.

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<tr>
<th>Dataset</th>
<th>Description</th>
<th>Extension</th>
<th>Spatial resolution</th>
<th>Temporal resolution</th>
<th>Time period</th>
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<td>GRACE</td>
<td>Gravity Recovery and Climate Experiment (GRACE) product RL05</td>
<td>Global</td>
<td>1 degree</td>
<td>Monthly</td>
<td>2003-2016</td>
<td>Seo et al. (2006)</td>
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<td>NOAA</td>
<td>Rainfall and temperature derived from the interpolation of weather stations</td>
<td>USA and Mexico</td>
<td>1/16 degree</td>
<td>Daily</td>
<td>1950-2013</td>
<td>Livneh et al. (2013)</td>
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<td>VIC</td>
<td>Output from Variable Infiltration Capacity model</td>
<td>USA and Mexico</td>
<td>1/16 degree</td>
<td>Daily</td>
<td>1950-2013</td>
<td>Livneh et al. (2015)</td>
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<tr>
<td>NLDAS</td>
<td>North American Land Data Assimilation System (NLDAS) version 2</td>
<td>USA and northern of Mexico</td>
<td>1/8 degree</td>
<td>Monthly</td>
<td>1979-2016</td>
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<tr>
<td>MODIS VI</td>
<td>Moderate-resolution Imaging Spectroradiometer (MODIS) Vegetation Index (VI)</td>
<td>Global</td>
<td>250 m</td>
<td>16 days</td>
<td>2001-2016</td>
<td>Bastiaanssen y Ali (2003)</td>
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</table>
4. Water use in Mexico’s northeast

The study area comprises the Eagle Ford play in the Sabinas and the Burgos basins in the arid/semiarid region of Mexico.
4. Water use in Mexico’s northeast

The study area is composed mainly by alluvial unconfined aquifers with groundwater availability estimates from CONAGUA.
4. Water use in Mexico’s northeast

Agricultural groundwater demand is the most important use in the study area (72%) followed by Industrial and Municipal.
5. Results: Water storage change

Water storage changes at total study area

- Total Water Storage Changes
- Storage Changes
- Precipitation anomalies
- NDVI temporal changes

Results: Water storage change

P-ET-Q
GRACE

∆TWS (mm/mes)

∆Storage (mm/mes)

∆SM>
∆TWS

Negative ∆GW on wet seasons?

Severe Drought


Catchment scale
Agricultural areas

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5. Results: Water storage changes

Water budget validation across Mexico

12 Watersheds with area > 8000 km²
Streamflow gauges with data from 2000-2010
Natural discharge or poor controlled flow
5. Results: Products validation

Validation of results using GLDAS and GRACE datasets

Total Water Storage correlation between GLDAS and GRACE

Total Water Storage with GRACE and Soil Moisture standard deviation
5. Results: Storage anomalies

Trends in water storage and NDVI across the study area

- Subregions analysis

- Allende-Piedras Negras
- Sabinas watershed
- Pesqueria watershed
5. Conclusions

- Water balance estimates (GW) using remote sensing shows significant uncertainty in Mexico’s drylands due to inconsistencies between datasets (GLDAS, NLDAS, GRACE).

- The study area is sensitive to Drought periods: during rainless years storages shown strong depletions and in humid years it shows a faster recovery.

- The Allende-Piedras Negras aquifer shows a lower recovery capacity (TWS and SM) after a long drought period.

- Historical droughts and future water demands should be considered for water management in semiarid/arid regions with potential of shale oil/gas regions to avoid conflicts between users.

EIA (2013). Technically recoverable shale oil and shale gas resources: An assessment of 137 shale formations in 41 countries outside the United States. Washington, DC.


