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Risk Report

THE EFFECTS OF ARGENTINIAN SHALE PRODUCTION ON AGRICULTURE AND PUBLIC HEALTH

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List of Abbreviations:

CDC	Centers for Disease Control
CFK	Cristina Fernández de Kirchner
EPA	Environmental Protection Agency
NGO	Non-governmental organization
NORM	Naturally occurring radioactive material
VOC	Volatile organic compound
WRI	World Resources Institute
YPF	Yacimientos Petrolíferos Fiscales

BOLTS: OPERATIONAL, FINANCIAL, COMPLIANCE.

TAGS: ARGENTINA, SHALE, AGRICULTURE, PUBLIC HEALTH, GOVERNMENT, ENVIRONMENTAL PROTECTION, REGULATION, FRACKING, RESOURCE MINING, WATER, SANITATION, WASTE MANAGEMENT.

Contents

Introduction:

In the past two decades, countries around the world have begun to exploit shale reserves of oil and natural gas. While the development of shale reserves will likely bring about monumental changes in international economic and strategic relations, such developments may also lead to potentially drastic effects on the environment, with concomitant effects on agriculture and public health.

Improved techniques in hydraulic fracturing and horizontal drilling of shale reserves led to a boom in natural gas and oil production in the US since the early 2000s[1]. As a result of this rapid increase in production, the US passed Russia and Saudi Arabia to become the world's largest producer of crude oil in 2018[2]. Other countries, such as China and Argentina, have since attempted to use similar techniques to increase their own exploitation of domestic shale reserves. While the reserves in China may be the world's most abundant, they are buried in irregular formations and at deep levels and will prove to be more costly to extract than elsewhere[3]. Reserves in Argentina are comparatively accessible, and the country has spared no effort to develop the reserves in recent years.

[1] Rapier, Robert. "How The Shale Boom Turned The World Upside Down." Forbes, 21 Apr. 2017, https://www.forbes.com/sites/rrapier/2017/04/21/how-the-shale-boom-turned-the-world-upside-down/#2fd01ad477d2. Accessed 11 July 2019.

[2] United States; U.S. Energy Information Administration; Today in Energy; *The United States is now the largest global crude oil producer*; US Energy Information Administration, 12 Sep. 2018, https://www.eia.gov/todayinenergy/detail.php?id=37053. Accessed 11 July 2019.

[3] "China Sits on the World's Biggest Shale Gas Prize. Pumping It Out Is the Hard Part." *Bloomberg*, 19 Jul. 2018, https://www.bloomberg.com/news/features/2018-07-19/petrochina-sinopec-are-chasing-an-elusive-shale-boom. Accessed 11 July 2019.

The Start of Shale Production in Argentina

Construction and development of shale fields in Argentina began in 2010[4]. That year Argentina's state oil company, YPF, began work on the Vaca Muerta fields. Other local and foreign oil companies have since invested in the region. In 2013, a well run by YPF began producing oil for the first time[4]. Since then, production has increased dramatically, and the trend is expected to continue into the next decade[5, 6]. Major players in the field currently include YPF, Shell, Total, ExxonMobil, and Pan American Energy[4]. Overall output for the region reached an estimated 160,000 barrels of oil equivalent per day in September 2018[5]. In comparison, the Permian Basin in the US currently produces about 4 million barrels per day[7]. Furthermore, Argentina reached an important milestone in June 2019, as the country began the first exports of light crude oil and liquified natural gas (LNG) from the region[8].

The rapid developments in Vaca Muerta have the potential to significantly improve Argentina's energy security and economic situation. Argentina has imported more energy than it exported since 2011[6]. In 2017, Argentina exported roughly $2.68 billion worth of mineral products, which included refined petroleum and petroleum gas[9]. That year, Argentina imported $2.15 billion of petroleum gas, $2.1 billion of refined petroleum, and $443 million of crude petroleum[9]. In the years ahead, increased domestic production at Vaca Muerta may lead to a dramatic reversal in this energy trade imbalance. Argentina plans to become a net energy exporter

[4] Mander, Benedict. "Macri's energy reverse unnerves Argentina's shale investors." *Financial Times*, 28 June 2018, https://www.ft.com/content/3158be92-78b3-11e8-bc55-50daf11b720d. Accessed 11 July 2019.
[5] Neff, Clay. "Unlocking the potential of Argentina's oil and gas reserves." *Financial Times*, 23 Sept. 2018, https://www.ft.com/content/b0bd3358-b10b-11e8-87e0-d84e0d934341. Accessed 11 July 2019.
[6] Parraga, Marianna. "Argentina aims to boost gas output, supply with higher investment: official." *Reuters*, 11 Mar. 2019, https://www.reuters.com/article/us-ceraweek-energy-argentina-oil/argentina-aims-to-boost-gas-output-supply-with-higher-investment-official-idUSKBN1QS2L7. Accessed 11 July 2019.
[7] Domm, Patti. "This Texas area is expected to double oil output to 8 million barrels in just four years, boosting US exports." *CNBC*, 8 Mar. 2019, https://www.cnbc.com/2019/03/08/permian-oil-output-doubling-to-8-million-barrels-boosting-exports.html. Accessed 11 July 2019.
[8] Mander, Benedict. "Argentina delivers first exports from Vaca Muerta deposit." *Financial Times*, 27 Jun. 2019, https://www.ft.com/content/5d137e72-9901-11e9-8cfb-30c211dcd229. Accessed 11 July 2019.
[9] MIT Atlas Media; Countries; Argentina; Argentina- Exports and Imports; MIT Atlas Media, https://atlas.media.mit.edu/en/profile/country/arg/. Accessed 11 July 2019.

by 2020, and the Vaca Muerta will play a significant role in this process[10]. The former populist president (2007-2015) Cristina Fernandez de Kirchner (CFK) is currently the running mate of Alberto Fernandez, who is polling higher than the incumbent president Mauricio Macri. If Alberto Fernandez and CFK are elected in October, the government may return to the use of restrictive policy tools such as export taxes and price controls which CFK utilized during her term as president[11].

A rapid increase in Argentinian shale production may potentially lead to serious negative effects on the local environment. Many NGOs and members of the scientific community warn that rapid development coupled with less than stringent regulation of shale developments could release shale-related pollutants into the nearby soil, air, and water. These pollutants could lead to serious risks for the local agricultural sector and the public health of the nearby community at large.

Past Problems with Shale

In the past, researchers and journalists have documented instances in which shale developments (otherwise known as shale "plays") in other countries have led to negative consequences for the local environment. Each step in the shale production process, including extraction, processing, distribution and waste disposal could potentially release harmful pollutants into the local water, soil, or air. Additionally, the retrieval of hydrocarbons from shale wells

[10] "Shale helps Argentina hit new oil, natural gas output record." *Reuters*, 2 Jul. 2019, https://www.reuters.com/article/us-argentina-shale/shale-helps-argentina-hit-new-oil-natural-gas-output-record-idUSKCN1TX28W. Accessed 11 July 2019.
[11] "Dead-cow bounce." *Economist*, 23 Aug. 2014, https://www.economist.com/the-americas/2014/08/23/dead-cow-bounce. Accessed 20 Aug. 2019.

requires significant amounts of water and may lead to increased water strain for a given area. Shale projects under construction can strive to minimize the environmental risks associated with past plays.

A typical shale play includes various installations and activities above and below ground[12]. A well descends thousands of meters underground from the well pad. For several hundred meters down near the surface, the well includes cement reinforcement and casing to prevent methane from leaking into groundwater at that level. At deeper levels, the well then turns horizontally at the "well heel" as it reaches shale oil reserves. Fracking fluid is pumped out of the well at this level in order to break up the shale, prop open cavities, and facilitate the retrieval of the fuel trapped in the shale. Fracking fluid is approximately 90% water, 9% proppants such as sand or glass, and 1% chemical additives to fight corrosion and bacteria, and act as a lubricant. After hydraulic fracturing commences and the well is first opened, a preliminary mix of materials will run up through the well; this initial mix of spent fracking fluid and other materials is known as "flowback water[13]." Thereafter, the well will continually bring a combination of shale fuel and wastewater, also called "produced water," back to the surface until operation ceases[12]. After this step, the wastewater must be separated from the fossil fuels then either processed for reuse as fracking fluid or stored safely. Wastewater is often stored in open-air surface pits that have the potential to overflow, leak, and release liquids or gasses into the environment. Flare pipes burn methane released from the well to account for the risk of pressure

[12] Ehrenberg, Rachel. "The facts behind the frack: Scientists weigh in on the hydraulic fracturing debate." Science news182.5 (2012): 20-25. Accessed 9 July 2019.
[13] Rosa, Lorenzo, et al. "The water-energy nexus of hydraulic fracturing: a global hydrologic analysis for shale oil and gas extraction." Earth's Future 6.5 (2018): 745-756. https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2018EF000809. Accessed 11 July 2019.

build-up and explosions. Without effective safety measures, harmful pollutants can enter the environment at each of the aforementioned stages involved at a typical shale development.

Despite prevention efforts, past shale plays have led to the release of pollutants into the local environment. The most widespread issue arises from a faulty seal or cracks in the underground concrete around the well which may lead to methane seeping into the local groundwater, potentially triggering fires[14, 12]. The EPA has estimated a list of 1,084 chemicals used in US-based fracking operations[15]. Past studies have demonstrated that casings fail to prevent leakage for roughly 1% to 10% of all wells[16]. Both the initial flowback water and ensuing produced water contain organic and inorganic compounds that pose risks for the local environment and for human health through the effect on drinking water. The flowback and produced water often contains high levels of salinity, and may enter the local groundwater, soil, or waterways. High local soil salinity limits agricultural output[17]. Associated health risks vary by chemical use and consequently by site, but past risks have included the release of a multitude of confirmed carcinogens, neurotoxins, chemicals harmful to the kidney, and endocrine and immune system disruptors into the environment[18, 15]. For example, flowback water can carry significant levels of salt, mercury,

[14] Vidic, Radisav D., et al. "Impact of shale gas development on regional water quality." Science 340.6134 (2013): 1235009. http://pages.iu.edu/~kforinas/E/Nonrenewable/4.pdf. Accessed 11 July 2019.
[15] U.S. EPA (U.S. Environmental Protection Agency). 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Office of Research and Development, Washington, DC. EPA/600/R-16/236Fa, https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990. Accessed 11 July 2019.
[16] Golden, Mark. "Stanford-led study assesses the environmental costs and benefits of fracking." *Stanford News*, 12 Sep. 2014, https://news.stanford.edu/news/2014/september/fracking-costs-benefits-091214.html. Accessed 11 July 2019.
[17] Shrivastava, Pooja, and Rajesh Kumar. "Soil salinity: a serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation." Saudi journal of biological sciences 22.2 (2015): 123-131, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4336437/. Accessed 11 July 2019.
[18] "Treated Fracking Wastewater Contaminated Watershed With Radium and Endocrine Disrupters, Study Finds." *Yale Environment E360 Digest*, 17 Jul. 2017, https://e360.yale.edu/digest/treated-fracking-wastewater-contaminated-watershed-with-radioactive-material-and-endocrine-disrupters-study-shows. Accessed 11 July 2019.

arsenic, and naturally occurring radioactive material (NORMs)[19, 12, 20]. Wastewater can contain arsenic and manganese, which may disrupt the endocrine system, as well as Polycyclic aromatic hydrocarbons, which are carcinogenic[20]. These examples provide only a snapshot of the multitude of chemicals and pollutants released by shale operations.

The development of shale plays also requires high volumes of water and may place a strain on the environment. Each well uses on average between 2 and 8 million gallons (7.57 to 30.28 million liters) of water. A typical shale play contains thousands of wells, and thus may put a further strain on local water sources over time if the area already exhibits water strain[21, 22]. For example, 61% of shale reserves in China can be found in areas that exhibit high water stress or an arid environment[23]. In contrast, 72% of shale reserves in Argentina currently exhibit low to medium water stress[23].

Past Effects of Shale Development and Government Responses

Shale development has caused negative effects on the environment in a number of past cases and has led to public focus on effective government monitoring and regulation. For example, one study of the Marcellus shale play in Pennsylvania demonstrated that proper wastewater treatment and disposal still caused high salinity and radioactivity in downstream waterways and river sediments[23]. Another study by Mark Zoback at Stanford detailed a case of wastewater spills in Pennsylvania in 2009. Four thousand gallons (over 15 thousand liters) of wastewater spilled into

[19] Li, Rui, et al. "Mercury pollution in vegetables, grains and soils from areas surrounding coal-fired power plants." Scientific reports 7 (2017): 46545, https://www.nature.com/articles/srep46545. Accessed 11 July 2019.
[20] Sun, Yuqing, et al. "A critical review of risks, characteristics, and treatment strategies for potentially toxic elements in wastewater from shale gas extraction." Environment international 125 (2019): 452-469, https://www.sciencedirect.com/science/article/pii/S0160412018322487. Accessed 11 July 2019.
[21] Kumar, Devika Krishna, and DiSavino, Scott. "U.S. shale output forecast to hit record 8.46 million bpd in May: EIA." *Reuters*, 15 Apr. 2019, https://www.reuters.com/article/us-usa-oil-productivity/u-s-shale-output-forecast-to-hit-record-8-46-million-bpd-in-may-eia-idUSKCN1RR20S. Accessed 11 July 2019.
[22] "Infographic: Protecting Water Security, Promoting Energy Security." *World Resource Institute*, Sept. 2014, https://www.wri.org/resources/data-visualizations/infographic-protecting-water-security-promoting-energy-security. Accessed 11 July 2019.
[23] Vengosh, Avner, et al. "The effects of shale gas exploration and hydraulic fracturing on the quality of water resources in the United States." Procedia Earth and Planetary Science 7 (2013): 863-866, https://www.sciencedirect.com/science/article/pii/S1878522013002944. Accessed 11 July 2019.

a local creek, which led to the deaths of local fish and invertebrates[12]. Such pollutants would undoubtedly lead to negative effects for the local environment and for local public health.

Governments have taken some steps to regulate the shale industry, but legal loopholes and weak regulations have allowed many companies to release harmful materials into the environment. In the US, the Energy Policy Act of 2005 contained a loophole that allowed companies to inject fracturing fluid underground without following the Safe Drinking Water Act[24]. As a result, harmful materials from the fracturing fluid may enter the groundwater. Additionally, in some US states, companies are not required to release the list of chemicals that their fracturing fluid contains[25]. In one instance, an EPA report on contaminated drinking water in Pennsylvania did not require federal action, while a separate CDC investigation of the same water found high enough levels of lead, cadmium, arsenic, and copper to pose a danger to residents' health[25]. Insufficient state-level regulation has led to thousands of complaints in local courts related to the effect of fracking on local drinking water quality[25]. Thus, US regulations of the fracking industry require improvements in scope and enforcement. Without an improved regulatory framework, the accidental release of harmful materials into the environment remains a significant risk.

[24] Stone, Judy. "Fracking And What New EPA Means For Your Health." *Forbes*, 17 Feb. 2017, https://www.forbes.com/sites/judystone/2017/02/17/fracking-and-what-new-epa-means-for-your-health/#14d61c1638e1. Accessed 11 July 2019.

[25] Banerjee, Neela. "Special report: How the U.S. government hid fracking's risks to drinking water." *NPR State Impact Pennsylvania*, 22 Nov. 2017, https://stateimpact.npr.org/pennsylvania/2017/11/22/special-report-how-the-u-s-government-hid-frackings-risks-to-drinking-water/. Accessed 11 July 2019.

The Current Shale-related Policy Environment in Argentina

The regulatory system in Argentina also faces challenges regarding the limitation of environmental effects from shale development. Since 2002, companies have required permits to use local water sources and dispose of wastes in local bodies of water[26]. And yet, the Ministry on the Environment and Sustainable Development has not promulgated a standard with which to determine whether the disposed fluids are safe[27]. The government allows companies to inject wastewater underground. Surface water use for hydraulic fracturing is not limited by regulation[13]. Companies are required to have action plans in place to deal with potential crises, such as spills. In the case of a spill, gas leak, or related crisis, companies are required to report to the Secretariat of Energy within one day. In 2012, Neuquén Province, the location of the Vaca Muerta shale play, promulgated a series of new regulations[27]. These regulations require companies to submit an environment report before beginning development, prohibit the disposal of wastewater in surface water or storage of wastewater in open tanks, and prohibit the use of groundwater in the production process. Lastly, Argentina's legal system allows the public to request information on the federal executive branch and on companies that have received national-level subsidies or other financial assistance. For instance, in 2013 the Argentinian government initiated the Plan Gas subsidy program to stimulate

[26] ***The Shale Dilemma: A Global Perspective on Fracking and Shale Development*. Edited by Gamper-Rabindran, Shanti, University of Pittsburgh Press, 2018.**

investment in natural gas[27]. One recipient of funds under this program is the state-controlled oil company, YPF.

Thus, both the national and provincial governments have passed some regulations that have the potential to limit the negative environmental impacts of shale. Yet the government must pass further regulations to fix the current regulatory lacunae. The public and even legislators have faced challenges attempting to access data on shale plays[27]. Additionally, while in some instances the policies are sufficiently strict, the government either cannot or chooses not to enforce them in every applicable instance. The alacrity of the boom in the industry has placed a strain on current regulatory agencies, as under-staffed or under-funded regulators may be unaware of regulatory breaches or overlook them completely[27].

Agricultural Output in Argentina

The Vaca Muerta shale development could pose water use and salinity risks for the farmland in both the Neuquén and Río Negro Provinces. The shale reserve can mainly be found in Neuquén, but the Limay River, Neuquén River, and many other waterways from that province feed the Negro River, which is a major source of water for farming in Río Negro Province.

Argentina produces significant levels of agricultural goods for export. In 2017, the country exported $13.2 billion in vegetable products and $13.3 billion in foodstuffs[9]. Major agricultural exports include soybeans, soy meal, wheat, and corn[9]. The fertile Pampas region, which centers on the

[27] Cohen, Luc. "Argentina plans 2019 payment of $1.5 bln in delayed gas subsidies." *Reuters*, 15 Mar. 2018, https://www.reuters.com/article/argentina-energy/argentina-plans-2019-payment-of-15-bln-in-delayed-gas-subsidies-idUSL1N1QX1RZ. Accessed 11 July 2019.

Buenos Aires region, produces a significant portion of the country's overall agricultural output.

The Neuquén and Río Negro Provinces may not be the main hubs of Argentinian agriculture, but they produce a significant amount of produce for export. In fact, 85% of the country's apples and pears are produced in Río Negro Province, and 10% in Neuquén Province. Fruit and vegetable farms in Neuquén cover roughly 10 million hectares and act as a major part of the provincial economy[28]. The country exported $75 million of apples and $256 million of pears in 2019[29]. Farming for these two fruits provides employment for a large section of the population, with over 2,000 separate producers, and separate companies that provide packing and storage services[30].

Shale-related Pollution and Water Use in Argentina

Evidence provided by various NGOs and journalists suggests that Argentinian shale production has already led to pollution of the environment and may lead to strain on water resources in the future. Legally certified inspectors from Earthworks in 2018 used a special camera, the FLIR GF320, to monitor levels of methane, VOCs, and toxic gases released at shale plays near the cities of Allen, Añelo,

[28] Forni, Laura, et al. "Navigating the water-energy governance landscape and climate change adaptation strategies in the northern Patagonia region of Argentina." Water 10.6 (2018): 794, https://www.mdpi.com/2073-4441/10/6/794. Accessed 11 July 2019.

[29] Balbi, Maria Julia. "Argentina- Fresh Deciduous Fruit Annual." *USDA Foreign Agricultural Service*, 16 Nov. 2018, https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Fresh%20Deciduous%20Fruit%20Annual_Buenos%20Aires_Argentina_11-16-2018.pdf. Accessed 11 July 2019.

Vista Alegre, and Neuquén[30]. Breathing in VOCs can prove especially harmful, as they can cause cancer, severe health problems, or even immediate death. They found evidence of these three types of leaks of in nearly all of the over 25 sites visited. Besides fugitive emissions, oil plays release contaminants into the soil and water sources. On average, two spills occur per day near the reservoir that provides the city of Neuquén with water[31]. In October 2018, gas and oil from one play was accidentally released into the environment near Añelo and the Neuquén River for 36 hours. Given the relatively over-burdened government regulatory system, the lack of nationwide standards for shale waste disposal, and opaque state of government data on environmental impacts, emissions and spills like these are perhaps much more widespread and could continue into the future.

While the WRI Aqueduct project shows low to medium water risk in the area that contains the Vaca Muerta fields as of August 2019, areas in Río Negro Province fed by rivers that start in the Vaca Muerta region face high water risk [32]. Since Argentinian policy does not limit the use of water for shale development, water use by shale plays may put a strain on water resources over time. One study argues that extended fracking will lead to increased water stress, decreased reservoir levels, and a decrease in the quantity of water that could be used for irrigation[13]. Over time, this would increase water risk for areas in both Neuquén Province and Río Negro Province. Water volumes of the Limay and Neuquén Rivers have already decreased by 30% in the past 20 years for non-shale related reasons, but shale developments could add to this trend[29]. Areas in Río Negro Province that are currently at high water risk will face an even more severe level of strain on water resources.

[30] "Toxic Gases Registered in Argentina's Oil and Gas Sector with Infrared Technology." *Center for Human Rights and Environment*, 23 Apr. 2018, http://center-hre.org/toxic-gases-registered-in-argentinas-oil-and-gas-sector-with-infrared-technology/. Accessed 11 July 2019.
[31] Gatehouse, Mike. "Argentina: toxic waste from fracking in Patagonia." *Latin America Bureau*, 19 Dec. 2018, https://lab.org.uk/argentina-toxic-waste-from-fracking-in-patagonia/. Accessed 11 July 2019.
[32] World Resource Institute; *Aqueduct Water Risk Atlas-Current Conditions*; 2014, https://www.wri.org/applications/maps/aqueduct-atlas/#x=-55.17&y=-33.07&s=ws!20!28!c&t=waterrisk&w=def&g=0&i=BWS-16!WSV-4!SV-2!HFO-4!DRO-4!STOR-8!GW-8!WRI-4!ECOS-2!MC-4!WCG-8!ECOV-2!&tr=ind-1!prj-1&l=4&b=terrain&m=group. Accessed 11 July 2014.

The Effects of Shale-related Water Use and Pollution in Argentina

Shale developments have already begun to affect the Argentinian environment near Vaca Muerta and will continue to do so into the future. A growing body of evidence describes how shale developments lead to both pollution and water strain. Shale plays lead to increased local soil salinity, which can decrease agricultural outputs. Hydrocarbon fracturing requires high levels of water and poses a risk to water availability in both the Neuquén and Río Negro provinces, which could also lead to lower agricultural productivity in the future. The presence of other pollutants in the soil and water could lead to the rejection of Argentinian agricultural exports by other countries or regions due to safety concerns.

In the future, developments could also pose a major public health risk for people living near the shale plays. Some shale oil production sites currently release unspecified levels of pollutants into the local air, soil, and water. The provincial and central government in Argentina must improve oversight and regulation of shale-related pollution. The released pollutants could lead to serious health consequences for individuals that live nearby or even a general public health crisis for the provinces involved if the pollution is not sufficiently monitored and curbed.

Strategic Summary:

Risks:

- Due primarily to pollution and water use, current shale developments threaten the public health of local residents and the long-term productivity of local agriculture.
- Weak enforcement of current regulations for the shale industry and lack of sufficient government resources contribute to the development of these problems.

Opportunities:

- The Argentine government can enforce the use of (often cost-effective) techniques and technologies that limit the negative environmental effects of shale developments.
- If the Argentine government begins to implement such regulations with alacrity, it can lessen the long-term costs of associated risks for public health and agriculture.

Tactical Breakdown:

Operational:

- Given a continued lax regulatory environment and continued shale growth, such growth may lead to increased soil salinity, which would in turn negatively affect local agriculture.
- The companies developing shale can implement measures to limit the environmental effects for each stage of the production process.

Financial:

- In the long-term, public health risks and lower agricultural output in shale-producing regions may arise, leading to associated financial costs for the government.
- Argentina began exports from Vaca Muerta in June 2019.

Compliance:

- Current regulatory gaps allow companies to dispose of production-related chemicals and utilize local water sources in harmful and unsustainable manners.
- Current regulatory bodies that govern shale companies lack sufficient resources to monitor the rapidly developing industry.

Conclusion

Shale developments in Argentina will increase in number and output levels over the next decade. These developments will lead to significant levels of pollution and water strain if national and regional-level governments maintain current levels of regulation and oversight. These government bodies must enforce strict policies for companies at every stage of the shale development process. Shale companies do not have the incentives in place to follow regulations unerringly; they have incentives to move fast and break ground. Effective and comprehensive regulation could significantly decrease the negative effect of shale developments on the Argentinian environment, and lead to concomitant benefits for agriculture and public health.

Figures

Figure 1: **Formación VACA MUERTA (2018). (Image Credit: Energy Analytics Institute).**

***Figure 2*: The Limay, Neuquén and Negro River Basins (2018). (Image Credit: Multidisciplinary Digital Publishing Institute).**

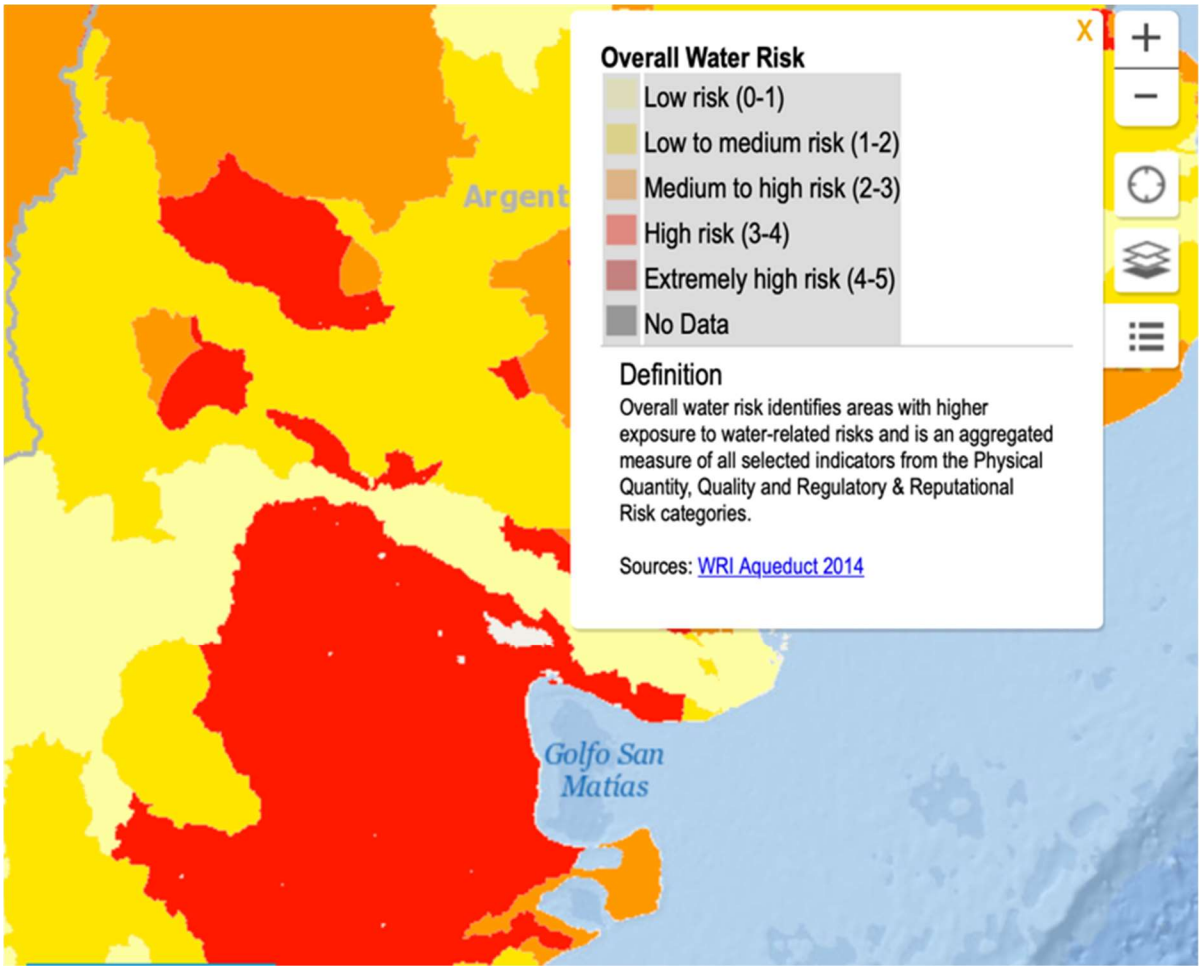

***Figure 3*: Aqueduct Water Risk Atlas (2019). (Image Credit: World Resources Institute).**

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