When the Rivers Run Dry: Water and Development in Argentina's Wine Country

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1/ The Logic of Expansion

This is an account of the rise of an enduring model of expanding agriculture, a modernization project that attempted to overcome its contradictions, and the unexpected ways that modernization project instead intensified the contradictions and ultimately unravelled the model. My focus is on water, and this is an attempt to expand on an increasingly rich envirotech literature on irrigation and dams into perhaps more mundane but deeply consequential realm of groundwater.

Water had long been key to Mendoza, of course, whose flatlands receive 20 cm of annual rainfall, but it became dramatically more important with the rise of the wine industry. Starting in the 1880s, grapes brought Mendoza prosperity, as a few hardscrabble vineyards were built into the fifth-largest wine sector in the world. Displacing imported wine, the vineyards produced for a robust and growing internal market, becoming the lead sector of a dynamic provincial economy for a half-century and making the leading winemakers into the core of the political establishment for decades. Even as the uneven distribution of that prosperity became the central axis of political dispute in the province, mobilizing growers, sharecroppers, and workers against the concentrated power of winery owners, no one questioned the central place of grapes themselves. On the contrary, expanding the acreage under vine, making the oasis ever larger, was the one common objective all parties agreed on. Mendoza embraced a sociotechnical imaginary of ever-expanding irrigation, and this engineering project produced a robust political and material infrastructure.

The dispute was over who would benefit from the bounty of the vines.

Mendoza is an arid province, with agriculture and population concentrated across the course of its four main rivers, all flowing from the snowy heights of the Andes eastwatd across the plains. Dependent on precipitation in the high mountains, all four vary dramatically in flow by season. None are fully navigable and, in dry years, all four can falter and dwindle to nearly nothing when flowing out of the province.

In 1884, a year before the national railroad arrived and the wine boom began in earnest, Mendoza passed its first modern Water Law. This law defined all surface water in the province as regulated by public authority. Water rights were attached to individual parcels of land, and could not be sold or assigned separately. There were two exceptions: recognized mineral water deposits and water courses contained entirely within the boundaries of a single plot of private property. All other water rights were publicly assigned. Rights were initially assigned according to prior use, in a census that began shortly after passage of the water law. Very quickly, however, the rights granted by this census went far beyond any reasonable mapping of existing irrigated areas. Over the following two decades, extravagant grants to the politically favored and speculation over future rights sparked disputes, violence, controversy, and finally a reaction. In 1916, conservatives lost power, reformist groups won office and drew up a new constitution. Water was a key issue: the constitution froze water rights, stating that further grants could only be made by acts of Congress until the province carried out a full scientific study documenting river flow and confirming the water available.

Together, the 1884 Water Law and the 1916 Constitution created a triple gap in water.

First, by establishing the principle that no new rights could be granted without scientific study, the constitution made expertise politically consequential. But it did not establish any specific mechanism or timetable for its application. This created a gap between the demand for technical authority and the absence of specific institutions for applying it. Expanding technical knowledge of

supply later on would rarely produce comprehensive accounts of usage and, in over a century, never produce a definitive study enabling water rights to be allocated again.

Second, already by 1916, legal rights to water exceeded what the irrigation system could provide. There was thus a large gap between what the law promised and what the system could deliver. Closing that gap would be a powerful driver for expanding irrigation infrastructure. Here too fulfilling the law required technical expertise and sizable investment; here too no concrete mechanisms were established for how to set priorities or govern this expertise.

Third, while the law carefully demarcated the legal standing of surface water, it made no mention of groundwater and offered no provisions for how it should be treated. This created a legal void beneath the soil. Groundwater remained up for grabs, in legal and material terms. Should it be incorporated into an expanded version of publicly regulated water rights? Or was it simply private property, subject to civil law like short water courses or mineral deposits?

A decade after the Water Law came a new institution to govern it, the Departamento General de Irrigación (DGI). This consisted of a central administration responsible for planning the system, maintaining key canals, collecting fees, and legally adjudicating disputes. Over its first decades of life, the DGI would gradually strengthen its authority with material improvements. Alongside this were established elected local irrigation boards, first dozens and eventually hundreds, subject to central supervision. The first heads of the DGI were engineers, and the institution became an increasingly prestigious source of technical authority and a key political actor in local disputes and the broader development of the province. The DGI would become a powerful instrument of government by and for irrigators.

The farms and wineries of Mendoza were located along four major rivers: the Mendoza and Tunuyán in the north, and the Diamante and Atuel in the south. The north, especially the Mendoza, was settled earliest and most densely. The south was colonized in the late nineteenth century, by

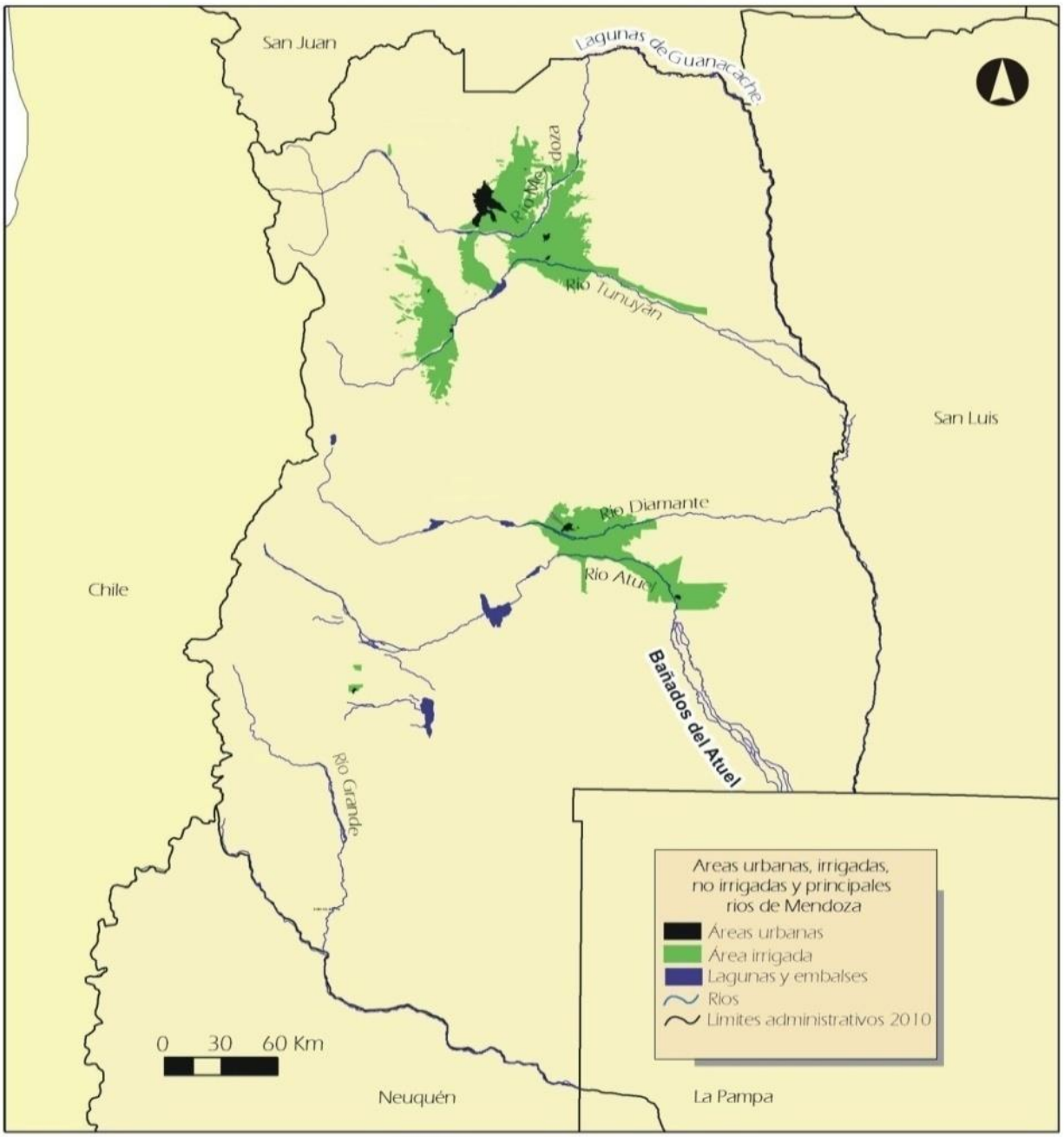

Figure 1. The Rivers of Mendoza (irrigated areas circa 2010 in green)

means of extravagant and sometimes scandalous land grants designed to draw European immigration. Up until 1940, the irrigation system advanced incrementally in all four river basins, continuing despite the intense polarization of local political life in the 1920s and 1930s—a period of

assassinations, national interventions, and coups—and even as water and the DGI became key sites of political dispute.

But as early as 1935, Superintendent of the DGI Alfredo Vicchi, soon to become the conservative governor of the province, noted in his annual report that the province "has already granted more rights than the rivers can meet in normal times and with the incipient hydraulic projects underway." The province only managed to meet demand because "a great quantity of rights that have been granted are not being used, but if they were … the difficulties would be great." He suggested a massive program of dams and reservoirs, but in the meantime, urged a complete census of irrigated crops, so that allotments of water could be aligned with actual agricultural needs, which varied dramatically between, say, alfalfa fields and vineyards. Within a few years, as governor, Vicchi would launch an ambitious dam-building program and an agricultural census, though the attempts at increased control over users would quickly founder.

When Peronism came to power in 1946, it called for a "broadening of the agricultural horizon" and made social justice in water a key part of its policies. It strengthened the power and influence of small growers relative to large growers and wineries, and expanded the canal system to the benefit of users downstream and in newer areas. The gap between promised rights and delivered water was narrowed, especially to the benefit of small growers, and the area under irrigation and under vine continued to expand. Yet by 1947, as a later study estimated, usage accounted for all of the surface water flowing through the irrigation network. And if no one spoke of it openly at the time, the complete drying up for the first time of the Mendoza River when it passed out of provincial territory, in the Lagunas de Guanacache near the northern border, was eloquent enough.

How to overcome these limitations? As Vicci had suggested, there were four alternatives.

First was greater efficiency in distribution and in use: lining dirt canals with cement, changing from traditional flood irrigation to more precise approaches. But this meant transforming the material and especially political infrastructure of irrigation, a difficult task.

A second alternative was to build dams. Following the plan sketched out by Vicchi, the authorities pursued this aggressively, starting with a first high dam on the Atuel River in 1947. But the building program ultimately focused more on generating hydroelectricity than expanding irrigation. Even when the dams were complete, decades later, they proved far more effective at regulating seasonal flows than at increasing the total available water supply. Moreover, most dams were located on the southern two rivers, Diamante and Atuel, and thus did nothing to increase water supply for the high-demand north.

A third was the aggressive proposal to divert water from the Grande River, the "Fifth River" which flowed south on the other side of the main ridge of the Andes Mountains, passing "unused" out of the province and into the Colorado River that crossed Patagonia. The scheme building a massive pump and piping system to cross the Andes, a heroic and quixotic engineering effort familiar worldwide during the middle decades of the twentieth century. First proposed in the late 1930s, revived under Peronism, retooled in the 1960s, designed in detail in the 1980s, further revised in the 2000s, the briefly but unsuccessfully funded in the 2010s, this has been a perennial utopian scheme for irrigators, but eighty years of debate have yet to yield a single meter of infrastructure.

Thus the authorities turned in the 1940s to the fourth alternative, which seemed like the easiest: tapping the massive aquifers lying underneath the province's river basins. All that seemed to require was a little expertise and some pumps.

2/ Groundwater as Salvation

From the 1940s a powerful and enduring imaginary began to form which saw groundwater as an abundant and easily-tapped resource essential to ensure the expansion --or, in dry years, the survival-- of grape lands. The overpromising of water rights was important here, because it established a long-term objective and even a political imperative for expansion. By 1967, for example, 500,000 hectares were legally entitled to water, but only 210,000 were under cultivation. This gap was an invitation to deploy technical expertise.

Starting in the 1940s, even as Peronism was expanding dam-building and strengthening the power of small growers on irrigation boards, the DGI was sending teams around the province to prospect for water, sinking the first expensive experimental high-volume wells. Meanwhile, private actors were beginning to dig wells for themselves.

In 1953, the DGI issued the first General Regulation for Groundwater. It aimed primarily at incorporating groundwater into the existing network of governance. Only Irrigación could issue permits for wells. And the focus of Irrigación's efforts was collective, not individual. The agency wanted to drill large wells and direct the water into downstream canals. It discouraged individual wells while encouraging growers to form cooperatives, just like local irrigation boards, to pool resources and meet needs. Irrigación was attempting to incorporate groundwater into existing water politics by mirroring its existing forms.

The strategy of mapping and later balancing use of the aquifer required determining the number of existing wells and, more difficult still, the volume they were extracting. Only with this law in 1953 did the government take its first count of wells and require irrigators to register existing or new ones. This would have consequences, since naturally many landowners would not register their wells or would understate their number, to avoid future taxes.

When Peronism was overthrown in 1955, this early attempt at collective logic was abandoned. The tensions within this regulation gave way to individualist disarray. The very idea of aquifers and the methods used to measure them reinforced a split, in conception and management, between surface and underground "sources." The DGI had no control over groundwater, other than to maintain a toothless and incomplete registry of wells. This original problem would have serious and lasting consequences for the sustainability of irrigation in the province.

Underground aquifers were naturally an unknown space for growers and water authorities. There was a need for experts who could research and document the existence of this "fugitive" resource, newly discoverable through new experimental methods and mathematical models. For various decades, debates over water in the region had been shaped and dominated by two groups: lawyers and engineers. Now new experts entered the fray. The first would be hydrogeologists, taking the lead in exploring and mapping the province's subsoil. They came to the water debate a little late, in truth, because the first process of mapping had begun with the discovery of oil in the 1920s. The techniques, expertise, and drilling equipment first employed for oil prospecting would now be applied to water. Indeed, the rapid expansion of wells in the 1960s would not have been possible without the mobile teams of drilling experts who had developed their expertise alongside the oil industry in the previous years.

The tone for much of the early discussion was set by the interplay between the rising expectations of growers and the increasingly technical responses of hydrogeologists. Broader public discussion would center primarily on the overall dimensions of aquifers. But locating and above all measuring the size of these aquifers would not prove simple. Estimates varied so wildly, from 850 to 2340 hm3, that they generated "a certain confusion" among experts and users.

Thus the main strategy for developing the sociotechnical imagination about groundwater would be comparing it to surface water.

In popular press and technical publications alike, enthusiasts spoke of aquifers in terms of known flows. This is not so surprising in a province where certain forms of technical discourse had become popular currency. In 1962, for example, the provincial newspaper Los Andes published a Sunday spread with glorious three page landscape photographs of each of the province's four main rivers and the untapped fifth one, the Grande. Each spread was only labeled with the name of the river, the location of the photograph, and – in giant letters – the cubic meters per second of average flow.

So it was easy for Irrigación to wax eloquent about groundwater with a 1966 headline article on "the new river" – or other articles on the great potential of "the sixth river". Through rough calculations it showed the numerical importance of groundwater, comparing it to surface flows. But bringing this technical imagination to fruition required investments that would affect technical feasibility as well as economic cost. The very article that waxed poetic about the free flow of "the new river" also called for government subsidies to make drilling "competitive," lest the boom that groundwater promised never arrive.

Most of Irrigación's official publications insisted on the importance of conserving the aquifer. But much more thought was given to how to use ever more groundwater than to how to avoid its possible -- and soon very real -- overuse. All of these analogies to surface water, of course, sidestepped the key point that there was an existing regulatory system, however imperfect, to govern river flows but almost none to govern underground flows. This halting recognition was captured in phrases like another 1967 Irrigación bulletin headline: "Happily enough, our resources are not yet exhausted."

The mid-1960s were a time of rapid if highly erratic expansion of the Argentine economy, accompanied by intense lobbying by Mendoza and San Juan to protect and expand the wine industry. The government intervened in the grape market to sustain high prices, protecting

independent growers against the power of wineries, while favoring growers, small wineries, and large wineries alike with tax subsidies to encourage new vineyards and new facilities. Since the 1920s, much of the expansion of wine acreage had been downstream and to the east, a process accelerated under Peronism which now continued in the 1960s. Much of the most dramatic expansion of wine acreage in these years came in previously uncultivated land along the northern rivers, especially the Mendoza, spreading ever further to the east.

High grape prices and tax subsidies made expansion attractive; new technology made it possible. There was now a handful of firms who could inexpensively drill deep wells. But the most important technology was rural electrification. It was the availability of electrical power and new electrical pumps that made groundwater finally accessible. In part this too was a product of broader water development, as new hydroelectrical dams in the south increased electrical production.

But the decisive element were rural electrical cooperatives that formed quickly, starting in 1953, and expanded across the new lands on the margin of previous settlement or infrastructure. By the early 1960s they had laid the wiring and infrastructure that made it possible to bring hundreds of wells online in very short order. In many ways, the model for these cooperatives were the existing irrigation boards, even in areas of the province where there had been no land with water rights and thus no boards. This is one further irony of the rapid growth of groundwater: it built on state initiatives and collective action in every way, but took place almost entirely outside any regulation, monitoring, or structure of governance.

In the crucial years of the early 1960s, ambitious rhetoric was accompanied by major government investment in expertise to guide water development. New experts were trained, new institutions were formed, and there was a surprisingly sustained attempt to bring water policy to the center of regional political discussion. This was part of a worldwide development push, an expansion and supplement to the high age of dam building then underway. Groundwater was seen

as an essential component alongside comprehensive river basin development. And both would bring long-awaited, broad-ranging, technically-guided agricultural and population growth to the neglected Argentine interior. This was a direct response to the way the interior had been politically mobilized under Peronism, and an attempt to articulate a new vision for national growth in the developmentalist 1960s. As the local paper noted, "for many years we have had a prestigious institution that rationalized the use of our river waters. But this is the moment to go further, to prepare a new vision of vast reach."

Key here was the rising figure of Guillermo Cano, water law expert and son of a conservative governor, who parlayed his political savvy into a series of consultancies, a broad national push for irrigation in Argentina's drylands, a position as national Secretary of Hydraulic Resources for the national government, and the founding of several key institutions in Mendoza.

In 1965, the national government and the UN Development Program launched the Programa de Investigación de las Aguas Subterráneas del Noroeste de Argentina (PASNOA), bringing a team of national and international experts to survey and measure the groundwater supply, the most high-profile of many efforts to apply expertise to expand irrigation.

The program, which began in the provinces of Mendoza and San Juan, aimed to expand intensive agriculture into the vast arid region of the northwest where the lack of surface water had been a major limitation. Baseline studies indicated that in Mendoza and San Juan alone, the heart of the Argentine wine belt, "agricultural production could be doubled through the use, for irrigation, of broad basins of underground water."

But PASNOA is perhaps most striking in another way: its attempt to comprehensively map out groundwater for long-term planning was simultaneous with the short-term boom and collapse in extracting groundwater.

3/ The Reckoning: Drawdown and the Experts

In the late 1960s, this powerful sociotechnical imaginary converged with three other factors to produce the "great drawdown" and a dramatic break: a decade of intensified subsidies for grape planting (tax incentives, easy credit, and newly available electricity), rapidly rising grape and wine prices, and the worst drought in a century.

Over the course of the 1960s, the annual flow of the Mendoza River dropped 35% from its historical average, falling from 1700 million m3 to 1100. Although this wasn't widely appreciated at the time, this was an intensification of a longer dry cycle that had begun in the 1940s. The most intense downturn was between 1967 and 1969, part of a major climatic shift evident all along the Andes which would lead Chile to experiment with cloud-seeding and draw scientists working in Peru and Ecuador to their first formulations of the ENSO cycle.

In Mendoza, the downturn in river flow brought a clear and dramatic response by growers. From 1967 to 1971, the annual number of new wells drilled rose from 464 to over 2,000 and the total number of wells in operation doubled.

Groundwater more than compensated for the loss of river flow, and the irrigated area of the province rose from 210,000 to 380,000 hectares. Tax incentives for new agriculture, which often covered all investment in buildings and pumps, only deepened the trend.

This rapid expansion made the whole system increasingly dependent on groundwater. In less than a decade, the percentage of land irrigated with groundwater rose from 42% to 86%. Equally dramatically, the percentage irrigated solely by surface water dropped from 55% to 14%. Measured another way, in the drought years pumping equaled more than half of the total river flow.

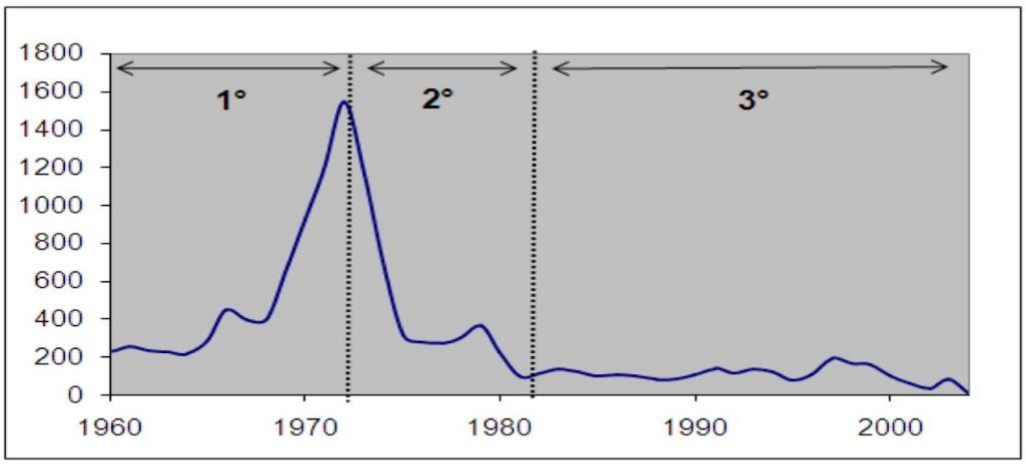

Figure 2: New wells/ year in Mendoza

It was just this "broadening of the agricultural horizon" that would soon break, perhaps for good, the long-standing association between expansion and progress. Grower incentives drove an ever-stronger increase in grape supply, supported by government intervention which sustained the price bubble. In the early 1970s, as the drought eased, the increased flows of surface water lessened the intense drawdown of the aquifer in the late 1960s. It seemed for a time that a new mode of sustained expansion had been discovered. The new model of combined water sources seemed to guarantee a prosperous, protected future for the much-greater acreage under vine. This in turn

produced a rapid and dramatic growth in vineyard prices and a speculative boom in consolidating wineries.

But this optimism in the wine sector came at a moment of profound political crisis in Argentina, and with the collapse of price and wage controls in 1975 and the rapid acceleration of inflation, the tide shifted quickly. The sharp crisis of a model of expansion based on indiscriminate drilling accelerated the bursting of the price bubble, and was followed by the rapid unravelling of a century-old model of winemaking.

The social and environmental costs of the collapse of the groundwater boom were even greater. Demand on the aquifer became unsustainable, as the first signs of failure, contamination, and salinisation appeared in the mid 1970s. This quickly led to the abandonment of wells that had been dug and vineyards that had been planted in the explosive growth after 1967. Between 1978 and 1990, more than 100,000 hectares of vineyards were abandoned in Mendoza. The region lost 39% of its acreage of vines. The vast majority had been irrigated using groundwater. An early sign of the depth of the crisis had been the swift drop in the number of new wells between 1973 and 1976, a pattern exactly mirroring the rise five years earlier. In addition, many existing wells were abandoned due to breakage, the dropping water table, or the rising prices of electricity and fuel with the onset of the oil crisis.

Through all of this, the specialists of PASNOA were steadily doing their work. They reached stark conclusions about the Mendoza River basin. Very quickly experts determined there was not a single aquifer, but several separate layers of aquifer, with quite distinct characteristics. Studies also clearly showed that the various aquifers were not untapped, but already in use. As early as 1967, experts were declaring to the press that most of the water in the aquifers came from the river systems, rather than a separate, deeper, untapped flow. Therefore any expansion was a matter of calibrating priorities. Thus the study suggested the priority was not prospecting for new sources, but

controlling and regulating the already existing wells. This task did not demand a high-level team of internationally-known hydrogeologists, but rather a more powerful state with better monitoring and more effective regulatory powers.

In the end the aquifer did not dry up, as the abandonment of vineyards meant pumping declined from the late 1970s, while a shift in climate patterns brought increased surface flows and recharge to aquifers, especially during the 1980s. But much of the northern aquifer was rendered useless by a rapid increase in salt content, for the reasons experts had outlined. And it would take another decade for Irrigación to impose the kinds of controls and limits on groundwater use the experts suggested.

In its five years of existence, PASNOA generated an impressive range of studies, reports, surveys, and conclusions When PASNOA funding ended in 1970, it was succeeded by a permanent national office, the Centro Regional de Agua Subterránea (CRAS), headquartered in San Juan but with "local" offices in Mendoza. Over the following decade, CRAS would carry out many studies, although fewer than initially expected, a shortfall due to persistent underfunding and conflicts with provincial governments. CRAS set out several research programs that required 10 years to arrive at generalizable conclusions. Unfortunately, massive pumping was on a rather shorter time cycle. As impressive as the studies was the absence of any sustained, effective response by public authorities. Guillermo Cano, the well-connected operator who had helped launch and fund the program, years later claimed that its results "were unknown" because "nobody read them." This clearly marked the limited real impact of the knowledge produced by the program.

If enthusiasm during moments of expansion rendered institutions invisible, during the crisis they moved front and center, as the generic causes of all failures. Common explanations for this collapse include: poor institutional coordination, overlapping authorities, a "lack of qualified personnel" and resources, and generally a state apparatus of supposedly exceptional incompetence.

But this failure was not the result of weak institutions so much as the product of false expectations produced by prior strong ones.

In political discourse, water policy in the 1960s was presented as a great effort to unify and strengthen energies that up until then had been dispersed: political will, scientific knowledge and social investment would come together in a planned and lasting development project that would yield the dramatic expansion of the grape lands. But rapid growth, further accelerated by the great drawdown, made starkly clear the fragmentation and weakness of existing institutions and economic models.

The crisis would be reflected in a widening set of contradictory initiatives, many growing out of the original common project, which ranged from the recognition of the exhaustion of the model of expansion to renewed efforts to revive or even deepen it.

One sign of this is a comprehensive 1986 report produced by a new agreement between the UN Development Program and the national government, a revival of the PASNOA approach. After detailing the results of dozens of critical studies, and systematically documenting the failure of previous programs to yield sustainable expansion, the report still held out the hope for more than doubling the area under irrigation without any new infrastructure. With infrastructure, of course, they claimed it could be tripled!

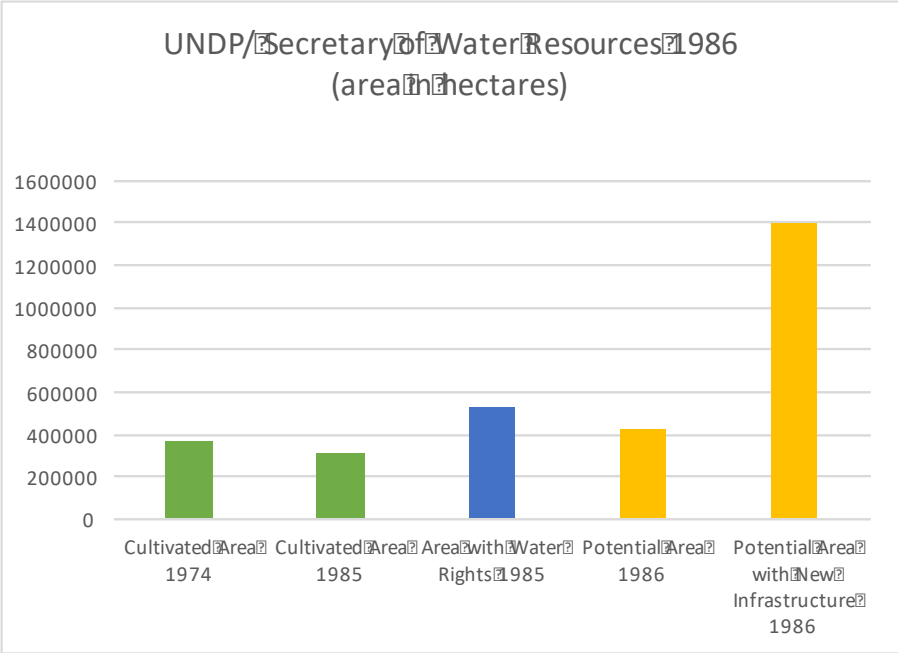

Figure 3. Technocratic dreams, 1986

4/ Conclusion

This could be told as a story of how an enduring sociotechnical imaginary and cheap electrical pumps frustrated an ambitious project of expertise and undid a century-old political and material infrastructure. In that sense, it is perhaps a triumph of technology over expertise and certainly over sustainability. Of course, that expertise was deeply complicit in the narrowness of the sociotechnical imaginary and the deployment of the technology in the first place.

In the broader conversation about maintenance in environmental history and science and technology studies, this case poses some interesting puzzles. What infrastructure is to be maintained? What kind of expertise and what kinds of institutions are required? Mendoza developed quite robust institutions and significant though flawed expertise. But they worked together to further a broader project which would be its own undoing. To be sure, there are moments of clarity, and

attempts to reorient these institutions, to found new ones, and to use expertise to develop more sustainable alternatives. And undoubtedly any policy for the future must build on these institutions, expertise, and infrastructure. But one is struck by the fundamental irony that it was precisely at the moment that "comprehensive" studies were being undertaken that the century-old model comprehensively fell apart. The attempt to find a technical fix for the challenges of maintaining grape production led to a fixation with dramatic solutions that would only make those challenges far more grave.