Engineering Institutions: Irrigation and the Persistence of Early Modern Expertise in Ottoman Egypt

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The rural world was made. There is nothing natural about a field, a river, or a forest. They all have a history of negotiation, choice, manipulation, accident, conflict, and compromise. One of the great insights of environmental history is to show how humans, nonhumans, and geophysical and climatic processes participated in the forging of the pasts of all environments and, therefore, the histories of the societies supported by these environments. These observations are particularly salient for Ottoman historians. The lands that would become the Ottoman Empire had been manipulated for millennia and, unlike many regions of the globe, evidence exists to narrate these changes. The Ottomans did not find an untouched pristine wilderness when they entered the Middle East, the Balkans, and North Africa. Quite to the contrary, they came upon a highly arranged and cultivated world of a particular historical and ecological order that had been forged through millennia of environmental management techniques. Over the centuries of Ottoman rule, these regions would of course continue to be manipulated and remade through imperial, environmental, economic, and social processes.

Focusing on just one aspect of this highly complex and vast history, this chapter tells the story of the role of local engineers in rural Ottoman Egypt in the years between 1660 and 1715. Identified as *mühendis* (*muhandis* in Arabic) in the archival record, these individuals were integral parts of the manipulation of rural environments and helped to maintain and develop constructive relationships between local communities and the imperial administration. A shared

interest in the upkeep and functionality of infrastructure such as canals, embankments, roads, bridges, and quays meant that rural peoples and the Ottoman state were in regular communication over complicated matters related to the repair, manipulation, and expansion of these public works.[1] The figure of the engineer is of particular importance because he was a kind of middleman between peasant interests and imperial concerns. Judges and other imperial officials in rural Ottoman Egypt relied on them to ensure that the relationship between local needs and imperial desires maintained. The history of these engineers thus illuminates something of the logic and function of Ottoman governance in rural areas of the empire in the early modern period. Against this backdrop, this chapter ends with a consideration of what came of these engineers and of engineering expertise in the early nineteenth century.

Downstream, 1664

In the summer of 1664, a problem emerged with a canal embankment in the village of Shārimsāḥ in the subprovince of al-Daqahliyya in the northeast of the Egyptian Delta.[2] In that year, the *kāshif* of the village came to the court of al-Manṣūra to present this problem to the imperial administration in the hopes of finding a solution. Three sections of the face of the embankment had deteriorated and become disjointed (*takhalkhala*), falling into the canal's water. These three surface sections had been eroded to the point that the dried mud and clay that made up the internal portions of the embankment had become as soft as manure (*ṣāra sibākhan*). Water was thus allowed to spill wastefully out of the canal instead of being properly channeled

[1] For examples of this communication, see: Alan Mikhail, *Nature and Empire in Ottoman Egypt: An Environmental History* (Cambridge: Cambridge University Press, 2011), 38-66.
[2] Dār al-Wathā'iq al-Qawmiyya (National Archives of Egypt, Cairo) [hereafter DWQ], Maḥkamat al-Manṣūra 4, p. 108, case 281 (Evail M 1075/25 Jul.-3 Aug. 1664). On the village of Shārimsāḥ, see: Muḥammad Ramzī, *al-Qāmūs al-Jughrāfī lil-Bilād al-Miṣriyya min 'Ahd Qudamā' al-Miṣriyyīn ilā Sanat 1945*, 6 vols. in 2 pts. (Cairo: al-Hay'a al-Miṣriyya al-'Āmma lil-Kitāb, 1994), pt. 2, 1: 243.

to fields. The land behind the embankment had become a soppy (*ghamīqa*) muddy mess. There was, moreover, a real possibility that these damaged sections would be completely destroyed by the rushing waters of next season's flood, obviously a cause of enormous concern for those living near the embankment and those further downstream as well.

The judge sitting in his court in al-Manṣūra was not an expert in irrigation works or infrastructural repair. To make a decision about what to do in this case, expert information was needed to ensure that any monies paid out to repair the embankment were properly and effectively spent. This imperative for expertise was not simply a bureaucratic and financial requirement to fulfill the court's legal function. The correct and timely repair of the embankment of course had real-world consequences. Peasants (*ahālī*) from various downstream villages on the canal came to the court to testify that failure to repair the embankment would cause their fields, and hence lives and livelihoods, great harm.[3] They added that neither any of them nor their village leaders had the financial or technical wherewithal to help in the repair of the upstream embankment in Shārimsāḥ that controlled so much of their agricultural fate. Thus for different individual reasons, the court, local leaders, and peasant communities were all in need of someone to provide the expert information required to fix the broken embankment.

Enter the engineer. Al-Mu'allim 'Aṭā' Allah was identified in this case and in others as the engineer of al-Manṣūra (*al-muhandis bil-Manṣūra*) and was, as his title suggests, likely a local Egyptian who resided somewhere in the subprovince. He was summoned to the court, explained the situation, and was then dispatched to the field to gather the information needed to allow water to once again flow properly. He went right to work.

[3] On the use of the term *ahālī* in Ottoman Egypt, see: Alan Mikhail, "Unleashing the Beast: Animals, Energy, and the Economy of Labor in Ottoman Egypt," *American Historical Review* 118 (2013), 326, n. 31.

His first task was to consult with rural cultivators in Shārimsāḥ and its downstream villages about the state of the embankment and the effects of its disrepair on their communities.[4] Adding to their earlier testimony, they reported to him about the massive deleterious consequences of the failure to fix the embankment. The yearly flood was only weeks away. Should it arrive with its full force before the embankment was repaired, the resulting damage to fields and the canal would be enormous. The uncontrolled water would surely sweep away much of the embankment, along with other irrigation structures, and the waterway would be left in an unfixable state (*lā qudra li-aḥad ʻalā saddihi*). These peasant communities thus implored ʻAṭāʼ Allah to do all he could to fix the embankment quickly and sturdily.

With his initial charge from the court and now with this corroborating on-the-ground information about the current situation, ʻAṭāʼ Allah and his assistants went to measure the embankment's damage. Three parts of the structure had been destroyed. The first broken section measured 13 by 1.5 *qaṣaba*s, and was opposite a group of three waterwheels.[5] The second damaged portion was near a basin known as al-Waḥdāniyya and measured 8 by 1.5 *qaṣaba*s. The third damaged area was 9 by 1 *qaṣaba*s. With these measurements in hand, ʻAṭāʼ Allah then estimated the total cost of these repairs, taking into account the needed repair materials, their transport to the construction site, the specialized tools required to move these materials, and the necessary labor.

He then returned to the court to report his findings to the judge and the *kāshif* of Shārimsāḥ. He relayed what locals around and below the embankment had told him about its

[4] These downstream villages included Bisāṭ, Kafr Tiqay, and al-Zaʻātra. See the text of this case for a complete list. On these three villages see respectively: Ramzī, *al-Qāmūs al-Jughrāfī*, pt. 2, 1: 242, 245, 246.
[5] One *qaṣaba* equals 3.99 meters. Walther Hinz, *Islamische Masse und Gewichte umgerechnet ins metrische System* (Leiden: Brill, 1955), 63. There is some discrepancy about this conversion. In her discussion of the repair of the Maḥmūdiyya Canal in the early nineteenth century, Helen Anne B. Rivlin takes one *qaṣaba* to equal 3.64 meters. Helen Anne B. Rivlin, *The Agricultural Policy of Muḥammad ʻAlī in Egypt* (Cambridge: Harvard University Press 1961), 218. Elsewhere she writes that the *qaṣaba* ranged between 3.75 meter and 3.99 meters. Ibid., 125. Unless otherwise noted, throughout this chapter I take one *qaṣaba* to equal 3.99 meters.

disrepair and summarized his measurements of the damaged structure and his estimates for the cost of its repair. The grand total to fix the embankment was 200,000 *niṣf fiḍḍa*—a huge sum for this period. Other comparative repair jobs from al-Manṣūra in this period usually cost orders of magnitude less than this. In 1646, for example, a series of repairs carried out on a canal and its embankments in the city of al-Manṣūra cost 18,120 *niṣf fiḍḍa*.[6] In Shārimsāḥ in 1664, costs were high, but there was simply no way around spending an enormous sum. The court's expert witness had reported his findings, and the consequences of not carrying through with his recommendations would be much greater than 200,000 *niṣf fiḍḍa*. The court recorded what 'Aṭā' Allah had to say and ordered the repairs.

Engineer 'Aṭā' Allah was one of the most powerful parties in this case. The whole project to repair the canal's embankments rested on his expert recommendations. His consultation with locals, his measurements, and his cost estimates moved the repair process forward. Without him, the embankment would have languished in disrepair, fields would have flooded, and tax revenues would have fallen. His elevated position over most all of the case's other parties was made clear by the fact that the initial recommendations of the *kāshif* to reinforce the embankment with another surface structure (*raṣīf*) were left aside. He presented this idea to the court before 'Aṭā' Allah was called upon for his recommendation, but ultimately the engineer's ideas trumped the *kāshif*'s. The testimony of local peasant cultivators was also an important component of this case. Their recommendations though were ultimately filtered through 'Aṭā' Allah and so were also jettisoned to his ideas. The judge in this case obviously deferred to 'Aṭā' Allah as well, since he was the one who called upon him in the first place. The point is that the repair of the embankment and a massive expenditure of imperial funds turned on the engineer 'Aṭā' Allah's privileged knowledge and expertise.

[6] DWQ, Maḥkamat al-Manṣūra 1, p. 84, case 197 (20 Z 1055/6 Feb. 1646).

His expertise was the crucial link between the imperial institution of the court and the many peasant communities directly affected by the empire's actions on the canal. The logic governing Ottoman management of irrigation in rural Egypt recognized that water usage linked peasants in often distant locales not only to other villages in the Egyptian countryside but also to the palace and to other areas of the empire far beyond Egypt. Grains grown by the Nile's irrigated water and the tax revenues they helped to raise connected Egyptian peasants to Istanbul and elsewhere. 'Aṭā' Allah was an intermediary in this relationship between al-Manṣūra and Istanbul, between a small-scale canal's particular ecology and the empire it supported. He liaised between the court and the countryside and between Shārimsāḥ and its downstream villages. Similar to the ways in which all these Egyptian villages were bound together through their shared use of the canal, Istanbul, the Hijāz, and other areas of the empire that consumed Egyptian grains were also downstream communities. That is, the status of a canal embankment in a village like Shārimsāḥ deeply impacted many other places. Engineers were therefore not simply fixing irrigation works but also working to keep the connective tissue between empire and community healthy and functional.

Scale, 1680

Engineers were such central actors in rural Ottoman Egypt in part because of the sheer scale of the projects in which they participated. Regularly assisting the imperial administration in infrastructural work of such immense size—the previous case's 200,000 *niṣf fiḍḍa* for example—ensured their essential place in the function of the empire. Gargantuan amounts of resources, cash, labor, and effort relied upon the information and expertise provided by engineers in rural Ottoman Egypt.

In 1680, the tax farmer (*multazim*) of the village of Ṭunāmil, Muḥammad Aghā, came to the court of al-Manṣūra to register a problem with a canal known as Baḥr al-Fuḍālī.[7] This canal served as the main source of water for his and ten other villages, and in this year it was barely flowing because of the enormous amount of silt and plant matter that had been allowed to accumulate in it.[8] Muḥammad thus asked the court to dredge and clean the canal. To corroborate and offer further details on Muḥammad's claims, the court asked the engineer of al-Manṣūra (again *al-muhandis bil-Manṣūra*), al-Mu'allim Ḥasan, to inspect the canal. After measuring it—it was 80 *zirā'* in length and an average of 20 *zirā'* in width—Ḥasan reported back to the court that the canal was indeed in dire need of dredging.[9]

While at the canal site, Ḥasan also noticed a problem on one of the banks of the waterway. He and his assistants measured the distance between the canal and a large orchard in Ṭunāmil and found that there was not enough room for people to pass on the canal bank. One could, however, avoid this narrow section of canal bank by passing to the other side of the canal and then back again on two bridges that spanned the canal on either side of the orchard. Each of these bridges was 5 *zirā'* wide, 20 *zirā'* long, and 10 *zirā'* high, and both were in need of repair. According to Ḥasan's report, their reconstruction would require 100,000 mud bricks (*tūba*) and an enormous amount of stone. The work needed to clean the canal and fix the two bridges would last for 30 days, and on each day 40 workers would be required. These men were to be paid the going rate for this kind of work and were also to be given provisions of food. On the basis of Ḥasan's report to the court, the imperial administration authorized the commencement of the canal's dredging and also undertook the repair of the two bridges.

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[7] DWQ, Maḥkamat al-Manṣūra 7, p. 134, case 340 (7 Za 1091/29 Nov. 1680). On Ṭunāmil, see: Ramzī, *al-Qāmūs al-Jughrāfī*, pt. 2, 1: 174, 179.

[8] The ten other villages were Dammās, Kafr al-Rūla, Minyyat Gharb, Durra, Tanbūl, Tūḥ, Nūr Ṭīq, al-Sandalāwī, Barhamnus, and Shubrahūr.

[9] One engineering *zirā'* (*zirā' al-handasa*) equals 0.656 meters. Hinz, *Islamische Masse und Gewichte*, 58.

Ḥasan's authority to direct the repairs in this case is obvious. On his word alone, the court not only approved the original work it had been asked to do but also undertook even further repairs to irrigation works that had not initially been brought to its attention by the *multazim* of Ṭunāmil. More significantly, this case also makes obvious the enormous scale of this sort of regularly-pursued irrigation work in rural Ottoman Egypt. The numbers are telling—11 villages, 100,000 mud bricks, and wages and food for 40 workers for 30 days. The capital, resources, and organization demanded by these numbers underscore both the level of environmental, social, and economic manipulation such projects entailed and the enormous trust and power invested in the person of the engineer. As 'Aṭā' Allah had done in Shārimsāḥ a few years earlier, Ḥasan moved this project on Baḥr al-Fuḍālī forward. He measured the canal, informed the court about the two broken bridges, and came up with the estimates of the work's cost and labor demands. Projects of such vast scale could only be entrusted and managed by those of knowledge, expertise, and proven reliability. These people were engineers like Ḥasan.

Knowledge, 1705

A case from roughly twenty-five years later offers further information about how the expertise of engineers was organized and utilized.[10] Also from the court of al-Manṣūra, this case concerns the repair of a deteriorating embankment at the mouth of the large canal of al-Baḥr al-Ṣaghīr that flowed east to the Lake of al-Manzala in al-Daqahliyya. In 1705, the embankment was badly in need of maintenance after years of neglect. Parts of it had broken off and fallen into the canal and other sections had badly silted up. State funds (*al-māl al-mīrī*) were to be used to fix the embankment and so the heads of the seven military blocs in al-Daqahliyya, judges from

[10] DWQ, Maḥkamat al-Manṣūra 16, p. 257, case 527 (18 Z 1116/13 Apr. 1705).

the subprovince, and other local elites came to the court to discuss these repairs.[11] As in the previous cases, they consulted with the engineer of al-Manṣūra about these repairs and deferred to his expertise.

In 1705, the engineer was a man named al-Ḥājj Shāhīn, and his title was head of the corporation of engineers of al-Manṣūra (*shaykh ṭā'ifat al-muhandisīn bil-Manṣūra*).[12] This title tellingly points to the presence of an organized institution of engineers in rural Ottoman Egypt. As with other guild formations, engineers understood the power they could derive from their expertise and sought out corporate organization to advocate and protect their interests.[13] Their trade was not in a craft skill, however, but in knowledge and expertise. This was an early modern knowledge economy.

The commodification of this collective engineering expertise was made crystal clear in this case. Shāhīn and his associates were brought from Damietta to inspect the damaged embankment and to offer advice about how to repair it. This case states unequivocally that these men were valued for their expertise (*li-kaun anna lihum khibra wa ma'rifa*).[14] Their "importation" from Damietta is repeatedly mentioned throughout the case. Moreover, although not stated explicitly in the text, there was likely a cost associated with bringing these men from Damietta, and perhaps they were even paid for their services. These men are therefore most usefully thought of as expert travelling consultants who were employed by the Ottoman state for their knowledge and expertise in technical matters.

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[11] The use of state funds for this repair is specifically mentioned in the following case: DWQ, Maḥkamat al-Manṣūra 16, p. 289/290, case 599 (17 S 1117/10 Jun. 1705).
[12] DWQ, Maḥkamat al-Manṣūra 16, p. 257, case 527 (18 Z 1116/13 Apr. 1705).
[13] Generally on Ottoman guilds, see: Eunjeong Yi, *Guild Dynamics in Seventeenth-Century Istanbul: Fluidity and Leverage* (Leiden: Brill, 2004); Ammon Cohen, *The Guilds of Ottoman Jerusalem* (Leiden: Brill, 2001); Suraiya Faroqhi, *Artisans of Empire: Crafts and Craftspeople Under the Ottomans* (London: I.B. Tauris, 2009); Suraiya Faroqhi and Randi Deguilhem, eds., *Crafts and Craftsmen of the Middle East: Fashioning the Individual in the Muslim Mediterranean* (London: I.B. Tauris, 2005).
[14] DWQ, Maḥkamat al-Manṣūra 16, p. 289/290, case 599 (17 S 1117/10 Jun. 1705).

Conceptualizing these engineers' knowledge as a commodity also helps to explain their movement across the subprovince of al-Daqahliyya. The Ottomans were masters of comparative advantage.[15] They regularly transported resources between different parts of the empire to achieve optimal configurations of effort and capital. In the case of Egypt, this meant moving the province's excess grain to other parts of the empire and moving wood from southern Anatolia and elsewhere to the timber-bereft Nile Valley.[16] Like grain and wood, the engineering knowhow of Shāhīn and his fellow engineers was similarly moved to areas where it was needed most.

And what did these men find when they got to the canal of al-Baḥr al-Ṣaghīr? Their first recommendation to the imperial bureaucracy was to remove the massive quantity of silt that had collected in the canal. The total volume that had to be dredged was 906.5 cubic *zirā'*. The cost of dredging a single cubic *zirā'* was 80 *niṣf fiḍḍa*, so the total cost of this part of the repairs was 72,520 *niṣf fiḍḍa*.[17] In the embankment itself, a section measuring 700 square *zirā'* had to replaced. The cost of repairing a single square *zirā'* of the embankment was again 80 *niṣf fiḍḍa*, bringing the cost of this portion of the work to 56,000 *niṣf fiḍḍa*. Another 10,000 *niṣf fiḍḍa* was needed to purchase dirt, stones, and other building materials. Thus the grand total estimated for this work by the engineer Shāhīn and his associates was 138,520 *niṣf fiḍḍa*. Throughout the text of this case, all of these measurements and repair costs were reported as being on the authority of the engineers (*al-takhmīn bi-ma'rifat al-muhandisīn*). Subsequent cases recorded after the repairs had been completed confirmed the accuracy of the engineers' estimates.[18]

[15] For further discussion of this point, see: Mikhail, *Nature and Empire*, 124-25.
[16] Ibid., 82-169.
[17] All of these measurements and cost estimates come from the following: DWQ, Maḥkamat al-Manṣūra 16, p. 257, case 527 (18 Z 1116/13 Apr. 1705).
[18] DWQ, Maḥkamat al-Manṣūra 16, p. 289/290, case 599 (17 S 1117/10 Jun. 1705).

Rural engineers' authority and the value of their expertise was thus in large part a function of the accuracy of their estimates. Running way over cost or overestimating the amount of time needed for a repair job obviously did not help engineers to sell their knowledge to the Ottoman state. Perhaps the Ottoman administration of Egypt undertook the added complexity of bringing Shāhīn and his associates from Damietta (rather than using other local engineers) precisely because they were known to give accurate estimates in their repair work or, more generally, because of their proven integrity and honesty. Reputations clearly mattered in Ottoman Egypt's knowledge economy, and engineers like Shāhīn used this fact to their advantage.

Unlike other cases, there was not much input from peasant communities in the repair of al-Baḥr al-Ṣaghīr's embankment in 1705. The main reason for this was that the canal was part of the state's imperial irrigation infrastructure. There were two classes of canal in rural Egypt: *sulṭānī* (imperial) and *baladī* (local).[19] If a canal served a large group of peasants rather than the interests of a privileged few, contributed to the common good, or aided in the achievement of equality among peasants, it was considered a *sulṭānī* canal, the responsibilities of which fell on the Ottoman state in Egypt. *Baladī* canals, by contrast, were those that served the irrigation needs of only one particular community. These were to be maintained by local leaders. Although of course both *sulṭānī* and *baladī* canals ultimately remained the property of the state, their upkeep very often fell on the shoulders of locals—engineers, Egyptian peasants, and rural elites—who lived near them, since they were the ones who most directly used and relied on these waterways. Since al-Baḥr al-Ṣaghīr was a *sulṭānī* canal, the responsibility to repair it fell

[19] On the distinction between these two types of canal, see: Stuart J. Borsch, "Environment and Population: The Collapse of Large Irrigation Systems Reconsidered," *Comparative Studies in Society and History* 46 (2004), 458-60; Sato Tsugitaka, *State and Rural Society in Medieval Islam: Sultans, Muqta's and Fallahun* (Leiden: Brill, 1997), 225-27; Mikhail, *Nature and Empire*, 40-46.

squarely on the shoulders of the state, hence the use of imperial funds (*al-māl al-mīrī*) to repair it.

Soundness, 1709

State funds were also regularly used to repair *sulṭānī* irrigation works in Fayyūm throughout the first half of the eighteenth century, and in these cases, engineers played prominent roles as well.[20] In 1709, the Divan of the Ottoman sultan Ahmet III sent a firman to the *vali* in Cairo about an ongoing situation of damage to the regulation mechanisms on the important canal of Baḥr Yūsuf in Fayyūm.[21] This single canal was the lifeline of Fayyūm. Lying in a depression southwest of Cairo, the region is unique in Egypt since it is the only major agricultural zone that is neither in the Nile Valley nor the Delta.[22] In the eighteenth century, Baḥr Yūsuf provided all of Fayyūm's water. Problems of the sort in 1709 thus led to widespread environmental stress throughout the entire region.

According to the firman in this case, much of Fayyūm had been found to be unwatered (*sharāqī*) because of the failure of Baḥr Yūsuf's irrigation mechanisms.[23] From its downstream perspective, the sultan's council wrote that it was not only Fayyūm that was directly affected by this deterioration in the irrigation network. Repeating an idea we have seen already, the bureaucracy made clear that the great destruction to agricultural lands that might result should this situation remain unaddressed would hurt Egypt's overall agricultural output and thus greatly reduce the amount of tax revenue available to the state. To stave off these deleterious

[20] On this repair work, see: Alan Mikhail, "An Irrigated Empire: The View from Ottoman Fayyum," *International Journal of Middle East Studies* 42 (2010): 569-90.
[21] Başbakanlık Osmanlı Arşivi (Prime Ministry's Ottoman Archive, Istanbul) [hereafter BOA], İbnülemin Umur-i Nafia 94 (Evasıt Ra 1121/21-30 May 1709).
[22] For a description of Fayyūm's geography and irrigation, see: Mikhail, "An Irrigated Empire," 574-76.
[23] The Egyptian Arabic word *sharāqī* refers to land that is not reached by water and is hence parched and dry. In contrast to *būr* land, which is uncultivatable wasteland, *sharāqī* earth has the potential for cultivation given the proper amount of water.

possibilities, the imperial bureaucracy once again turned to engineers. The sultan ordered his *vali* to send to Fayyūm a group of engineers of sound judgment (*mühendisin-i sahih ül-tahmin*) to oversee the reconstruction of the canal's dams and embankments as quickly as possible (*alavechitta'cil*). To fund this work, 11 Egyptian purses (*kise-i Mısrī*) were made available from the annual tribute (*irsaliye*) of 1708/1709.[24]

Inspections and repair work on the canal continued for several years under the watchful collective direction and management of the engineers of Fayyūm. In 1711, they registered a report with the imperial administration about the deteriorated state of many of the canal's irrigation works.[25] In the major dam of al-Gharaq, for instance, there was a damaged area measuring 27,234 square *zirā'*. Broken sections in the foundation (*paye*), walls (*divarlar*), and support girdle (*kemer*) of the dike of al-Lāhūn measured a total of 9,980 square *zirā'*. Between just these two structures (there were others damaged as well), the total area in need of repair was thus 37,214 square *zirā'*. It was estimated (*alavechittahmin*) that the cost of repairing one square *zirā'* would be 15 *para*, making the total cost of fixing these two irrigation works 22 Egyptian purses and 8,510 *para*. The bulk of these funds were to purchase the necessary building

[24] The Egyptian purse equaled 25,000 *para*, the official Ottoman name given to the *nişf fiḍḍa*. In Stanford J. Shaw's words, "The silver coin in common use during Mamlûk and Ottoman times in Egypt was called *nıṣf fiḍḍe* colloquially and *para* officially." Stanford J. Shaw, *The Financial and Administrative Organization and Development of Ottoman Egypt, 1517-1798* (Princeton: Princeton University Press, 1962), 65, n. 169. Repairs to irrigation works in Fayyūm were often funded from the Egyptian *irsaliye*. The *irsaliye* represented the overall revenue garnered from an Ottoman province in any given year, and it was the responsibility of the *vali* to send these funds to Istanbul. The Egyptian *irsaliye* was historically the largest in the empire. For cases concerning various aspects of the organization of the yearly Egyptian *irsaliye*, see: Topkapı Sarayı Müzesi Arşivi (Topkapı Palace Museum Archive, Istanbul) [hereafter TSMA], E. 664/4 (n.d.); TSMA, E. 664/64 (1 C 1059/12 Jun. 1649); TSMA, E. 5207/57 (Evail B 1056/12-21 Aug. 1646); TSMA, E. 5207/58 (Evasıt B 1056/22-31 Aug. 1646); TSMA, E. 7016/95 (n.d.); TSMA, E. 5207/49 (Evahir Ca 1056/5-14 Jul. 1646); TSMA, E. 664/66 (n.d.); TSMA, E. 4675/2 (20 N 1061/6 Sep. 1651); TSMA, E. 3522 (24 Ş 1148/8 Jan. 1736). For further discussion, see: Shaw, *Financial and Administrative Organization and Development*, 283-312, 399-401. For a detailed accounting of each component of the *irsaliye* from 1596 to 1597, see: Stanford J. Shaw, *The Budget of Ottoman Egypt, 1005-1006/1596-1597* (The Hague: Mouton, 1968).

[25] BOA, Mühimme-i Mısır 1: 167 (Evasıt S 1123/31 Mar.-9 Apr. 1711).

materials—mainly lime (*kireç*), wooden supports (*şecār*), and stone (*taş*). Istanbul directed that these monies were to be taken out of the Egyptian *irsaliye* of 1710/1711.

In short, the engineers of Fayyūm worked in conjunction with the imperial administration to fix problems on Baḥr Yūsuf. Engineers were a clearly identified and recognized group in Fayyūm whose trustworthiness and soundness of mind were both confirmed by the Ottoman state and relied upon to carry out needed infrastructural work.

Intermediary, 1713

The role of the engineer as intermediary between the imperial and the local is further evidenced by cases of irrigation repair that, like the previous example from Fayyūm, climbed all the way up the bureaucratic ladder to reach the palace in Istanbul. Such cases most usually involved very large irrigation structures whose damage or destruction would have deeply impacted imperial governance in Egypt and throughout the empire. In 1713, a petition from Manfalūṭ in southern Egypt reached the sultan's court.[26] The supports of a weir on a canal in the village of Waḥīshāt near Manfalūṭ had been broken by the force of the water's incessant pounding and were now in a dangerous state of disrepair. Should the supports give way entirely, water would rush through the canal uncontrollably, and the many villages that relied on the canal would therefore lose their primary source of water, causing agricultural lands to remain parched and dry and food supplies and tax income to suffer.

This threatening situation occasioned great concern for the Ottoman sultan and his retinue. They understood the downstream implications of the massive loss of agricultural resources and revenues from an area of high cultivation like Manfalūṭ. Indeed the seriousness of this situation is evidenced by the fact that this petition was not handled by the court in Manfalūṭ,

[26] BOA, Cevdet Nafia 120 (Evasıt Ca 1125/5-14 Jun. 1713).

but instead bubbled all the way up to the palace itself. In response, the sultan issued a firman instructing his *vali* to hire, yet again, an engineer and other local experts (*ehl-i hibre ve erbab-i vukuf*) to inspect the situation.[27] The engineer's name was el-Hâc Mehmet, and, quite tellingly, of the men of technical knowledge identified in this case, only the engineer was specifically named. Thus again we find a corporate institution of technical expertise in the Egyptian countryside that took the lead in inspecting and repairing irrigation works.

After Mehmet and his associates had gone to the site of the deteriorating weir and completed their measurements, they reported back to the palace, through the *vali*, that the area of the weir in need of repair measured 9,110 square *zirā'* and would cost 18,130 *para* to fix. After some deliberation, and with the stated goal of properly reinforcing the weir to prevent future damage, funds were made available to undertake the repairs. Throughout the text of the firman issued to release these funds, the authority of the engineer is again invoked to evidence the exigency of the repair work and to justify the costs.

Thus, as before, this case also turned on the expertise of the engineer. Mehmet was the one who directed how much the state was to spend on repairing a damaged weir. The line of communication in this case was very clearly drawn from a particular petitioning community in Egypt through the engineer to the sultan. It was the engineer's technical knowledge that integrated him into the imperial administration. The sultan in many ways devolved authority over technical matters such as the repair of a weir to local experts who had proven both their acumen and their trustworthiness. Mehmet could not fix irrigation works without the money provided by the state, and the state could not fix them without the knowledge provided by experts like Mehmet. This was why engineers were so indispensible to Ottoman governance and why Ottoman governance was so indispensible to engineers.

[27] For more on these local experts, see: Mikhail, *Nature and Empire*, 66, 176-78.

Persistence, 1816

The knowhow and expert function of local Egyptian engineers like ʻAṭāʾ Allah, Ḥasan, Shāhīn, and Mehmet would remain important well into the period of Mehmet ʻAli's reforms in the first half of the nineteenth century. Mehmet ʻAli's major innovation in the realm of engineering was the establishment of a School of Engineering in the fall of 1816. Although he imported European teachers, textbooks, and training as part of the founding of the school, Mehmet ʻAli nevertheless continued to privilege the knowledge and technical skill of Egyptian engineers. Local engineers still drove how Ottoman rulers used expertise. The story of the engineering school's founding logic makes this abundantly clear. As the Egyptian chronicler al-Jabartī relates:

> A Cairene named Ḥusayn Çelebi ʻAjūwa had the idea of a wheel to use in stripping rice. He made a model of it in tinplate which revolved with great ease, so that whereas the conventional apparatus required four oxen to drive it, his needed only two. The pasha admired this model when it was presented to him, so he gave Ḥusayn some money and ordered him to build a wheel in Damietta crafted according to his knowledge of engineering. With a decree authorizing the wood, iron, and whatever money he needed, Ḥusayn made the machine, thus verifying what he had claimed. After constructing another at Rosetta, he gained renown.
>
> The pasha became convinced, based on Ḥusayn Çelebi's feat, that Egyptians have a superior aptitude for the sciences. Accordingly he ordered that a school be built in the courtyard of his palace in which a group of natives and the pasha's mamluks were

> enrolled under the teacher Ḥasan Efendi, known as al-Darwīsh al-Mawṣilī. With the collaboration of a Turk named Rūḥ al-Dīn Efendi and several Europeans the principles of accounting and engineering were taught, as well as arithmetic, geometry, and trigonometry, and algebra.[28] Various technical instruments of English manufacture were provided, with which the students could measure distance, elevation, and area. Provided monthly stipends and yearly clothing allowances, they met regularly in this school, which was called the School of Engineering, every morning of the week until shortly past noon, when they returned to their homes. Some days they made field trips to the open country to study surveying. In fact, knowledge of surveying was the pasha's main goal.[29]

The institutionalization of engineering knowledge in a formal school was of course something novel in Ottoman Egypt.[30] What is even more striking, however, is the great extent to which the role of early modern engineers and of engineering knowledge persisted into the nineteenth century. Engineers were still in direct communication with Ottoman officials about their abilities to improve rural technologies, and, as before, the imperial state gave them money to facilitate their work—as is made clear in the story of Ḥusayn Çelebi related by al-Jabartī. Reputation, moreover, remained of the utmost importance to the economy of engineering in the early nineteenth century. It was Ḥusayn Çelebi's "renown" that proved his worth. The Ottoman administration of Egypt thus still clearly relied on engineers.

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[28] For more on Rūḥ al-Dīn Efendi's work in Egypt, see: ibid., 260-63, 284. On his career in the imperial translation office in Istanbul, see: Christine M. Philliou, *Biography of an Empire: Governing Ottomans in an Age of Revolution* (Berkeley: University of California Press, 2011), 91-93.

[29] ʻAbd al-Raḥman al-Jabartī, *ʻAbd al-Raḥman al-Jabartī's History of Egpyt: ʻAjā'ib al-Āthār fī al-Tarājim wa al-Akhbār*, eds. Thomas Philipp and Moshe Perlmann, 4 vols. (Stuttgart: Franz Steiner Verlag, 1994), 4: 359.

[30] Related to surveying, another motivation behind the founding of the school was the desire to create a class of technocrats who could advise Mehmet ʻAli on his massive irrigation schemes and other infrastructural manipulation projects. On this point, see: Mikhail, *Nature and Empire*, 260-61.

Mehmet ‘Ali’s belief “that Egyptians have a superior aptitude for the sciences” came from the centuries-long role of engineers in Egyptian society. Mehmet ‘Ali’s school was a formal recognition of this fact and an attempt to institutionalize these engineers’ knowledge. Many of the students in the school, those referred to as “natives” by al-Jabartī, were engineers like ‘Aṭā’ Allah, Ḥasan, Shāhīn, and Mehmet—locals from rural communities throughout Egypt who were brought to Cairo in an effort to centralize their expertise for the benefit of Mehmet ‘Ali’s government. And even though others now participated much more directly in the development and utilization of engineering expertise in Egypt—Europeans, Ottoman officials, Mehmet ‘Ali’s own mamluks, and government technocrats—local Egyptian engineers, the *ehl-i hibre ve erbab-i vukuf* of the countryside, still offered the best advice and most expert knowledge.

This was in evidence when Mehmet ‘Ali’s son, Ibrahim Paşa, undertook a cadastral survey in 1821. He assembled several groups of surveyors and engineers: officials from the School of Engineering, 60 engineers from Upper Egyptian towns and villages, a group of European engineers, and a number of Coptic surveyors led by the Coptic notable al-Mu‘allim Ghālī. Each of these groups of engineers represented a different tradition and understanding of technical knowledge, and each pressed for its right to have priority in administering this cadastre. To help him in choosing which group of experts to use for the survey, Ibrahim Paşa decided to arrange for a kind of engineering contest. “He announced that he wanted precision combined with speed and set a test on a plot of land which would demonstrate precision and variations.”[31] The winners of this competition were the Coptic engineers. If we accept al-Jabartī’s claim that the School of Engineering was founded primarily for purposes of surveying, then, at least in this instance, the school seems to have failed in this mission. Its graduates could not compete in a

[31] al-Jabartī, *‘Ajā’ib al-Āthār*, 4: 448.

surveying contest with Egyptian engineers who had no connection to the school. Thus despite the emergence of European and other forms of scientific knowledge, local Egyptian engineering knowhow still won out as the most useful and significant.[32] A local tradition of engineering expertise persisted.

Conclusion

We are accustomed to seeing the decades around 1800 as a period of complete rupture. The early modern centuries are, we are told, vastly different from the nineteenth century. In the face of this assertion of a temporal divide, the persistence of engineering knowledge in Ottoman Egypt serves as an important example of some of the many continuities between these supposedly incommensurable periods. The founding of the School of Engineering, a marker of innovation and rupture, while of course a significant event in and of itself, did not radically alter the role or status of local engineering knowledge in Egypt. Engineers drawn from local communities throughout Egypt still directed the state in its management and manipulation of the countryside.

This kind of before-and-after-1800 historiography of the Ottoman Empire has a corollary in the field of environmental history that is worth considering in this context. Environmental historians have identified a notion of pristine nature as both a fiction and a trap.[33] Pristine nature is the idea that somehow nature was in a perfect state of harmony, balance, and sustainability before humans came to destroy it. Embedded in this idea of pristine nature is the specter of ecological "decline"—another conceptual fiction that Ottoman historians are all too aware of.

[32] For more on this dynamic, see: Mikhail, *Nature and Empire*, 279, 288.
[33] William M. Denevan, "The Pristine Myth: The Landscape of the Americas in 1492," *Annals of the Association of American Geographers* 82 (1992): 369-85; William Cronon, "The Trouble with Wilderness: Or, Getting Back to the Wrong Nature," *Environmental History* 1 (1996): 7-28. For further discussion, see also the several essays on this topic and William Cronon's response in the same issue of *Environmental History*.

The declensionist narrative of environmental history posits that the overwhelming majority of human interactions with nature have been detrimental.[34] Humans have depleted, mangled, and scarred environments in various irreversible ways that have forever ruined what could only have been a pristine, because now lost, version of nature. Critiques of these ideas emphasize that the relationships between humans and the rest of nature are much more complex than this simple story of one-way decline and ruin. Environments shape humans, humans then reshape environments, these new environments offer a new set of limits for humans, and so on and so forth.[35] It is this dialectical relationship that we must understand to fully grasp environmental history. The idea of pristine nature thus in many ways takes ecology out of history. Environmental history works to put ecology back into history and history back into ecology.

These ideas and their critiques are highly useful and instructive for Ottoman historians. The empire's early modern history was not a pristine moment of unvariegated state and society relations waiting patiently—outside of history as it were—for the forceful ideas, actors, and wars of the nineteenth century. As I have tried to show a bit of in this chapter, the early modern centuries were a dynamic and conflicted period in their own right, not a mere empty stage awaiting the main event of the century of history. The notion of a pristine early modernity thus sets up a false dichotomy between what came before and what came after 1800. The divide is not so unassailable.

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[34] For an analysis of some of the political and ecological uses of a declensionist environmental narrative in colonial North Africa, see: Diana K. Davis, *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa* (Athens: Ohio University Press, 2007), 131-176; idem., "Potential Forests: Degradation Narratives, Science, and Environmental Policy in Protectorate Morocco, 1912-1956," *Environmental History* 10 (2005): 211-38.

[35] In William Cronon's words, "environment may initially shape the range of choices available to a people at a given moment, but then culture reshapes environment in responding to those choices. The reshaped environment presents a new set of possibilities for cultural reproduction, thus setting up a new cycle of mutual determination." William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England*, rev. ed. (New York: Hill and Wang, 2003), 13.

Rural engineers are an important component of this story of continuity. As their example shows, certain kinds of actors and forms of expertise persisted across the purported temporal divide of 1800. Indeed, the ways in which engineering knowledge came to shape nineteenth-century rural Egypt followed patterns set much earlier. As we saw with the examples of ʻAṭāʼ Allah, Ḥasan, Shāhīn, and Mehmet, engineers were the experts on whom the Ottoman administration came to rely to defuse the tension and conflict inherent in the management of irrigation works and, ultimately, to properly repair early modern Egypt's rural infrastructure. Their authority derived from their expertise, reputation, and ability to provide accurate estimates of repair dimensions and costs. They served as crucial intermediaries between imperial desires and ambitions and local ecological realties and economic interests. Engineers helped to make the rural world.