

# INDIAN RIVERS, ‘PRODUCTIVE WORKS’, AND THE EMERGENCE OF LARGE DAMS IN NINETEENTH-CENTURY MADRAS\*

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**ABSTRACT.** *The nineteenth century witnessed a major expansion in the construction of public works including canals, roads, and railways across the British empire. The question that colonial governments faced during the nineteenth century was on how to finance public works. Focusing specifically on irrigation works and the rivers of southern India, this article shows how different experiments were attempted, including raising capital and labour from local communities as well as corporate investment in irrigation works through London capital markets. The article argues that by the latter part of the nineteenth century, a definitive answer had emerged, i.e. irrigation projects on rivers would be financed through state debt. An enormous body of scholarship in Britain and India debated the relationship between public works and public debt. This article rethinks this scholarship as a technological and environmental history. The article argues that colonial modes of raising capital were dependent on speculating on Indian rivers. Historiography wise, in contrast to scholarship which takes for granted the role of the state in building large dams, it suggests that the emergence of the state as the builder of large dams was part of a more fundamental relationship between rivers, technology, and colonial capital that emerged in the nineteenth century.*

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In a minute to the British parliament in 1844, the marquis of Tweeddale, George Hay, also the governor of the province of Madras, made a powerful plea to mobilize the potential of British India’s rivers.<sup>1</sup> Hay argued that the ‘unlimited supply’ of water offered by rivers for irrigation, harnessed by

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<sup>1</sup> Minute by the marquis of Tweeddale, *Proceedings and correspondence: public works commission Madras presidency* (Madras, 1855), pp. 24–5.

application of ‘only ordinary skill’ and little capital, could turn barren tracts across south India into productive agricultural fields, earning a considerable corpus of revenue for the Raj.<sup>2</sup> Hay’s remarks were part of a wider thinking that emerged in British India among military engineers and revenue officials in the 1830s and 1840s which sought to tap river water across the Indian sub-continent for large-scale irrigation schemes. By the 1880s, the Madras government, a provincial government in southern British India, had built its first large dam, the Periyar dam, on the Vaigai River – a feat deemed both technologically and financially unfeasible in the early decades of the nineteenth century.<sup>3</sup>

The article makes an intervention in the historiography of large dams in South Asia and the governance of natural resources in the British empire. In most scholarly accounts of damming and irrigation works, which largely focus on post-colonial India, the state as the instigator of large-scale dam projects on rivers is taken for granted. Daniel Klingensmith’s and Daniel Haines’ work on post-colonial dam projects take as their point of departure the export of the Tennessee Valley Authority dam project to India and the territorial control that dams afforded to the newly independent states of India and Pakistan.<sup>4</sup> Amita Baviskar’s work shows how the post-colonial state projected promises to the people through large dam projects.<sup>5</sup> In short, the large dam was an iconic representation of the post-colonial Indian state. This work complicates, in the Indian context, Karl Wittfogel’s thesis on ‘hydraulic civilizations’, which asserted that only state bureaucracies could mobilize the required resources to construct and control large irrigation projects, in the process asking questions on development, geopolitics, and resistance.<sup>6</sup> Unlike most historiography focusing on post-colonial history that takes for granted that states

<sup>2</sup> Ibid.

<sup>3</sup> While this article focuses on Madras, the colonial state planned to build large-scale irrigation projects to increase land productivity across India. On the Indus basin, see David Gilmartin, *Blood and water: the Indus river basin in modern history* (Berkeley, CA, 2015); on the famous ‘canal colonies’ of Punjab, see Neeladri Bhattacharya, *The great agrarian conquest: the colonial reshaping of a rural world* (Ranikhet, 2018); Indu Agnihotri, ‘Ecology, land use and colonisation: the canal colonies of Punjab’, *Indian Economic and Social History Review*, 33 (1996), pp. 37–58.

<sup>4</sup> Daniel Klingensmith, *‘One valley and a thousand’: dams, nationalism, and development* (New Delhi, 2007); Daniel Haines, *Rivers divided: Indus basin waters in the making of India and Pakistan* (London, 2017).

<sup>5</sup> Amita Baviskar, ‘The dream machine: the model development project and the remaking of the state’, in Amita Baviskar, ed., *Waterscapes: the cultural politics of a natural resource* (Ranikhet, 2007), pp. 281–313.

<sup>6</sup> Karl August Wittfogel, *Oriental despotism: a comparative study of total power* (New Haven, CT, 1957); Rohan D’Souza’s work on lower Bengal and David Gilmartin’s work on the Indus basin are exceptions to this trend. However, they do not ask how and why the state started building large dams. Rather, their focus is on how the state facilitated forms of colonial capitalism and revenue extraction and how it imagined and created communities. See Rohan D’Souza, *Drowned and dammed: colonial capitalism, and flood control in eastern India* (New Delhi, 2006); Gilmartin, *Blood and water*.

built dams, this article delves into the colonial era to argue that it was not inevitable that the state would finance and construct large infrastructure projects dams on rivers. Rather, the colonial state, in the face of several alternatives, emerged as the most stable mobilizer of capital, technology, and labour to build large dams.<sup>7</sup>

The article further makes a broader historiographical argument on the relationship between British imperial governance structures and natural resources. While several works from the fields of economic history and environmental history have pointed out the extractive relationship that developed between the British empire and colonial natural resources, few have understood how the governance categories that facilitated this came about.<sup>8</sup> Corey Ross suggests that imperialism was an 'attempt to transform forests, savannahs, rivers, coastal plains, and deserts into productive and legible spaces'.<sup>9</sup> Historians have used several *analytical frameworks* to show how colonial spaces of natural resources have been transformed. Richard Drayton for instance shows how British knowledge as a form of power was imposed through Kew Gardens and the sensibility of 'improvement' on the colonial world.<sup>10</sup> Early historiography on colonial forestry in South Asia, notably Madhav Gadgil and Ram Guha, argued that British imperialism was a clear case of colonial expropriation.<sup>11</sup> Namely colonial officials felled forests to construct the railways and used timber as fuel for factories. Forests were therefore denuded and forest dwellers dispossessed of livelihoods. In the case of rivers, Rohan D'Souza shows how 'colonial capitalism', primarily through refiguring property relations, transformed the flood dependent landscape of eastern India into a flood vulnerable one.<sup>12</sup>

Rather than creating a new analytical framework, this article shows how histories of technology, finance, and global economic and environmental

<sup>7</sup> 'Capital' here is used as being synonymous with mobilizing funds and investment, rather than being connected to 'capitalism'.

<sup>8</sup> A representative sample of work includes Daniel Thorner, *Investment in empire: British railway and steam shipping enterprise in India, 1825-1849* (Philadelphia, PA, 1950); Roger Owen, *Cotton and the Egyptian economy, 1820-1914: a study in trade and development* (Oxford, 1969); P. J. Cain and A. G. Hopkins, *British imperialism: 1688-2015* (Abingdon, 2016); Jason W. Moore, 'Amsterdam is standing on Norway', Part II: 'The global north Atlantic in the ecological revolution of the long seventeenth century', *Journal of Agrarian Change*, 10 (2010), pp. 188-227; Prasannan Parthasarathi, *Why Europe grew rich and Asia did not: global economic divergence, 1600-1850* (Cambridge, 2011), ch. 6.

<sup>9</sup> Corey Ross, *Ecology and power in the age of empire: Europe and the transformation of the tropical world* (Oxford, 2017), p. 3.

<sup>10</sup> Richard Drayton, *Nature's government: science, imperial Britain and the 'improvement' of the world* (New Haven, CT, 2000).

<sup>11</sup> Ramachandra Guha and Madhav Gadgil, 'State forestry and social conflict in British India', *Past and Present*, 123 (1989), pp. 141-77; for a similar argument, see Pallavi Das, 'Colonialism and the environment in India: railways and deforestation in nineteenth-century Punjab', *Journal of Asian and African Studies*, 46 (2011), pp. 38-53.

<sup>12</sup> D'Souza, *Drowned and dammed*.

moments produced new categories to facilitate the colonial state's control over natural resources. 'Wasteland', for instance, is one category that has received sustained scholarly attention. Waste was a form of categorization deployed by colonial officials in multiple ways, often as a frontier of land that was 'in-waiting' for cultivation.<sup>13</sup> In the case of colonial Madras, Bhavani Raman shows that waste was a complex register of a 'range of ecologies' including garden lands, orchards, and shrub lands, formulated through legal dispute and subject to contestation.<sup>14</sup> In a similar fashion, this article traces the development of the category of 'productive works', through examining British colonial attempts to control river water. This article further examines the precise ways in which the category of 'productive works', which would go on to shape how large infrastructure projects were built in the twentieth century, emerged. The article investigates the administrative categories through which colonial governments monetized natural resources in the colonies.

The article is divided into four further sections. Tracking the career of the engineer Arthur Cotton and his successful improvement works on the Cauvery River, section I shows how the Madras government was convinced by the 1850s that larger capital expenditure on irrigation works would amount to exponential revenue increases. Sections II and III turn to the search by successive administrations in Madras and provinces across British India for capital to construct irrigation works. Section II shows how revenue officials and engineers of the public works department initially attempted to mobilize capital from local zamindars and coerce labourers to work on irrigation works. Yet, as the section shows, this attempt failed. In the face of this failure, section III shows how Arthur Cotton and other irrigation engineers championed the cause of private enterprise in constructing river improvement works. It traces the history of the Madras Irrigation and Canal Company, the initial euphoria the company caused in capital markets in Britain, and its eventual failure. Section IV shows how the colonial state emerged as the primary financier of large-scale river improvement works. Taken together, the devastating famines that hit southern India in the late nineteenth century and the failure of community capital and labour and corporate enterprise pushed the state into this position.

The manner in which the state would fund river improvement projects, under the head of 'public works', is significant. Irrigation-related public works projects were to be divided under two headings – 'protective' and 'productive'. Protective works would be financed from current revenue, and were largely

<sup>13</sup> Vinay Gidwani, "'Waste" and the permanent settlement in Bengal', *Economic and Political Weekly*, 27 (1992), pp. PE39–46; David Gilmartin, 'Water and waste: nature, productivity and colonialism in the Indus basin', *Economic and Political Weekly*, 38 (2003), pp. 5057–65.

<sup>14</sup> Bhavani Raman, 'Sovereignty, property and land development: the East India Company in Madras', *Journal of the Economic and Social History of the Orient*, 61 (2018), pp. 984, 999.

for undertaking systematic repairs and executing small projects.<sup>15</sup> The second category, of 'productive works', was novel and would go on to shape the state's relationship with rivers and reservoirs into the twentieth century. The category of 'productive works', instituted in 1879, was a method of financing large infrastructural projects in British India. A project classified as 'productive' implied a large financial outlay, drawn through complex networks of loans from financial markets in London, including the Bank of England, and guaranteed by the government of India. Provincial governments would have to approach the government of India with plans for particular public works projects in order to obtain loans.<sup>16</sup> Key to approval was financial viability. Technical plans made by engineers would have to guarantee certain returns from a project, typically within ten or twenty years, depending on the project. In other words, projects would have to be self-financing, not immediately, but in the future.<sup>17</sup> This category of 'productive works' – a way in which the economic potential of rivers could be harnessed through technology and finance – was profoundly important for the rise of the large dam as a state-led enterprise. The article argues that at the heart of the large dam, therefore, was a more fundamental relationship between the expansion of Victorian capital, contingent events such as the famine, and natural resources in the colonies.

## I

When the colonial government gained political control of large parts of south India in the late eighteenth and early nineteenth centuries, irrigation works were in a decrepit state across the region.<sup>18</sup> There were three kinds of irrigation works of importance, including tanks, small embankments, and large *anicuts* (dams that diverted the direction of water flow). Tanks, both large and small, were structures designed to store water at the tail end of rivers.<sup>19</sup> They had existed across south and western India since 300 BC, but multiplied rapidly during the reign of the Chola dynasty in the thirteenth century.<sup>20</sup> Tanks in 1800 were largely in a state of dysfunction across the province. Individual landlords who were often owners of tanks failed to maintain them and ensure that they were connected via canals to fields. Embankments were temporary

<sup>15</sup> Peter P. Mollinga, *On the waterfront: water distribution, technology and agrarian change in a south Indian canal irrigation system* (Hyderabad, 2003), p. 53.

<sup>16</sup> Loren Howard Michael, 'Water resource management in south india: irrigation and hydroelectric power in the Cauvery river basin, 1878–1939' (unpublished thesis, Wisconsin–Madison, 1979), pp. 29–30.

<sup>17</sup> A. K. Connel, *The economic revolution of India and the public works policy* (London, 1883), p. 8.

<sup>18</sup> Arun Bandopadhyay, *The agrarian economy of Tamilnadu, 1820–1855* (Calcutta, 1992), p. 44.

<sup>19</sup> For a visual depiction of how tanks work as technology, see Esha Shah, *Social designs: tank irrigation technology and agrarian transformation in Karnataka, south India* (New Delhi, 2003), p. 2.

<sup>20</sup> Vinod Chandra Srivastava, *History of agriculture in India, up to c. 1200 A.D.* (New Delhi, 2008), p. 501.

structures made of mud or clay, erected to either save lands from inundation or temporarily store rainwater and water from small streams and rivers.<sup>21</sup> They were usually maintained by village communities, but there existed no centralized rules or regulations for their upkeep. Large *anicuts* were few in the province, the most important was the Grand *Anicut* located on the Cauvery River at its entry into Tanjore district. The Grand *Anicut* was severely silted up at its base, leading to water overflows, rather than the precise diversions of water. For company state officials, if amounts of water supplied by such irrigation works increased, cultivators would shift from growing dry crops such as millets to the more lucrative wet crops such as rice. In turn, the company state could charge higher rates of tax, as wet crops commanded a higher price in the market.<sup>22</sup>

Considering the poor state of irrigation works, the colonial bureaucracy focused on surveying and repairing older irrigation works and constructing new ones. District collectors commissioned small improvement works, while an office known as the superintendent of tank repairs handled larger works.<sup>23</sup> By 1814, a department of public works under the board of revenue, a superintendent of roads, and the military board were all in charge of public works of different kinds. In the 1830s, discussions began over centralizing and streamlining the multiplicity of agencies which had a stake in building and maintaining irrigation facilities in Madras. Irrigation and river improvement projects were brought under the control of a *maramut*, or repair department, and the office of the superintendent of tank repairs was abolished.<sup>24</sup> In 1838, the Madras presidency was rearranged into eight divisions, each headed by a civil engineer.<sup>25</sup> Three categories were drawn up, under which all irrigation works were to be classified. 'Emergent' was urgent work which could not be postponed; 'ordinary' signified regular and periodic repairs on works exposed to water; and 'extra-ordinary' was a category reserved for those projects requiring significant expenditure.<sup>26</sup>

As a new bureaucracy was established to regulate, repair, and manage irrigation works, significant developments occurred between 1830 and 1852. Military engineers across British India achieved huge increases in land productivity by modifying rivers through minor capital investment. While engineers celebrated successes across India on different kinds of irrigation works, this article focuses

<sup>21</sup> For more on the technical working of embankments, see D'Souza, *Drowned and dammed*, pp. 101–2.

<sup>22</sup> This is the basic premise upon which irrigation ushered in the commercialization of agriculture. K. N. Raj, ed., *Essays on the commercialization of Indian agriculture* (Delhi and Oxford, 1985).

<sup>23</sup> Sarada Raju, *Economic conditions in the Madras presidency, 1800–1850* (Madras, 1941), pp. 124–5.

<sup>24</sup> *First report of the commissioners appointed to enquire into and report upon the system of superintending & executing public works in the Madras presidency* (Madras, 1852), p. 1.

<sup>25</sup> *Ibid.*, p. 6.

<sup>26</sup> *Ibid.*, p. 10.

on Arthur Cotton's successes in remodelling the Grand *Anicut* and constructing new works on the Cauvery River in the Madras presidency. The improvements effected by Cotton demonstrate the ways in which hydraulic engineers modified large rivers to increase the revenue returns to the government.

Arthur Cotton, an experienced engineer who had joined the Madras military engineering corps in the 1830s, fundamentally changed the government's approach to controlling river water flows.<sup>27</sup> In 1804, in a survey of the River Cauvery, Captain Caldwell, a military engineer, remarked that unless silting at the bed of the Grand *Anicut* on the Cauvery could be stopped, the river would no longer be a 'useful stream' for irrigation.<sup>28</sup> Thirty-two years later, beginning with the Cauvery, Cotton began a series of hydraulic initiatives intended to improve the revenue-yielding potential of rivers across the Madras presidency. As [Figure 1](#) shows, the Cauvery flowed from Coorg in the Mysore state in south-west India and drained into the district of Tanjore. At its entry into the Tanjore district, it bifurcated into two major rivers—the Coleroon and Cauvery—and then further split into multiple smaller rivers and channels rendering the delta one of the most fertile regions in India, but dependent largely on river water.<sup>29</sup>

According to later accounts, Cotton's improvements on the Cauvery rendered the Tanjore district as the 'Lombardy of Southern India'.<sup>30</sup> That is, from a state of stagnating productivity, Cotton's engineering improvement works had rescued the Cauvery delta by the 1850s, and turned it into one of the highest revenue generating regions in British India. Irrigation works in the Cauvery delta, as elsewhere in British India and the world, relied on two fundamental principles. First was to ensure adequate supply of water for agriculture. Second was to protect the land from the effects of waterlogging.<sup>31</sup> The Coleroon's current was much quicker than that of the Cauvery as features of the Coleroon's slope allowed for a rapid flow of water that was also much larger in volume than that of the Cauvery.<sup>32</sup> It was therefore evident to engineers that as silt continually deposited on the head of the Cauvery, increasing quantities of water were flowing into the Coleroon.<sup>33</sup> Initially, labourers were engaged to de-silt the head of the Cauvery to allow water flow, but this was

<sup>27</sup> Lady Elizabeth Hope and William Digby, *General Sir Arthur Cotton, his life and work* (London, 1900).

<sup>28</sup> *Ibid.*, p. 45.

<sup>29</sup> Reverend G. Richter, *Gazetteer of Coorg* (Bangalore, 1870), pp. 13–14.

<sup>30</sup> Richard Baird Smith, *The Cauvery, Kistnah, and Godavery: being a report on the works constructed on these rivers for the irrigation of the provinces of Tanjore, Guntoor, Masulipatam, and Rajahmundry, in the presidency of Madras* (London, 1856), p. 2. Lombardy was a province in southern Italy which engineers had considerably modified in the early nineteenth century. See Richard Baird Smith, *Italian irrigation: a report on the agricultural canal of Piedmont and Lombardy* (London, n.d.).

<sup>31</sup> Smith, *The Cauvery, Kistnah, and Godavery*, p. 5.

<sup>32</sup> *Ibid.*, p. 10.

<sup>33</sup> *Ibid.*



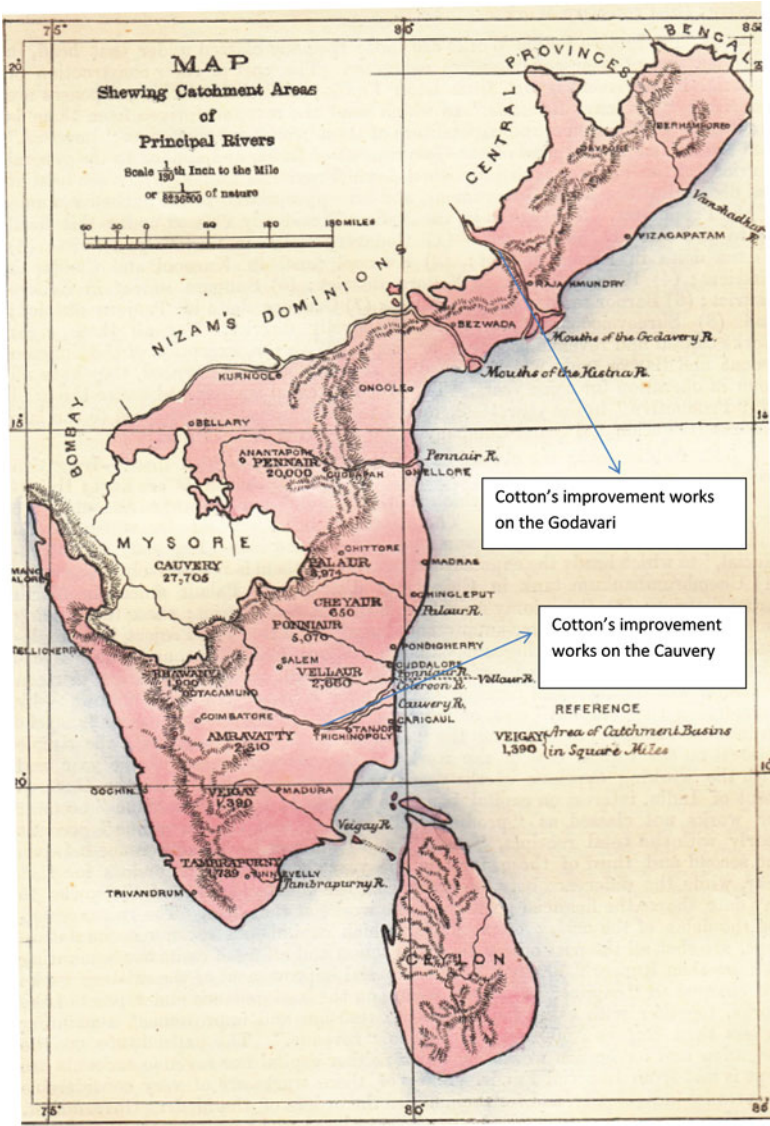


Fig. 1. Map showing Cotton's river improvement works.

Source: *Manual of administration of the Madras presidency volume 1* (Madras, 1885), p. 393.

not a sustainable engineering arrangement as it required yearly work. However, these initial forays into engineering the river allowed engineers to conduct research on solving this problem. Engineers found that the dam at the Grand Anicut, which had withstood over a thousand years of the river's currents, was



held together by stone and clay. There was a growing belief among engineers in Madras that by using more modern materials such as mortar, a dam could be built which would not merely hold the river back during years of flooding, but actively move water from the Coleroon to the Cauvery.<sup>34</sup>

Cotton began work on an engineering solution to move water from the Coleroon to the Cauvery in 1836. His calculations, averaged over several years, showed that the water flow of the Cauvery before it split was 16,875 cubic feet per second. The amount of water required for irrigation in the districts of Tanjore and Trichinopoly was around 16,745.5 cubic feet per second, which would irrigate 669,900 acres in the two districts. While the overall quantity of water was sufficient for irrigation, the anomaly was that while the Cauvery was irrigating 584,900 acres of land with 9,375 cubic feet per second of water entering its mouth, the Coleroon was providing for only 165,000 acres with 7,500 cubic feet per second. Considering the disparity, engineers believed that water from the Coleroon could be redirected to flow into the Cauvery, since it was irrigating more land with less water.<sup>35</sup> Using techniques of hydrometric approximation through meter gauge records, under the supervision of Cotton, engineers built a dam of a particular height across the bed of the Coleroon from 1836 to 1838.<sup>36</sup> This diverted water to the Cauvery which was irrigating a larger portion of the deltaic region. The dam was made of brick masonry, supported by hydraulic cement. At its foot were a series of twenty-two sluice gates enabling silt and sand, which collected at the lower reaches of the dam, to pass through.<sup>37</sup>

Other engineers followed up on Cotton's hydraulic improvements, which led to major increases in revenue by the 1850s. In 1839, it became clear that the sluice gates were insufficient. The river had responded by sanding up at the foot of the dam across the Coleroon, raising the level of the river bed, rendering the dam inadequate.<sup>38</sup> Colonel Baird Smith, an engineer who succeeded Cotton in Madras, proposed that instead of fixed sluice gates of smaller dimensions, large movable ones with gears, such as those being used in the Northwestern province, could be installed. This would allow the periodic release of sand.<sup>39</sup> These engineering works at the mouth of the two rivers now reversed the prior condition. Improvement works on the Cauvery immediately yielded close to 80 per cent returns per annum on limited investments.<sup>40</sup> The works had brought into new cultivation over 250,000 acres of land, in

<sup>34</sup> *Ibid.*, pp. 12–13.

<sup>35</sup> *Ibid.*, p. 15.

<sup>36</sup> *Ibid.*, p. 17.

<sup>37</sup> *Ibid.*

<sup>38</sup> Engineers water communication between the Cauvery, Coleroon, and Munnywar suggested by Colonel Sim. India Office Records, British Library (IOR)/Z/E/4/16/S627.

<sup>39</sup> Smith, *The Cauvery, Kistnah, and Godavery*, p. 20.

<sup>40</sup> Elizabeth Whitcombe, 'Irrigation and railways', in Tapan Raychaudhuri et al., eds., *The Cambridge economic history of India*, II: c. 1751–c. 1970 (Cambridge, 1983), p. 710.

addition to 750,000 acres already irrigated by the Cauvery in the Tanjore delta.<sup>41</sup> A board of revenue estimate in 1858 computed returns from the Cauvery improvement works at 118 per cent of investment.<sup>42</sup>

Two kinds of hydraulic technologies, which were relatively cheap, played an important role in remodelling the Cauvery. First, hydraulic cement allowed for dams to be built on the Coleroon and Cauvery, which in turn ensured diversion of water flows from one river to another. Second, geared shutters further refined these diversions of water, allowing engineers to manipulate water flows between the rivers maintaining the precarious balance of irrigation but not inundation.<sup>43</sup> Both these technologies were undergirded by hydrometric approximation of river flows. That is, a trial and error method, whereby engineers had to experiment physically with different kinds of shutters and gears, suggesting technological uncertainty in the face of a moving and tempestuous river. In this way, by the late nineteenth century, the public works department was able to control somewhat the flow and distribution of water from the Rivers Cauvery and Coleroon to various field channels. From the 1830s onwards, through masonry dams and geared shutters, Madras engineers were able to control the directional flow of water and divert river water from areas where it was perceived as being in surplus, to regions of deficit.<sup>44</sup>

Cotton and other engineers, however, repeatedly emphasized, even as early as the second half of the nineteenth century, that regulating directional flows of water was only one part of controlling river flows. In a public address, Cotton argued that ‘there was no want for water in India’.<sup>45</sup> Rather, the problem lay in the nature of seasonal rainfall, and its propensity to occur in fits, starts, and bursts. In a comparative sense, a whole year’s rain in Norfolk would occur in just two nights in the Carnatic region.<sup>46</sup> Cotton argued that ‘the local rains sometimes failing over a certain tract, and when there is no deficiency that it sometimes falls in such untimely bursts, that form the great peculiarity of the Indian climate.’<sup>47</sup> Cotton proposed two simple solutions to the problem. The first, as discussed above, was to build an efficient network of canals and diversion dams to lead water from rivers on to fields in an even manner. Second, Cotton emphasized the need to *store* rain and river water in large reservoirs. The Cauvery works had been executed at extremely low costs.<sup>48</sup> The question which confronted the Madras government now was on

<sup>41</sup> David Arnold, *Science, technology, and medicine in colonial India* (Cambridge, 2000), p. 116.

<sup>42</sup> *Reports on the direct and indirect effects of the Godavery and Krishna Anicuts in Rajahmundry, Masulipatam, Guntoor and the Coleroon Anicuts in Tanjore, south Arcot* (Madras, 1858), p. 238.

<sup>43</sup> F. R. Hemingway, *Madras district gazetteers: Tanjore* (Madras, 1915), p. 105.

<sup>44</sup> Rohan D’Souza, ‘Supply-side hydrology in India: the last gasp’, *Economic and Political Weekly*, 50 (2003), pp. 3785–90; Rohan D’Souza, ‘Water in British India: the making of a “colonial hydrology”’, *History Compass*, 4 (2006), pp. 621–8.

<sup>45</sup> Arthur Cotton, *The famine in India* (London: Trubner & Co., 1866), p. 10.

<sup>46</sup> *Ibid.*, p. 11.

<sup>47</sup> *Ibid.*

<sup>48</sup> Arnold, *Science, technology, and medicine in colonial India*, p. 117.

how to finance river improvement works of greater magnitude and scale. It is to this story of finance which this article now turns.

## II

In the early years of company administration, officials argued that the upkeep and construction of irrigation works across India should be the responsibility of the village community. As one writer put it,

[a]t the commencement of our [British] rule it was hoped and expected that all irrigation works would eventually be maintained by the village communities concerned without cost to the State, although from the first it was clear that state funds must be advanced on loan to put them into satisfactory condition to begin with.<sup>49</sup>

In the early years of company administration, it was general practice that while the state would advance small loans to ensure that improvement works began, it would largely be left to the village communities to raise capital and utilize their labour to modify water bodies and subsequently increase agricultural produce.<sup>50</sup> As this section will show, however, the sheer complexity of the system to raise capital and mobilize local labour, including problems of corruption and uncompetitive returns on irrigation work for local zamindars, dissuaded the Madras government from continuing with this practice.

With Cotton's success in various river improvement works, the Madras government looked for new ways and means to finance such works. One method was to collect money advances from zamindars and engaging voluntary labour from the village community. Combined, engineers and administrators argued that finance from landholders and labour from the village community could propel Cotton's technological visions of making river water productive. Mobilizing capital from landlords and zamindars and labour from the village community was not for large works alone, but more generally for any kind of river improvement projects. In the years 1830–52, the company state made efforts to mobilize community capital and labour to construct and maintain irrigation works.

In 1838, Captain Arthur Thomas, a military engineer in Madras, wrote a memorandum detailing how the government might finance public works projects from local zamindars and landlords. He argued that private investments were required for 'Government to effect extensive and lasting improvement without any immediate outlay'.<sup>51</sup> Thomas put forth that wealthy and influential

<sup>49</sup> A. T. Arundel, *Irrigation and communal labour in the Madras presidency* (Madras, 1879), p. 29. This was consistent with the thoughts of Henry Maine and others who believed that the village was the ideal institution of social organization. See Karuna Mantena, *The alibis of empire: Henry Maine and the ends of liberal empire* (Princeton, NJ, 2010).

<sup>50</sup> *Ibid.*

<sup>51</sup> 'Cotton, Captain Arthur Thomas, Plan suggested by, for raising funds for construction of works of public utility by means of loans from individuals', IOR/Z/E/4/44/C1013: 1835–8.

landlords, who had both a financial stake in works being built by government, and a longer interest in the permanence of British rule, might be persuaded to invest in river improvement projects. Crucially, such landed and wealthy elements sometimes came with a supply of labour and material.<sup>52</sup>

There were, however, two problems. First, while the government most certainly considered irrigation works as investments yielding substantial returns, their returns could not be converted into money immediately. Unlike roads or bridges upon which tolls could be levied instantly upon construction and revenue generated returned to the financier, irrigation projects had no such guarantee. Zamindars were hesitant to invest in irrigation projects as a few years usually lapsed between the construction of a project and increase in revenues owing to land productivity. Furthermore, zamindars were not convinced that irrigation projects would improve productivity of lands and yield returns to investors.<sup>53</sup> Second, revenue officers scouring the countryside for potential investors noted that interest rates were much higher in the unsecured loan market as compared to what the government could offer in return for investing in irrigation projects. Typically, the government would offer an interest rate of 4–5 per cent return on investment, whereas a zamindar could earn interest of at least 16 per cent (up to 50 per cent) giving loans to cultivators. Moreover, there existed a coercive relationship between large landlords and small peasants, and extraction of interest and principal amounts were easier for zamindars.<sup>54</sup> Therefore, the proposal for raising loans from zamindars and landlords for constructing river improvement projects was abandoned by the 1850s.<sup>55</sup>

Three major concerns plagued the colonial state when employing (on both paid and voluntary terms) labour from local communities. The first problem was of delay and corruption. There was a long list of intermediaries who were demi-officials and contractors that the state believed funnelled money into their own pockets while mobilizing labour from the community. *Tahsildars* (low-ranking revenue officials), as soon as they received an order from the government for a river improvement project, would ask the village headman and *cornam* (accountant) to arrive at the *cutcherry* (local revenue office) and bring along labourers. The nature of the work was then scoped and an agreement signed with a monetary advance paid by the local revenue office, usually the *tahsildar*.<sup>56</sup> However, there were two reasons for delay of projects. First, local

<sup>52</sup> Ibid.

<sup>53</sup> Ibid.

<sup>54</sup> Nirmal Sengupta, *Managing common property: irrigation in India and the Philippines* (New Delhi, 1991), p. 51.

<sup>55</sup> It must be noted that in some regions, especially in the deltaic tracts of the province, some zamindars enthusiastically responded to the government and provided finances for projects. Christopher John Baker, *An Indian rural economy, 1880–1955: the Tamilnad countryside* (Oxford and New York, NY, 1985), pp. 77–8.

<sup>56</sup> *Second report of the commissioners appointed to enquire into and report upon the system of superintending & executing public works in the Madras presidency* (Madras, 1853), p. 51.

zamindars would appropriate the advance paid by the government, and pay workers with grain or coerce workers to perform unrelated tasks. Labourers would therefore either refuse to work on improvement projects or undertake employment on unrelated concerns on government money. Second, the *maistry*, or a skilled builder contracted to the state, would not be able to visit the actual site of the irrigation work often enough. The supply of skilled builders was insufficient, and they often had many projects to supervise, resulting in long delays.<sup>57</sup> At times the *tahsildar* would sanction repair or construction where none was needed, 'throwing Government money into the hands of his own friends or connections among the village Meerasidars [landlords]'.<sup>58</sup> Therefore, ideas of colonial difference, that is, the native intermediaries as corrupt and inefficient, coloured the colonial state's perception of and ability to mobilize the necessary labour to construct larger projects.<sup>59</sup>

Second, wages were uncompetitive and payments delayed. The Madras public works commission report found that wages offered on government projects were at times uncompetitive, especially for skilled workers. Evidence from the Madura district suggested that it would be more remunerative for skilled workers to work with private contractors, as this paid three times as much. Furthermore, artificers and bricklayers could usually find work in their own towns among family and friends, but had to travel to remote parts of taluks to work on government projects on low pay. Finally, there were delays in wage payment. Arthur Cotton found one case where labourers who had worked on a project were Rs. 2,000 in arrears. Accounts were closed months after the actual work was completed. Often, until a civil engineer actually checked the work, some money for labour and materials was held back.<sup>60</sup>

Third, labourers were often coerced to work on public works projects. The colonial state was ambivalent about this practice. Through the nineteenth century, colonial officials had coerced labourers to carry out various tasks, such as carrying army equipment. Whether it was labour for working on tea gardens in Assam or to construct public works such as roads, coercion through multiple forms, including violence or the law, was a systematic part of the colonial government's labour policy.<sup>61</sup> Officials in Madras believed that labour could be mobilized for construction of irrigation works via both payment, but also coercion. However, the Madras public works commission

<sup>57</sup> *Ibid.*, p. 52

<sup>58</sup> *First report of the commissioners*, p. 10.

<sup>59</sup> Partha Chatterjee, *The nation and its fragments: colonial and postcolonial histories* (Princeton, NJ, 1993).

<sup>60</sup> *Ibid.*, p. 23. Furthermore, as the public works commission report suggested, the problem of organizing labour constituted a major accounting problem

<sup>61</sup> Lipokmar Dzūvichū, 'Empire on their backs: coolies in the eastern borderlands of the British Raj', *International Review of Social History*, 59 (2014), pp. 89–112; Chitra Joshi, 'Public works and the question of unfree labour', in Alessandro Stanziani, ed., *Labour, coercion, and economic growth in Eurasia, 17th–20th centuries* (Leiden, 2012), pp. 273–88.

was unequivocal that coercing labourers for construction of irrigation works was unacceptable. It argued that the government must pass a legislation making 'voluntary labour' for constructing irrigation projects mandatory. Without legislation, coercing labourers, either directly or by local landowners at the behest of the government, was unfair to the well-being of the labourer.<sup>62</sup>

Considering these objections, the Madras public works commission of 1852 recommended that labour should not be mobilized from the community on a large-scale basis in order to construct irrigation works. The idea was nevertheless not entirely forgotten. Indeed, from the 1860s, the Madras government officials began to suggest that provision of voluntary labour for repair on local irrigation works was a traditional practice in south India. A series of laws were drafted but never passed and ratified by the governor to formalize *Kudimaramat* (community repair works) or compulsory labour from the village community for upkeep of irrigation works.<sup>63</sup> Nevertheless, from the 1850s, mobilizing voluntary community labour for *large state projects* was seen as impossible.

### III

The second means of raising capital that colonial officials considered was to encourage private corporations to construct river improvement projects. By the mid-1850s, as company rule came to an end, the British crown adopted a more centralized approach to construction of public works. British capitalists began to look at British colonies outside the Americas, especially India and Egypt, as investment destinations.<sup>64</sup> Alongside, engineers such as Arthur Cotton encouraged British capitalists to invest in river improvement projects across British India. This section shows how a corporate company, the Madras Irrigation and Canal Company (MICC), with the limited backing of the colonial state, began constructing a river improvement project in the northern regions of the Madras presidency, eventually running into losses and shutting down.

Beginning in the 1830s, major changes were afoot in the nature of corporate governance in Britain. The British parliament passed an act in 1844 allowing joint-stock companies to be incorporated far easier than before. Prior to this, only acts of parliament could create joint-stock companies. Behind these reforms lay a broader shift from incorporation as 'a closely guarded privilege,

<sup>62</sup> *First report of the commissioners*, p. 10.

<sup>63</sup> For more, see David Mosse, *The rule of water: statecraft, ecology, and collective action in south India* (New Delhi, 2003), pp. 247–54. As Mosse argues, the decline of the state's interest and ability in organizing community labour or *Kudimaramat* was a larger trend towards centralization.

<sup>64</sup> Aaron Jakes, 'Boom, bugs, bust: Egypt's ecology of interest, 1882–1914', *Antipode*, 49 (2018), pp. 1035–59; Sven Beckert, 'Emancipation and empire: reconstructing the worldwide web of cotton production in the age of the American Civil War', *American Historical Review*, 109 (2004), pp. 1405–38; Owen, *Cotton and the Egyptian economy, 1820–1914*.



to a freely available right', and a shift in the public perception of activities such as speculation as morally reprehensible to desirable.<sup>65</sup> While exceptions existed (companies operating railways still required parliamentary approval), this act induced a phenomenal response, with close to 966 companies being floated in the following years. This trend only increased in the 1850s, and nearly 2,500 companies were incorporated in the years 1856–62.<sup>66</sup> While most companies operated domestically, many saw opportunities in the colonies. Furthermore, as H. L. Jenks shows, this coincided with a massive banking expansion in the London financial markets. Over £320,000,000 was raised in loan issues to foreign governments, and half as much was raised on the credit of the governments of India and of other parts of the British empire.<sup>67</sup> Financial investors in London were now giving large sums as loans for business ventures, ranging from railway construction to contracts for transporting agricultural commodities in British India, with government backing.

In the second half of the nineteenth century, British companies looked to invest in a variety of sectors across colonial economies. Shipping was one of the most important. For instance, a conglomerate of British and French companies invested in the construction of the Suez Canal.<sup>68</sup> British corporations also invested substantially in the Indian railways. Critically, river improvement projects assumed a particular importance as the British textile industry in Manchester required cotton, a water-intensive crop. With the American Civil War (1861–5) looming by the 1860s, the slave labour supported supply of cheap raw cotton was under threat. As a result, many corporations trained their eyes on India and Egypt to cultivate cotton.<sup>69</sup>

This kind of unfettered capital channelled into corporates interested in British colonies such as India catapulted men such as Arthur Cotton into the centre stage of London finance, a far cry from his encounters with the Cauvery as a small-time military engineer in the 1830s. Cotton wrote extensively in British newspapers such as *The Times* and gave a number of lectures on the subject of irrigation. In one meeting held at Moorgate in London, several speculators made fanciful claims about Cotton's Madras works. One estimate put down the returns at 70 per cent, while another claimed that in a few years, profits would amount to 140 per cent and had the potential to reach 400 per cent.<sup>70</sup> Pointing to his successes with limited funds in Madras, Cotton's message was clear—Indian rivers, specifically of Madras, were ripe for

<sup>65</sup> James Taylor, *Creating capitalism: joint-stock enterprise in British politics and culture, 1800–1870* (Woodbridge, 2014), pp. 135–76, at p. 135.

<sup>66</sup> Mary Poovey, *The financial system in nineteenth-century Britain* (New York, NY, 2003), p. 16.

<sup>67</sup> H. L. Jenks, *The migration of British capital until 1875* (London, n.d.), p. 216.

<sup>68</sup> Daniel Headrick, *The tentacles of progress: technology transfer in the age of imperialism, 1850–1940* (New York, NY, 1988), pp. 25–6.

<sup>69</sup> Beckert, 'Emancipation and empire'.

<sup>70</sup> Headrick, *The tentacles of progress*, p. 182.

investment.<sup>71</sup> While Cotton had his detractors, even in London financial circles, investing on the advice of an engineer with such vast experience was hardly viewed as a risk.

One such company that took Cotton's bait was the MICC. The prospectus of the MICC quoted *The Times* and other publications such as *Blackwood's Magazine*, all of which echoed Cotton's exaggerated claims that Indian land simply needed water to 'bloom like a garden'. Furthermore, water could be easily secured from Indian rivers, which dwarfed their British counterparts.<sup>72</sup> John Westwood, secretary to the MICC, for instance, optimistically argued that cotton could be grown in southern India if investments were made in canal irrigation.<sup>73</sup> Extracts from a parliamentary committee report on irrigation and navigation in Madras argued that rivers were primed for investment for many reasons, including the fact that land tenure in Madras was more flexible than in other parts of India, allowing for increased taxation yearly.<sup>74</sup> However, British corporations did not enter colonial markets blindly. Corporates sought assurances that there would be no sudden changes in land tenures and that the contracts they entered into would be enforced by courts. Acting on these demands, the colonial state introduced a guarantee scheme, where individual provinces would secure investments with different guarantees of interest on investment.<sup>75</sup> Arthur Cotton and other powerful lobbies in Britain, namely the Manchester Cotton Supply Association, a body representing mill owners, pressured the colonial government to guarantee loans taken by joint-stock enterprises involved in river improvement in India.<sup>76</sup> Finally, in June 1863, the MICC received a 5 per cent guarantee on its capital of £1 million, and received official backing to pursue its activities in India.<sup>77</sup>

Not all voices within the Madras government approved of private investment in the 'opening up of rivers' or river improvement. While engineers were

<sup>71</sup> D'Souza, *Drowned and dammed*, p. 132.

<sup>72</sup> *The Madras Irrigation and Canal Company, etc. (Prospectus. Extracts from official reports and documents showing the vast importance of works of irrigation and communication by navigable canals in the presidency of Madras and the Mysore territories, etc.)*, Madras Irrigation and Canal Company papers, MSS Eur B178: 1863–82, IOR

<sup>73</sup> John Westwood, *Our future cotton supply: a statement of facts showing that by the extension of works of irrigation and navigation in the southern portion of British India an immediate and inexhaustible supply of cotton will be secured to Great Britain within her own territories* (London, 1857).

<sup>74</sup> *Ibid.* The extracts seemed to suggest that while the permanent settlement in Bengal meant zamindars were clear owners over land and water in the Bengal presidency, no such clarity existed in Madras. Therefore, joint-stock companies could use water more freely than in Bengal.

<sup>75</sup> Jenks, *The migration of british capital until 1875*, p. 216. For more on the London financial markets and how they expanded through the loan system, see David Sunderland, *Financing the Raj: the City of London and colonial India* (London, 2006), p. 16.

<sup>76</sup> There is some debate about how much the 'Manchester millocracy' held sway over British policy. While Marx believed that it was considerable, Cain and Hopkins argue otherwise. Cain and Hopkins, *British imperialism*, pp. 311–14.

<sup>77</sup> D'Souza, *Drowned and dammed*, p. 134.

generally positive about the prospects of the MICC, revenue officials, especially district collectors, were sceptical. However, a series of drought-ridden years in the northern parts of the Madras presidency, and the secretary of state Lord Stanley's firm support for the MICC as an experiment to gauge whether private capital could carry out river improvement works, saw operations begin in 1863.<sup>78</sup> Unsurprisingly, the MICC appointed Cotton as a consulting engineer. Shortly after, he chose the Tungabhadra River, in northern Madras presidency, as the site on which the MICC would construct its first canal.<sup>79</sup> Cotton's plans were grand. At the first stage, the MICC would build canals from the Tungabhadra into the ceded districts at a cost of Rs. 134,000, charging farmers a water rate of Rs. 5 per acre of irrigation.<sup>80</sup> Furthermore, Cotton envisioned that canals could be built from Bellary to Bangalore city, connecting large parts of southern India, lifting people out of poverty while earning substantial amounts of revenue. For Cotton, the entry of private capital into river improvement would be revolutionary.<sup>81</sup>

Yet, the early efforts of the MICC to construct canals for irrigation and navigation met with roadblocks. The site initially chosen to build the *anicut* on the Tungabhadra was unsuitable, as it was impossible to carry water from the *anicut* to canals which were located at a higher level. A second site to construct an *anicut*, near the town of Kurnool, was once again found to be unsuitable, as the dam would have submerged the town.<sup>82</sup> Finally, a site was approved at Sunkalesa for the construction of the Kurnool–Cuddapah Canal. Upon completion of the canal the directors of the MICC were convinced of its profitability due to cheap labour and the small proportion of canal irrigated crops in south India, which could only expand. However, a major flood in 1864 breached the Sunkalesa *anicut*.<sup>83</sup> With the invested capital almost entirely depleted and only a breached *anicut* to show for its efforts, the MICC returned to the London capital market to raise more finance in the form of debentures. It managed to raise over £300,000 from the London capital market, and obtain a loan on the basis of future revenue amounting to £600,000.<sup>84</sup>

Using the new capital, the Sunkalesa *anicut* was repaired, and irrigation and navigation operations began in 1866. However, for the next ten years, revenues earned by the MICC on the *anicut* fell short of even the working capital required to maintain it.<sup>85</sup> Its failures were on account of both engineering

<sup>78</sup> M. Atchi Reddy, 'Travails of an irrigation canal company in South India, 1857–1882', *Economic and Political Weekly*, 25 (1990), p. 619; see also Sourin Bhattacharya, 'India's first private irrigation company', *Social Scientist*, 4 (1975), pp. 35–55.

<sup>79</sup> Reddy, 'Travails of an irrigation canal company in South India, 1857–1882', p. 636.

<sup>80</sup> *Ibid.*, p. 621. The ceded districts were ceded to the British from the Nizam of Hyderabad, and located in the north-east of the province.

<sup>81</sup> *Ibid.*, p. 620.

<sup>82</sup> *Ibid.*, p. 621.

<sup>83</sup> *Ibid.*

<sup>84</sup> Connel, *The economic revolution of India and the public works policy*, p. 99.

<sup>85</sup> *Ibid.*

miscalculations by company engineers and the MICC's inability to collect revenue efficiently. The MICC, under guidance from Cotton, believed that the Sunkalesa *anicut* on the Tungabhadra would yield similar revenues to the works constructed on the Cauvery. Yet, this supposition was flawed for a number of reasons. The Sunkalesa *anicut* did not service densely populated delta systems, as in the case of the Cauvery works, but a dry region. In addition, in the Tanjore delta, states prior to the advent of colonial rule had constructed improvement works and little investment led to substantial returns.<sup>86</sup> In this case, no such prior improvements existed. Furthermore, the company had to price water from the *anicut* at extremely low rates, due to insufficient demand. Unlike the colonial government which had the backing of a vast revenue bureaucracy which intimately interacted with revenue paying subjects, the MICC struggled to collect its dues from *ryots* (cultivators) in the ceded districts.<sup>87</sup> Ultimately, these reasons led to the failure of the company.

The failure of the MICC to sustain itself as an enterprise had broader implications. For years, it had made losses and the Madras government had recapitalized the company. By the late 1880s, the MICC, and the East India Irrigation and Canal Company, a sister enterprise of the MICC, had both closed operations.<sup>88</sup> Their unsustainability had angered speculators and investors in London, with one investor complaining that the MICC's activities in India were 'deceitful'.<sup>89</sup> In 1889, the Madras government bought over all the assets of the MICC, bringing an end to the brief era of enthusiasm in London investment markets over the revenue-earning potential of Indian rivers, or what Daniel Headrick called 'canal mania'.<sup>90</sup>

#### IV

This section shows how, as community financing of river improvement projects had failed, and private investment in river improvement projects was failing, the colonial state undertook the task of constructing river improvement projects. The three classifications of public works that existed prior to the 1850s, of 'emergent', 'ordinary', and 'extraordinary, underwent multiple transformations before consolidating into two categories in 1879 of 'productive' works and 'protective' works. The creation of the category of productive works, the

<sup>86</sup> S. Y. Krishnaswamy, *Rural problems in the Madras presidency* (Madras, 1947), p. 83.

<sup>87</sup> Reddy, 'Travails of an irrigation canal company in South India, 1857–1882', pp. 626–7.

<sup>88</sup> For an account of failure of private enterprise in eastern India, see D'Souza, *Drowned and dammed*, p. 149; Rohan D'Souza, 'Canal irrigation and the conundrum of flood protection: the failure of the Orissa Scheme of 1863 in eastern India', *Studies in History*, 19 (2003), pp. 41–68.

<sup>89</sup> The Madras government found that the Company had raised capital in the form of debentures, and paid interest on those mortgages from that capital itself. See letter from J. Westwood (secretary of the Company) dated 30 Dec. 1878, MSS EUR/B178: 1863–82, IOR.

<sup>90</sup> Headrick, *The tentacles of progress*, p. 182.

article argues, was central to the ability of the Madras government to build large dams.

By the 1850s, there was substantial interest in Britain on improving Indian rivers. A parliamentary commission set up in Britain in 1852, in a section titled 'The value of irrigation to revenue and general wealth', argued that the factors of 'natural advantages' possessed by India could be effectively organized as a resource.<sup>91</sup> Drawing from the successes of Cotton and other engineers on the Cauvery, Godavari, and Ganges, the commission articulated a feeling prevalent among many in Britain and India. Assembling large quantities of data on how river improvement works had helped both in delivering returns on irrigation and in developing the river as a means of communication, the report called for the Indian government to make strategic investments in the rivers of India.<sup>92</sup> The parliamentary commission's enthusiasm for the state to construct river improvement works was part of a broader impulse of utilitarian government reflected in India under the governorship of Lord Dalhousie. Drawing on the ideas of Jeremy Bentham and John Stuart Mill, Dalhousie believed that it was an expansive state which could affect the greatest material improvements for the maximum number of people in India.<sup>93</sup> In 1854, Dalhousie established a central public works department to oversee the work of provincial departments and build improvement works at its own initiative.<sup>94</sup> Under Dalhousie, provincial public works departments in all provinces of British India were established by 1860, with the Madras presidency being the first. These departments took control of railways, irrigation works, roads, and other kinds of public buildings from a multiplicity of organizations.<sup>95</sup>

Once a centralized public works department was established, two different strands of thinking emerged within the government over financing public works. First, a plan authored by Samuel Lang in 1861 aimed at financial decentralization, in an attempt to give provinces more autonomy in their expenditure and taxation. Lang argued that decentralization would allow each province to adapt its public works programme to its own conditions.<sup>96</sup> Taking public opinion and financial stringency into account, Richard Strachey, in charge of all-India public works, worked out a plan by which Indian public works projects – especially the construction of ports, roads, and river improvement works – could be financed through a complex network of loans from capital

<sup>91</sup> *Accounts and papers East Indies public works. Parliamentary papers: 1850–1908, volume 74* (London, 1902), p. 92.

<sup>92</sup> *Ibid.*, p. 99.

<sup>93</sup> For more on Dalhousie, see Suresh Chandra Ghosh, 'The utilitarianism of Dalhousie and the material improvement of India', *Modern Asian Studies*, 12 (1978), pp. 97–110; Eric Stokes, *The English utilitarians and India* (Delhi and New York, NY, 1989), pp. 248–51.

<sup>94</sup> Whitcombe, 'Irrigation and railways', p. 690.

<sup>95</sup> *Ibid.*

<sup>96</sup> Sabyasachi Bhattacharya, *The financial foundations of the British Raj: ideas and interests in the reconstruction of Indian public finance, 1858–1872* (Hyderabad, 2005), p. 145.

markets in London, but executed and guaranteed by the Indian state.<sup>97</sup> By doing so, the government of India was then theoretically able to spend more on a single project than *all* expenditure on irrigation previously.<sup>98</sup>

Thus, a streamlined apparatus, with the involvement of public works departments both at the central and provincial levels, for constructing river improvement works had begun to emerge by the 1860s, in conjunction with the financial structure allowing the government of India to borrow money from capital markets in London. In the late 1860s, Lord Canning, the first viceroy and governor general of the state after 1858, put forth in a minute that ‘the interference of Government in the management of these works must be close and constant, call it if you will, so vexatious and intolerable...the management must not merely be controlled by Government, but must be taken entirely into its hands’.<sup>99</sup> As Manu Goswami shows, and as shown in [Table 1](#), over the subsequent decade (1871–80), the colonial state, through different provincial governments, spent £9.2 million on building a number of irrigation projects across India.<sup>100</sup> Projects included the Lower Ganges Canals in the Northwestern provinces, Jamrao and Nira Canals in the Bombay presidency, the Son Canal in Bihar, and the Periyar and Kurnool and Cuddapah Canals in Madras.<sup>101</sup>

The call for public investment in improving infrastructure such as ports, railways, roads, and other means of communication and irrigation was not limited to the British parliament and utilitarians. Rather, from the 1860s onwards, bureaucrats, publicists in India and abroad, and newspapers across India and Britain began to call for a mechanism facilitating public investment in public works. For James Wilson, an administrator and bureaucrat who served in India, there was palpable excitement among colonial administrators at the possibility of infrastructure development in India. This was a ripe moment for tea plantations, coal mines, irrigation, and internal navigation to improve in unprecedented ways and scales.<sup>102</sup> Indeed, as Sabyasachi Bhattacharya argues, the two decades following 1858, and the transition to crown rule, was a period when British capital investment reached ‘unprecedented heights’.<sup>103</sup> As Bhattacharya writes, ‘Public opinion in India was in favour of government borrowing for public works development.’ Organs such as *The Times of India*, *Indian Economist*, *The Bombay Chamber of Commerce*, and several vernacular newspapers all

<sup>97</sup> *Ibid.*, p. 93.

<sup>98</sup> As Cain and Hopkins argue, while India became the second largest recipient of British investment after Canada, officials were also concerned that the levels of debt should remain manageable. See Cain and Hopkins, *British imperialism*, pp. 309–15.

<sup>99</sup> Lord Canning’s minute on private companies for canals and irrigation, 29 Nov. 1858, Home Department Revenue Branch, Proceedings, 11 Feb. 1859, no. 1/4, NAI.

<sup>100</sup> Manu Goswami, *Producing India: from colonial economy to national space* (Chicago, IL, 2010), p. 47.

<sup>101</sup> *Ibid.*

<sup>102</sup> Bhattacharya, *The financial foundations of the British Raj*, pp. 99–100.

<sup>103</sup> *Ibid.*, p. 100.



Table 1 *Growth of expenditure on public works in India*

| Year   | Expenditure on public works £ (millions) |
|--------|--|
| 1842–3 | .19                                      |
| 1852–3 | .63                                      |
| 1862–3 | 4.40                                     |
| 1872–3 | 12.52                                    |
| 1882–3 | 23.71                                    |

Source: P. J. Thomas, *The growth of federal finance in India: being a survey of India's public finances from 1833 to 1939* (London, 1939), p. 120.

argued that public borrowing for public works projects of 'permanent utility' was too low. The East India Association sent memorials to the House of Commons arguing that while India 'was rich in resources', it was 'poor in capital', and the means to unlock the revenue potential of natural resources was to increase public borrowing.<sup>104</sup> The *Madras Mail* urged the Madras government to borrow and begin constructing large schemes to store water for irrigation, arguing that 'of all irrigation projects belonging to the Presidency which have not yet been commenced, the Periyar scheme and the scheme for storing water of the Cauvery demand first attention'.<sup>105</sup> In short, a set of opinions—both British and Indian—emerged around the question of state financing of public works. Specifically, public commentators urged the government of India to borrow large sums to finance an extensive public works programme.

The government of India and provincial governments were not unresponsive. From the 1860s, these governments had begun to borrow limited sums of money to finance public works projects. Concurrently, the administrative categories of public works had multiplied during this period. However, there was no clear structure of public borrowing for constructing river improvement works. The three classifications of emergent, ordinary, and extraordinary, the principles upon which the Madras government took decisions over irrigation projects, were revised by Dalhousie in 1853. Initially introduced at an all-India level, 'ordinary works' implied any kind of public works project which would be paid for by current revenue. Conversely, 'works of permanent utility' were those classed under 'remunerative', 'reproductive', 'extra-ordinary' or 'productive public works'. These works were considered investments and expected to pay for themselves.<sup>106</sup> The definition of what constituted 'productivity', however, was unclear, and either bore a rate of interest acceptable

<sup>104</sup> *Ibid.*, p. 216.

<sup>105</sup> 'Revenue administration in Madura', *Madras Mail* (Thursday, 26 Aug. 1869).

<sup>106</sup> For more on Dalhousie's efforts, see Ghosh, 'The utilitarianism of Dalhousie and the material improvement of India'.

to private or public investors of various kinds, of which the state was only one actor.<sup>107</sup> In 1864, this category of ‘productive public works’ was further refined by Charles Wood, the new secretary of state. Wood, in a ‘Minute on Irrigation’, made it possible for government to borrow money through bonds and other instruments in order to finance ‘productive works’.<sup>108</sup>

Contiguous to this discussion on finance, new engineering experiments were simultaneously underway in the Madras presidency. The government’s main focus turned to bringing river water into the dry Madura district.<sup>109</sup> The *Geographical Magazine* commented that ‘[i]t will change the district of Madura into a second Tanjore, and convert the arid wastes of Ramnad into a garden’.<sup>110</sup> As there were no major rivers that flowed through the district, the only option, as a military engineer Captain Caldwell observed as early as 1806, was to reverse the flow of the Vaigai River, which drained into the Arabian sea on the west coast. In 1861, Captain Ryves resurveyed the region, and proposed to build a series of *anicuts* that could potentially alter the flow of the Vaigai, but was unsure if the diversion dams would stand the test of time.<sup>111</sup> A few years later in 1866, Captain Payne was sent to survey how the Vaigai could be diverted to the Madura district. Upon his return and subsequent consultation with Ryves, they concluded that ‘the most advisable and least expensive method of carrying out the project would be by damming up the river *entirely*’.<sup>112</sup> While Arthur Cotton was concerned with diverting the flood waters of one river into another, Ryves and Payne argued that it was only a dam of 150 feet that could hold the waters of the Vaigai in an artificial lake, which could then be brought into the Madura district.<sup>113</sup> While the government did not fully accept Ryves and Payne’s proposals and wanted further investigation, their eye remained firmly on what they labelled the Periyar ‘project’, which promised a return of 20 per cent yearly on an initial expenditure of £150,000.<sup>114</sup>

The discussions on the technical and financial aspects of public works amongst the British officialdom was also closely connected not merely with who would lend money for the construction of these works, but also how to eventually repay this sum. Therefore, across British India, a discussion on

<sup>107</sup> Ravi Ahuja, *Pathways of empire: circulation, public works and social space in colonial Orissa, c. 1780–1914* (Hyderabad, 2009), pp. 94–5.

<sup>108</sup> Headrick, *The tentacles of progress*, p. 184; Ahuja, *Pathways of empire*, p. 95.

<sup>109</sup> This project was eventually known as the Periyar project. For a detailed history, see A. T. Mackenzie, *History of the Periyar project* (Madras, 1899).

<sup>110</sup> ‘Irrigation in southern India: the Periyar project’, *Geographical Magazine*, 1 Nov. 1874, p. 332.

<sup>111</sup> ‘Revenue administration in Madura’, *Madras Mail* (Thursday, 26 Aug. 1869).

<sup>112</sup> J. H. Nelson, *The Madura country: a manual part V* (Madras, 1868), p. 58.

<sup>113</sup> *Ibid.*

<sup>114</sup> *Ibid.*

water laws emerged from the 1850s.<sup>115</sup> Officials were concerned that as the British government, or indeed private companies, did not own river water, they needed an instrument to tax water use by agriculturalists, which in turn would allow the builder of canals to repay any borrowings to construct irrigation works. If the state, or corporate companies, were to borrow and invest in building canals and dams, then taxing the public, specific to their use of the service, was required to repay the borrowed sums. David Gilmartin has argued that 'control over water' was a central aspect of effecting the state's 'public' legitimacy in the second half of the nineteenth century.<sup>116</sup> In addition to legitimacy, control over water through law was equally important for securing finance for large irrigation projects, and their eventual profitability. The complexities of water rights and ownership patterns across British India meant that the central government decided that it was best if different provinces enacted separate laws on the basis of these complexities, rather than an all-India law.

Provincial governments began thinking of the problem of collecting revenue from agriculturalists, alongside the increase in state expenditure on canals. In an attempt to tax water use from government-constructed canals, the Madras government enacted the Madras Irrigation Cess Act in 1865. From the 1850s, the Madras government debated the issue of government control over water. While the Madras government wished to control all waters in the presidency, the act provided for it only to tax 'government water', or water that had explicitly been made available to landowners through government-undertaken improvements.<sup>117</sup> This proved ineffective, and landowners frequently challenged what exactly constituted government water in the courts. Ultimately, the legal position in Madras was decided in the courts rather than through further legislation.<sup>118</sup> While the Madras government attempted to exert further control over waters in the presidency with the Irrigation Cess Act constantly reappearing in the Madras legislative council in different forms, it was never successful.<sup>119</sup> In other parts of India and the empire, efforts at establishing government control over water were more successful, but could never fully be manifested. Taken together, the idea of productive public works was therefore emerging through small financial borrowings, technical experiments, and the ability of the government to realize its forecasts through instruments such as the law. Nevertheless, considering the lack of a systematic policy for

<sup>115</sup> On Madras, see Aditya Ramesh, 'Custom as natural: land, water and law in colonial Madras', *Studies in History*, 34 (2018), pp. 29–47; on Bengal, see Debjani Bhattacharyya, *Empire and ecology in the Bengal delta: the making of Calcutta* (Cambridge, 2018), ch. 3; on north India, see Gilmartin, *Blood and water*, ch. 4; on Bombay, see Bombay Irrigation Act, 1879, IOR/L/PJ/6/3, file 93: Mar. 1879–Jan. 1880.

<sup>116</sup> Gilmartin, *Blood and water*, pp. 104–5.

<sup>117</sup> IOR/V/23/192, collection of papers relating to control of government over water in the Madras presidency [1851–9].

<sup>118</sup> Baker, *An Indian rural economy, 1880–1955*, p. 474.

<sup>119</sup> Ramesh, 'Custom as natural', pp. 37–42.

borrowing or extracting revenue from improvements, the government of India resorted to heavy borrowing only in the case of war, and rarely for public works projects.<sup>120</sup>

## V

From the late 1860s until the late 1870s, as discussions continued on how river improvement projects might be financed, severe famines affected India, which had consequences for public works policy. Famines were a regular occurrence in South Asia, whether during colonial or pre-colonial times. The spate of famines in the 1860s and 1870s collided with an intense discussion on the question of how to finance public works in India involving the central and provincial governments in India, as well as commentators, engineers, economists, and businesses in India and Britain.<sup>121</sup> As such, the famine and its devastating effects prompted a range of commentators to push the government of India further to systematize its borrowing mechanism for constructing large irrigation projects. Canals and dams, commentators argued, would protect India from famines of such magnitude.

The 'Great Famine' of 1876–8 had severe consequences for most people living in fourteen out of twenty-one districts in the Madras presidency. Meteorological accounts suggest that the final few decades of the nineteenth century saw particularly severe weather conditions, with prolonged droughts and minimal rainfall across the world.<sup>122</sup> In India, the famines severely affected eastern and southern parts of the country. Mortality figures for the decade between 1870 and 1880 suggest that the least deaths per year amounted to over 400,000 and the most, occurring in 1878, amounted to over 1,500,000 people dead. Caste and class structure shaped fatality.<sup>123</sup> With the failure of successive monsoons, a picture of low employment and high prices dominated the Madras countryside.<sup>124</sup> As Leela Sami has shown, it was largely agrarian labouring castes who died during the famine, while Brahmins, who controlled substantial amounts of wealth, were the least affected.<sup>125</sup> Such levels of mass mortality caused outrage across India and Britain.

<sup>120</sup> P. J. Thomas, *The growth of federal finance in India: being a survey of India's public finances from 1833 to 1939* (London, 1939), p. 108.

<sup>121</sup> Mike Davis, *Late Victorian holocausts: El Niño famines and the making of the Third World* (London, 2002); Richard Grove and George Adamson, *El Niño in world history* (London, 2018), pp. 93–104.

<sup>122</sup> An account of the normal distribution of the rainfall in the Madras presidency based on the records of twenty years, Madras, 1892, IOR/V/27/440/28. See also Davis, *Late Victorian holocausts*, pp. 12–13.

<sup>123</sup> Leela Sami, 'Starvation, disease and death: explaining famine mortality in Madras, 1876–1878', *Social History of Medicine*, 24 (2011), p. 703.

<sup>124</sup> For effects of the famine in the northern districts, see Kali Chittibabu, *Patterns of labour migration in colonial Andhra* (Newcastle, 2015), pp. 114–15.

<sup>125</sup> Sami, 'Starvation, disease and death', p. 703.

Ravi Ahuja and others have argued that the famines of the 1860s played no small role in forcing a rethink on the design and utility of public works projects. In 1877, the Bengal government congratulated itself on a remarkable development of public works, including railways, canal ways, and irrigation works in the decade following the famines.<sup>126</sup> Indian politicians, journalists, and even former colonial officials argued that increased spending on irrigation works would prevent famines in two ways. First, construction of canal systems and other kinds of smaller irrigation works would lead to more food production. Second, the construction of better navigation networks on rivers, railways, and roads could ensure quick transportation of food from areas where there was surplus to areas of deficit. As David Arnold suggests, therefore, 'food', or the lack thereof, 'was one of the principal sinews of power'.<sup>127</sup> It was therefore following the famine of 1876–8, when southern and eastern India faced an unprecedented situation of starvation and death, that the state turned its attention towards the link between a faltering public works system and the impact of famine.<sup>128</sup>

The inability of the colonial central and provincial governments to provide adequate relief and prevent large-scale mortality was castigated both by official reports and the general public. The famine commission of 1878, appointed by the British parliament, argued that it was not merely insufficient food that was the problem, but the inability of the colonial state to distribute food effectively.<sup>129</sup> Moreover, expenditure on public works in times of scarcity and famine became a source of tension between the provincial government and central government. Neither was satisfied with the efforts of the other, and mistrust grew as the need for finance limited the ability of the provincial government to supply relief.<sup>130</sup>

Tracts published in Britain blamed both the Madras government and the India Office for their lethargic attitude to constructing large public works projects, namely reservoirs. Large reservoirs, several commentators argued, would allow for water storage and expansion of food production. One memorandum written by a public works department engineer claimed that the Madras government and the government of India were continually delaying the sanctioning of the Periyar–Vaigai reservoir.<sup>131</sup> On the Cauvery, the same official claimed:

<sup>126</sup> Ahuja, *Pathways of empire*, pp. 224–5.

<sup>127</sup> David Arnold, *Famine: social crisis and historical change* (Oxford and New York, NY, 1991),

p. 3.

<sup>128</sup> *Ibid.*

<sup>129</sup> *Famine commission to enquire into the management of irrigation works in Madras, Orissa and Midnapur* (Calcutta, 1879).

<sup>130</sup> Leela Sami, 'Famine, disease, medicine and the state in Madras presidency (1876–1878)' (Ph.D. thesis, London, University College, 2006), pp. 121–4.

<sup>131</sup> *Memorandum of public works calculated to obviate or mitigate famine in Madras* (Madras, n.d.), p. 3. Needless to say, Arthur Cotton had made the link between mitigating famine and expansionary regime of irrigation works years ago. See Arthur Cotton, *The famine in India* (Manchester: Cotton Supply Association, 1866).

Coimbatore, Trichinopoly, Tanjore, and portions of Salem and South Arcot, are fortunate in lying within the basin of the Cauvery; from which...a never-failing revenue and supply of food are derived. It remains yet to develop these supplies indefinitely by the establishment of reservoirs...with the Cauvery valley itself offer the most promising field of research for reservoir sites.<sup>132</sup>

In India, William Digby, a journalist for *The Madras Times* at the time of the famines, was one of the most trenchant critics of the Madras government's policies on famine. In a two-volume record of the famine, Digby showed how cities across England, led by Manchester, had mobilized in favour of the government of India investing greater amounts in irrigation works to prevent famines which had caused such devastation.<sup>133</sup> Digby's account repeatedly pointed to the importance of constructing canal irrigation projects, which, even in the face of famine, managed to save certain regions.<sup>134</sup> Digby further pointed to the perils of reducing costs on irrigation works, which he suggested directly contributed to the famine.<sup>135</sup> As this article has suggested, however, discussions on large infrastructure projects and how to finance them for purposes of revenue extraction were on-going since the 1830s. The famines of the 1870s gave further fillip to discussions surrounding irrigation works, foregrounding them in discussions on government policy.

Following the famine and intense criticism, officials of the government of India sought to reorganize the ways in which public works projects were classified, aimed at two outcomes. First, to establish a systematic structure allowing the government of India and provincial governments to borrow money to build irrigation works. Second, to create an exclusive category of irrigation works maintenance policy for mitigating famine. A House of Commons committee in 1879 reorganized the various criteria under which irrigation works were being constructed into two categories. The first was 'productive works'. A productive work was a project which would be remunerative within a period of ten years, including interest charges on loans taken, maintenance overheads, and other expenses associated with operations.<sup>136</sup> More importantly, the government, while undertaking an improvement work considered productive, could take out a loan, on which interest was capped at 4 per cent of the amount borrowed annually. In other words, loans could not be floated by the government of India which required repayment at any rate of interest above 4 per cent.<sup>137</sup> For a productive work irrigation project to be constructed, the

<sup>132</sup> *Memorandum of public works*, pp. 3–4.

<sup>133</sup> See William Digby, *The famine campaign in Madras*, 1 (London 1878), pp. xiii–ix.

<sup>134</sup> Canal regions near the Bhavani River and those served by the Cauvery near Tanjore experienced less severe famines than drier districts without any canals. See *ibid.*, pp. 63, 68.

<sup>135</sup> *Ibid.*, p. 150.

<sup>136</sup> Michael, 'Water resource management in south India', p. 28; Latika Chaudhary, 'Agriculture in colonial India', in Bishnupriya Gupta, Tirthankar Roy, and Latika Chaudhary, eds., *A new economic history of colonial India* (New York, NY, 2016), p. 109.

<sup>137</sup> Whitcombe, 'Irrigation and railways', pp. 709–10.



Bank of England loaned money to the government of India, which in turn distributed this money to the various provinces. The engineering establishment of the various provinces were expected to submit projects to the government of India that were technically feasible and expected to yield yearly revenue, such that the entire loan could be repaid in less than ten years.<sup>138</sup> Upon receiving approval for a project, the provincial government was expected, for the first ten years, only to pay interest on the loan following which the capital amount also was to be repaid.<sup>139</sup> In case profits exceeded all expenditure after payment of the capital amount and interest, the provincial government could retain it. This system allowed the central public works department to regulate their provincial counterparts, which were actually responsible for planning and executing irrigation projects.<sup>140</sup> The category previously classed as 'ordinary', was now known as 'protective'. Protective works were essential to prevent famine, and would be financed out of current revenue without undertaking loans.<sup>141</sup> These included repair works for the large number of smaller tanks, weirs, canal systems, and channels which dotted the landscape of colonial India. On protective works, Peter Mollinga states that '[t]he irrigation systems constructed under this administrative head were systems that could not pass the productivity test, but were still constructed for reasons of famine prevention'.<sup>142</sup>

A complex system of public financing of irrigation projects formalized into 'productive' and 'protective'. At the same time as the arrival of the 'productive works' policy beginning in 1880, the government of India bought out the MICC. It further had to maintain the MICC's investments in the Kurnool–Cudappah Canal, for which the government realized that no profit could be obtained.<sup>143</sup> The MICC's demise, in light of its inability to obtain profit from its investment, spelt an end to a brief era in the experiments of private capital with irrigation projects in India. Thus, towards the late nineteenth century, the state, especially provincial governments, had emerged as the main agent of constructing large irrigation projects.

Some economists viewed the measure of 'productivity' as a risk. A. K. Connell, a vocal critic of British interference of any kind in building and upkeep of public works in India, argued that transferring 'the key of Indian finance' from the revenue department to the public works department would lead to a 'gigantic

<sup>138</sup> Provincial public works departments could sub-contract smaller aspects of productive works projects, such as hiring of labour or a particular piece of work, but the overall responsibility lay with provincial government.

<sup>139</sup> Michael, 'Water resource management in south India', p. 29; John Strachey and Richard Strachey, *Finances and public works in India* (London, 1882), pp. 95–6; Ahuja, *Pathways of empire*, p. 6.

<sup>140</sup> Michael, 'Water resource management in south India', p. 29.

<sup>141</sup> For more see Aditya Ramesh, 'The value of tanks: maintenance, ecology and the colonial economy in nineteenth-century south India', *Water History*, 10 (2018) pp. 267–89.

<sup>142</sup> Mollinga, *On the waterfront*, p. 58.

<sup>143</sup> Whitcombe, 'Irrigation and railways', p. 710.

[enterprise of] commercial speculation'.<sup>144</sup> In other words, provincial governments would borrow large amounts of money to construct public works, rather than finance them from the current revenues. According to Connell, a productive works project was speculative in nature as engineers of the public works department were required to draw up notional technical plans, upon which profits were to be derived.<sup>145</sup> Thus, if the plans for a public works project failed, it would mean that the government of India had to repay the loan to British financial markets, i.e. the Bank of England, irrespective of the income generated by that particular project.<sup>146</sup>

## VI

Arthur Cotton's improvements on the Cauvery and Godavari, and rhetoric in London on his achievements, contributed to fuelling a technologically speculative enterprise designed to extract growing amounts of revenues from rivers. That is, engineers now had to speculate on whether a particular 'public works' project could yield returns to pay interest and the capital amount, in order to borrow large amounts of money for building the project. Therefore, rather than unfettered speculative lending for river improvement, the state emerged as the most stable mobilizer of capital from London. Simultaneously, as this article shows, these discussions on finance were accompanied by a push towards engineering the flow of rivers in new ways and laws to extract revenue from landholders in cases where the government had constructed improvement works to provide water for irrigation. While the government initially experimented with using local finance and labour, and some investment by private firms for river improvement activities was forthcoming in Madras, eventually it was left to the state – particularly in the wake of the famine – to take up the role of chief borrower in constructing improvement works. The result of this, as the article shows using the case-study of the Madras presidency, was that river improvement works classified as 'extraordinary' in the 1830s, had, by the 1880s, been consolidated under the category 'productive works', following four decades of intense discussions surrounding how river improvement works could be financed.

Productive works was an extraordinarily powerful financial and administrative category. Most major government-funded projects in the twentieth century were circumscribed with the logic of productive works or borrowing against forecasting the eventual revenue from the project. This article argues therefore that the ways in which colonial governments monetized natural resources in the colonies were hardly self-evident. Manu Goswami stresses the

<sup>144</sup> Connell, *The economic revolution of India and the public works policy*, p. 8.

<sup>145</sup> *Ibid.*, p. 16.

<sup>146</sup> This was because the Indian state had to guarantee all private companies incorporated in Britain in the sub-continent.

importance of categories, arguing that scholarship resorts to 'presupposing rather than examining the sociohistorical production of such categories as a national space and national economy'.<sup>147</sup> Neeladri Bhattacharya shows how in Punjab colonial control over the countryside was formulated through new categories of governance.<sup>148</sup> A range of local land titles implying a variety of rights, duties, authorities, and customary practices were incorporated into the overarching categories of landlord and tenant. Similarly, this article shows how 'productive works', which redefined river improvement projects, was consolidated through technical, financial, and legal means.<sup>149</sup>

As a governance category, productive works made an immediate impact in the Madras presidency. In 1807, the collector of the Madura district remarked that a dam on the Vaigai River was neither technologically nor financially feasible. Yet, by the turn of the century, technical and financial plans for the Periyar project were a reality.<sup>150</sup> Colonel John Pennyquick, an engineer from the Madras public works department, was despatched shortly after in 1887 to England to buy the necessary equipment for the dam, and an engineering establishment was set up under his supervision to build the Periyar dam.<sup>151</sup> The public works department built the dam in 1895 mobilizing expertise, labour, and technology to store the abundant rainfall in the western *ghats*, and divert it towards the dry region of Madura.<sup>152</sup> The Periyar project in Madras was but a small experiment in the larger objective – to conquer abundant rainfall and tempestuous river water in the ample structure of the reservoir.<sup>153</sup>

<sup>147</sup> Goswami, *Producing India*, p. 4.

<sup>148</sup> Bhattacharya, *The great agrarian conquest*, p. 152.

<sup>149</sup> *Ibid.*, pp. 157–70.

<sup>150</sup> Anand Pandian, 'An ode to an engineer', in Amita Baviskar, ed., *Waterlines: the Penguin book of river writings* (New Delhi, 2004), p. 13.

<sup>151</sup> *Administration report of the public works department, irrigation branch in the Madras presidency for the year 1887–1888* (Madras, 1888), p. 39.

<sup>152</sup> For more, see A. T. Makenzie, *History of the Periyar project* (Madras, 1899).

<sup>153</sup> Sunil S. Amrith, 'Risk and the South Asian monsoon', *Climatic Change*, 19 Feb. 2016, pp. 1–12.