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Abstract

This article says that climate shaped the long-term pattern of economic change in India and that the climatically conditioned economic change generated a distinct set of environmental consequences in the region. From the nineteenth century, political and economic processes that made scarce and controlled water resources more accessible to more people, enhanced welfare, enabled more food production and sustained urbanization. The same processes also raised water stress. These propositions carry lessons for comparative economic history and the conduct of discourses on sustainability in the present times.

1 Introduction

Climate is an under-researched concept in economic history, an oversight that looks odd against the growing restlessness over climate change all over the world. In popular discourse, climate change has an economic past: the burning of fossil fuel to sustain excessive consumption led to irreversible changes in the earth's weather pattern. The environment-economy connection tends to be seen through the lens of the tragedy-of-the-commons when unrestricted rights to exploit a common resource leads to its degradation. This stylized narrative does not capture some of the fundamental ways that economic change in the tropical

* I wish to thank the organizers and participants of two events where parts of the paper were discussed. These are, 'Rural pluri-activity: how long did it last? Local dynamics in global perspectives,' panel at the European Congress of Rural History, Paris, September 2019; and conference on the Global History of Capitalism, Oxford University, September 2019. Conversations with Gareth Austin, Kenneth Pomeranz, and Kaoru Sugihara have been helpful.

regions impacts the environment. One of these ways consists of making scarce underground water cheaper and more easily accessible to more people. Making water more widely accessible enhances welfare, raises production, and sustains urbanization. Paradoxically, the same action potentially leads to a condition known as 'water stress.' Not capitalistic greed, but welfare and developmental policies cause environmental stress.

I argue in this paper that water extraction played a role in shaping long-term economic change in tropical monsoon regions, as important a role as fossil fuel extraction played in the economic emergence of Western Europe. I also argue that, in turn, the water-dependent economic change gave rise to a specific form of environmental stress that cannot be understood in the tragedy-of-the-commons framework.

I draw on Indian history for 150 years. India in the colonial times (c. 1857-1947), or mainland South Asia in the modern times, broadly falls in a climatic zone called the tropical monsoon. Tropical monsoon is a combination of two conditions. One of these is above-average heat. The heat causes faster evaporation of surface water, making mobilization of water for cultivation, industrial use, and consumption a costly activity. The heat also makes for the hydrologic cycle that produces a powerful monsoon. The second condition is seasonality. The conduct of agriculture under tropical monsoon conditions was marked by extreme seasonal fluctuations in the pace of economic activity, because of the concentrated occurrence of most rainfall. During a short busy time of year, capital and labour were fully employed. During the rest of the year, wages fell, labour became surplus, and capital awaited the busy season.

These two environmental conditions, water-shortage and seasonality, shaped rural poverty. So did institutions that shaped access to water sources. Together, these 'filters' modified the impact of the big drivers of global economic change since the nineteenth century – colonialism, commodity trade boom, migration, railways, public works, and technological change. Making productive use of these

drivers depended on how severe water shortage and seasonality were, and what could be done to mitigate these. For example, the prospect of exporting agricultural commodities would not offer a similar opportunity to a water-deficient area and a water-scarce one. These climatic filters did not equally influence all parts of the South Asian mainland. For example, the seaboard was considerably less dependent on agriculture, being service- and manufacturing-based, and usually received more rainfall on average thanks to the trajectory of the monsoon wind. The interior of mainland South Asia was exposed to these conditions to a greater extent.

The time-span for this paper is 1850-2000. Barring temporary disruptions like the ENSO (El Niño-Southern Oscillation), the climate changed little in the past centuries. What, then, was different during these years? The answer contains two parts, of which one concerns water and the other seasonality. The tropical monsoon climate made access to controllable (seasonally constant) sources of water relatively expensive in the past. This resource was usually privately owned, with exclusion rules embedded in cultural practice, so that most poor people lived on seasonally variable supply from the commons. From this baseline, state investment in irrigation, urbanization, political movements for equality, and advancements in hydraulic engineering turned controllable sources of water for agriculture and consumption into a public and semi-public good, enabling a huge rise in the capacity of the economy to grow food, sustain population growth, and generate urban growth. While these effects unfolded, a type of environmental crisis known as water stress began to build up. Water stress occurs when groundwater is taken from relatively small or unknown pools, a condition very common in the tropical world today.

The seasonality story goes as follows. From the time we have data to measure seasonality (say, monthly interest rate movements, available from the 1880s), the degree of the seasonal effect was far higher in India than in any temperate zone country.[1] The only effective mitigation to seasonality is a reallocation of

[1] See discussion in Roy, 'Monsoon and the Market for Money.'

capital and labour between livelihoods and regions that face the problem on different scales. The data to test how effective reallocation was are limited. We do know that seasonal short-distance migration increased since the late-nineteenth century and that there was some convergence in interest rates over time. Mitigation took the form of institutional changes that made labour more mobile between different types of work contracts and capital more mobile between fields of investment. Until the mid-twentieth century, after which the state controlled the capital market, the effects were modest. Neither the wages nor interest rates converged much.

Throughout, I use two phrases often, water access and water stress. Increasing water access refers to the process of water becoming a public good provided by the state, as opposed to being provided by private means and communities or gathered from the commons. Water stress refers, narrowly, to the situation when the withdrawal of water compromises sustainability, and broadly, to the situation when withdrawal causes conflicts and disputes.

The rest of the paper has five parts, the framework of analysis, historiography, the water narrative, the seasonality narrative, and the seaboard situation. In the concluding section, I return to some implications of the study for comparative economic history.

2 Framework of analysis

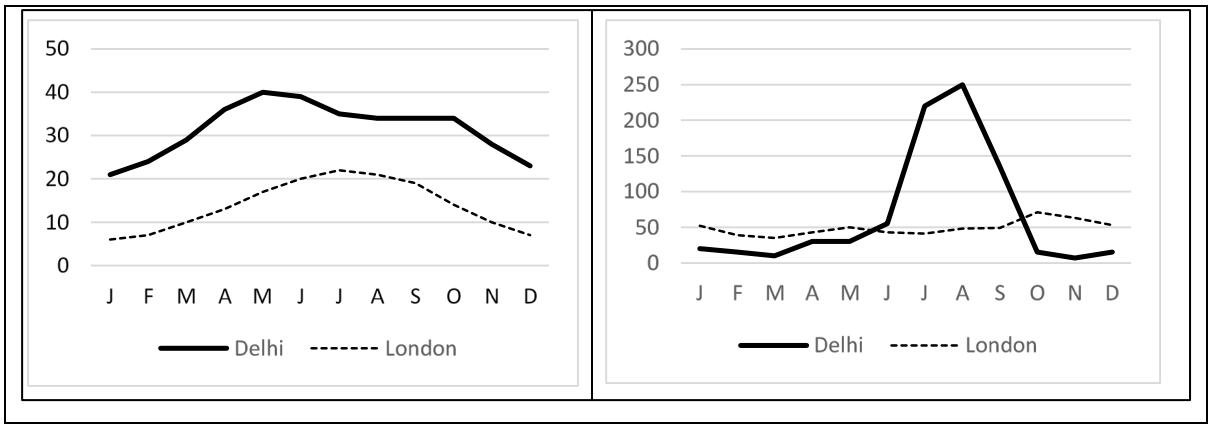
What is the tropical monsoon climate? To answer the question, I compare temperature and rainfall in a temperate-zone place (London) with a tropical monsoon zone one (Delhi). In an average year, the maximum temperature in Delhi is about twice as high as that in London for every month of the year and exceeds 36 degrees celsius from mid-April to end-June (Figure 1).[2] In an average

[2] WATCH (Water and Global Change) datasets. http://www.waterandclimatechange.eu/evaporation/average-monthly-1985-1999 (accessed 19 October 2019).

year, rainfall in Delhi is concentrated in three months, owing to its dependence on the monsoon winds, leaving the rest of the year drier (and hotter) compared with the temperate zone. The monthly average rainfall in London varies in a range of approximately 40-70 mm. The monthly average rainfall in Delhi varies in a range of 10-250 mm. In Delhi, 75 percent of the rains occur during the third quarter of the year; in London, quarterly rainfall ranges between 21 and 31 percent.

What do these data mean? First, the extreme heat in the tropical region dries up surface water. The average evaporation rate is a function of (among other variables) available surface water and the heat from the sun. During summer in the Himalayas or the Arctic, the rate reaches very high levels. In the deserts, the rate is very low around the year. If in any one region the rate is high in one season and low in another, that would mean that plenty of surface water exists in some months and that all this water dries up completely in certain other months. In most parts of India, the rate reaches 60-100 mm per month in June-September when the monsoon rain occurs in combination with high heat. As surface water dries up, the rate falls extremely quickly. By April-June, the rate (0-20 mm) that prevails in nearly all of India except the Bengal delta and the southernmost regions of the peninsular like Kerala tends towards the range that characterizes the great deserts of the northern hemisphere. On both sides of the North Atlantic, the range is narrower and the average higher throughout the year, meaning that more surface water withstands the summer temperature.

Figure 1. Maximum temperature (Celsius) and average monthly rainfall (mm) in Delhi and London.



These facts suggest that livelihoods in a tropical monsoon climatic region would need to address two issues that do not appear with the same force elsewhere. Because surface water dries up quickly, leaving little available in the dry months, agriculture and survival would require mobilizing water over long distances or mining it from below ground or relying on the seasonally variable common sources. The first two options are ordinarily expensive and the third uncertain. Second, there was usually one short season of economic activity in the tropical monsoon region. This season fell not on the rainier months, but early in the winter, when the rain-fed crops came into the market. This season was busy; that is, wages and interest rates rose to high levels. The slack season was very slack; that is, wages and interest rates fell, as labour was in surplus and capital idle. All agricultural societies experience seasonality; the tropical monsoon regions experience extreme degrees of seasonality.

In the past, and the absence of any artificial irrigation, the monsoon rains made one sowing relatively easy in most parts of India. The usual practice in the nineteenth century was to have two sowings in the monsoon, of which one was a major grain. In some regions, a weak winter monsoon enabled a second and minor crop. Growing any of the major grains in winter or some of the profitable year-round crops like sugarcane depended on irrigation that required harvesting

and storage of water on a large scale. Thus, the monsoon in a tropical region made earning subsistence easy, but improvements in yield difficult.

The tropical monsoon agriculture was, therefore, a cause of poverty. It was a cause of poverty by making agricultural intensification an almost impossible challenge without outside help. Drawing water outside the rainy season is expensive in the tropical monsoon region. Canals were costly, and not always reliable unless taken from rivers that carried water throughout the year. Calculations made in the late nineteenth century suggested that the cost of constructing a well in the Deccan Plateau was relatively high, and the chance of getting enough water from a well relatively low.[3]

The tropical monsoon climate was a cause of poverty also by enforcing idleness upon the rural workers. The average peasant 'has five months hard work. If he has a share in a well, he is busy for three more months,' said a Punjab officer in 1926.[4] He was right. Data collected during the Agricultural Labour Enquiry for the Indian Union (c. 1950) showed that the agricultural labourer in Punjab worked for about 155 days on the farm, and 20 days off-farm.[5] Similar low numbers appeared from nearly all regions of India except the eastern part of the Indo-Gangetic Basin, deltaic Bengal, and Assam. And even in these regions, the working year rarely exceeded 250 days. As the citation says, the possession of a well increased work intensity by about 60 percent. Well is an example of what I call a controllable source of water, as opposed to seasonally variable sources. Since a well was usually a private good, wells reduced poverty but increased inequality.

Most people in the countryside were water-poor. Such poverty manifested in a variety of ways, extra time spent (usually by women) in gathering water for consumption, dependence on unsafe water and disease risk, unavailability of

[3] Roy, 'Agrarian Crisis in Interwar India.'
[4] India, *Royal Commission on Agriculture*, Vol. VIII, 71.
[5] India, *Agricultural Labour Enquiry*.

water for agriculture in the dry seasons, and outright famine risk when the rains failed. Extreme seasonality became a life and death issue if two successive monsoons failed or the monsoon and the winter rains failed in the same year. India witnessed a series of famines in the nineteenth century, some of the worst ones occurring in the first half of the study period. These famines involved an occurrence of rainy days below the long-term annual average. These events had devastating effects upon agricultural labourers, tenants and poor farmers in the dry Deccan Plateau.

These conditions were not the legacy of regimes that ruled this land in the last two centuries. Recent national income estimates for periods before 1850 confirm that India was a considerably poorer place than Western Europe before the Industrial Revolution began.[6] These studies do not explain why it was a poor place for centuries. The only plausible answer is environmentally-enforced low yield and unemployment of resources.

What mitigating actions could those living in the countryside take to reduce poverty and famine risk? Migration and transhumance were a response to famines and seasonal water shortages. But these moves carried costs, and for the majority of the agricultural population with interest in a fixed plot of land, other mitigation strategies would be necessary. The most secure form of mitigation would be creating access to controllable sources of water. A controllable source is a rechargeable source where the owner can harvest water and recycle water throughout the year at will. An example is a well, tank, or a lake. Any other source, like streams and ponds, is susceptible to climatic actions, that is, dry up for some months of the year. Common resources were not always unreliable. When a river or a stream received snowmelt water, as in the case of the Himalayan rivers that enabled the formation of the Indo-Gangetic Basin, the seasonal evaporation cycle was weaker. Outside that zone, and even within it, most rivers and streams tended to shrink in the dry seasons.

[6] Broadberry, Custodis and Gupta, 'India and the Great Divergence: An Anglo-Indian Comparison of GDP per capita, 1600–1871;' Roy, 'Economic Conditions in Early Modern Bengal.'

About 1850 in India, water came from fixed sources (wells, *bandharas* or earthen dams, tanks), as well as flowing ones (rivers and streams). Fixed pools of water were usually privately or communally owned. The most secure form of supply came from masonry wells, almost always privately owned. In almost everything else, the level of water supply varied by season. Manmade lakes and tanks were far too expensive for local communities and needed state effort. Public welfare was rarely the objective of kings and chiefs building waterworks in the countryside. David Mosse has shown how the management of water-works in South India served to maintain the authority of the social leaders more than it served welfare or profitability.[7]

Entitlement to water, in short, was segregated and unequal. As far as we can gather based on nineteenth-twentieth century descriptions of almost any Indian village, seasonally secure sources of water were usually privately owned. The exclusion rules that applied to these private goods were embedded not only in property rights but also in cultural practice. From the late-twentieth century, applied development economics, which started taking an interest in the provisioning of public goods and the interaction between state and caste, as well as social researchers observed a correlation between being of the upper castes in an Indian village and having piped water or ownership of masonry wells, and being oppressed castes and dependence on segregated and poorer quality water sources.[8] The oppressed castes would rely on a poorly constructed well or rivers and lakes that the upper castes did not use. Exclusion from fixed sources entailed a denial of the right to own and cultivate the land, for land control without water control would mean little. In this way, water rights reinforced poverty and inequality.

In the long run, drawing water from underground or mobilizing water over the ground could lead to 'water stress.' The World Bank defines this as the

[7] *Rule of Water*.
[8] See discussion of the literature in Iversen, Kalwij, Verschoor and Dubey, 'Caste Dominance and Economic Performance in Rural India.'

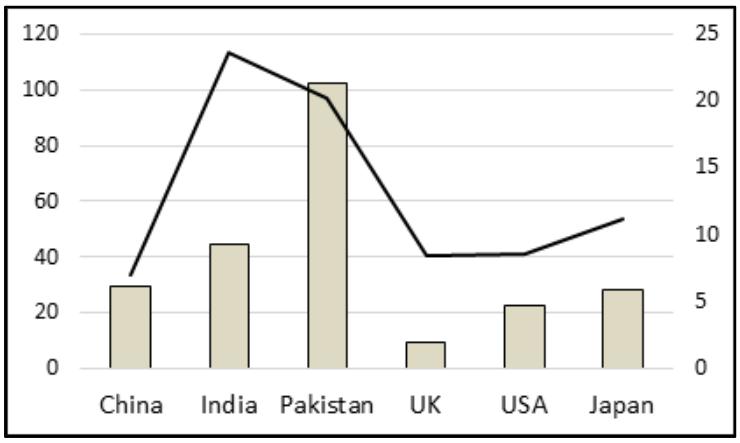
withdrawal of freshwater as a percentage of renewable freshwater supply. In 2016, levels of water stress ranged from 42 percent in India to 105 percent in Pakistan in 2016; the levels were considerably lower in the UK (10), USA (22), Japan (28), and China (30) (Figure 2). There is a close across-country correlation between average temperature and water stress, suggesting that the water stress pattern was a feature of world geography rather than being anthropogenic. The estimates of average renewable stock available for future or sustainable exploration are also very low for the South Asia region and add to water stress (Figure 3).

Elements of the tropical monsoon conditions existed in other geographies. We should still be careful not to place all tropical regions and all monsoon regions in one basket and start doing large-scale global history. The world's dry regions are not alike. Nor are the world's monsoon regions. The Sahel has a monsoon like India's, but a weaker one.[9] Both regions face a high seasonal cost of accessing water. This is a distinct problem from the aridity that characterizes the regions north of the Sahel. India cannot be compared with monsoon-dependent East Asia either, because South Asia is way hotter than East Asia, besides being much more water-stressed (see below and Figure 2).

How can the conditions of material life start to improve in a tropical monsoon climatic region like this one? How might such improvement impact the environment? In the next section I discuss scholarships that connect geography and economic change to see if we can find useful answers to these questions.

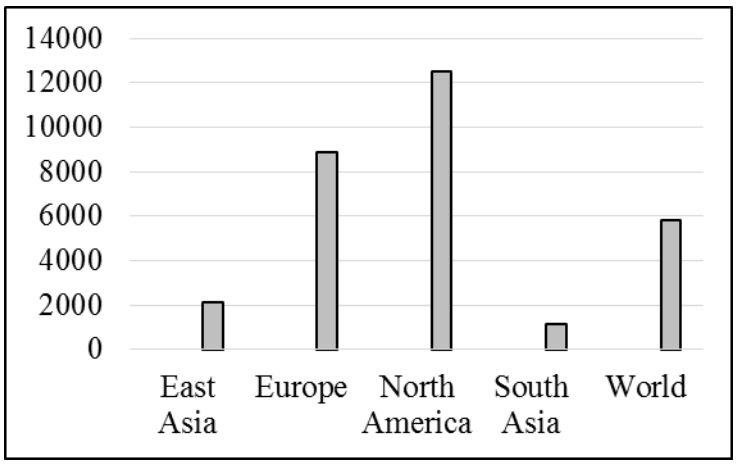
[9] The mean annual rainfall in the Sahel is 100-300 mm, that in India 300-650 mm.

Figure 2. Water stress (columns, percentages, left-hand axis) and average annual temperature (celsius) by selected countries.



Source: World Bank, https://data.worldbank.org/indicator/ER.H2O.FWST.ZS (accessed 19 October 2019). Also World Resources Institute, https://www.wri.org/resources/charts-graphs/water stress-country (accessed 15 October 2019).

Figure 3. Average Renewable Water Supply (cubic m/capita/year 2015)



Source: Pacific Institute, https://www.worldwater.org/ (accessed 15 October 2019).

3 Why climate matters

A now-defunct tradition in comparative economic history laid stress on water. Karl Marx, Karl Wittfogel, and Fernand Braudel included water in their theories of the oriental state and society. All three believed that water control was a crucial matter in drier Asia, required expensive technologies that could only exist as a public good, and therefore water supply explained forms of state authority. Their main evidence came from canals built out of rivers in China,

India, Mesopotamia, and Egypt. This literature, notwithstanding its interest in water, is not useful for the paper.

First, these writings presumed that water was a public good and a field of public investment. Whether this was or was not the case is not verifiable for India, and the claim is probably wrong. In India, imperial states did not own water-works on a large scale except in and near the capital city. States sometimes constructed water-works, as the fourteenth-century Tughlaq king of Delhi Feroz Shah did, but rarely regulated their use. Most states instead lived on local water resources. It is now generally accepted by Indianist historians that despotic empires never existed in India. Even the bureaucratic and centralized Mughal Empire relied too much on local power to behave like a despot. In such a decentralized state system, the local magnates that built waterworks were distinct from the kings and emperors, and their investment in, say, tanks or canals, do not implicate the power of the king, but a check on kingly power. In any case, Wittfogel et al. discussed water-works in the context of their construction and not that of usage or consumption.

Second, what these authors were really after was a theory of the state, not environmental history. If the states were as strong in Asia as to regulate water in a dry region, the societies were comparatively weak – and changeless. It then follows from this analysis that Asiatic society was changeless in comparison with the dynamism of preindustrial Europe, and therefore, real history in Asia began with the arrival of the Europeans. 'Those small and extremely ancient Indian communities,' Marx wrote, 'some of which have continued down to this day, are based on possession in common of the land, on the blending of agriculture and handicrafts, and on an unalterable division of labour.'[10] Braudel had an almost identical reason for being interested in wet rice cultivation, which to him 'implies a stable society, state authority and constant large-scale works.'[11] The image of inertia has been persistent in world history and is carried over into present-day

[10] Marx, *Capital*, Volume I, 513-5; see also Engels, *Anti-Duhring*, 228-9.
[11] Cited by Moore, 'Capitalism as World-ecology.'

writings about Indian history, for example, into Eric Jones' 'indestructible atoms' that composed India, the atoms including 'village agriculture' and the 'caste system.'[12]

Some older and recent versions of comparative economic history acknowledge a potential role for nature and climate, usually via a random selection of attributes. A contribution to institutional economic history argues that tropical pathogens had some role in the making of European colonial policy in these lands.[13] Others stress the population-resource ratio.[14] The main interest of these works is not the environment nor livelihoods, but the consequences of European expansion into Asia, Africa, and the Americas. This paper is not concerned with the process of European expansion. I believe that economic historians greatly exaggerate the importance of the European peoples and their colonial rules in the history of the tropical regions. The propositions advanced in this paper reinforce that belief.

The environmental history of the tropical world does discuss climate, in so far as the nineteenth and early-twentieth-century discourses on forest conservation expressed worries over climate change.[15] Except for this curiosity, the scholarship has been mainly interested in the relationship between European colonialism and the forests and commons of the tropics.[16] Much of this scholarship considers that the relationship was disruptive for the tropical environment. Any such claim requires the historian to develop a credible picture of the precolonial. On that point, ignorance rules, and because ignorance rules, there is often a tendency to start with an untested belief in 'the ecological

[12] Jones, *The European Miracle*, 193. Global economic historians do not usually talk about the Indian caste system in a precise meaning.
[13] Acemoglu, Johnson and Robinson, 'Colonial Origins of Comparative Development.'
[14] Pomeranz, *The Great Divergence*.
[15] Ravi Rajan, *Modernizing Nature*.
[16] There are good surveys of imperial regulation of the commons. See, for example, Rangarajan, 'Environment and Ecology Under British Rule,' and 'Introduction' in Grove, Damodaran and Sangwan, eds., *Nature and the Orient*.

wisdom of non-industrial peoples who have ordered their activities in ways that maintain harmony with the environment.'[17]

The tranquil precolonial enhances the drama of a collapse caused by colonialism and capitalism. After 1800, ecosystems collapsed, regulations and laws destroyed the commons or preserved these for state use, forests in India and Africa no longer being under community or self-management, degraded. Is this the true picture? The answer depends on the soundness of the image of a tranquil precolonial. Many historians have observed that the default reading of the precolonial overstates harmony.[18] Water reinforces the point. As I show, the premise of a pre-colonial that was either tranquil or equitable fails when we consider allocation of water rights in the past times.

I need to distinguish my usage of tropical monsoon from monsoon Asia, a concept that the development economist Harry Oshima made popular in the 1980s.[19] Oshima was explaining the economic miracle experienced by Northeastern Asia (including Japan, but excluding China). The concept of monsoon Asia builds on 'three major characteristics of monsoon paddy agriculture: the pronounced seasonality, the great labour-intensities of planting and harvesting, and the intricacies of traditional monsoon paddy cultivation.'[20] Together, these features made for a poor peasantry employed for half the year on-farm. The high seasonality made labour-force utilization the critical problem to solve in such societies. The premodern societies solved it by combining farming and non-farm activity and achieving high degrees of employment intensity. A post-war

[17] Robert Harms, cited by Beinart, 'Empire, Hunting and Ecological Change in Southern and Central Africa.'
[18] For a strongly worded critique of the myth of the 'eco-golden-age' in relation to water access in rural India, see Krishan, 'Water Harvesting Traditions and the Social Milieu in India.' See also Rangarajan and Sivaramakrishnan, eds., *India's Environmental History*. Similar arguments were made for other colonized regions. '[M]uch environmental research on Africa,' writes a paper on Tanzania, 'treats the pre-colonial period as a baseline in which [the] natural environments were literally "undisturbed".' Hakansson, Widgren and Borjeson, 'Introduction: Historical and Regional Perspectives on Landscape Transformations in Northeastern Tanzania.'
[19] Oshima, *Economic Growth in Monsoon Asia*. I should mention here another work that has stressed the importance of climate in a historical way, Amrith, *Unruly Waters*. This insightful book does not engage in economic history in the sense I do in this paper.
[20] Oshima, 'Transition from an Agricultural to an Industrial Economy in East Asia.'

industrialization policy involved intensive use of labour in industry and was thus consistent with these resource conditions, and yet was an advancement on it.

Although the concept of monsoon Asia and that of the tropical monsoon used here share an emphasis on seasonality, they differ on the emphasis on water, which was a far bigger problem for South Asia than for East Asia. If this was the case, then two conditions of the model of monsoon Asia did not apply to India – high labour-intensity of cultivation, and the availability of off-farm work. Dryland India did not cultivate rice. And if no cultivation is possible at all for seven months in a year, the condition would depress local demand for non-agricultural goods so much as to make extensive off-farm employment unlikely.

In the 1970s and the 1980s, economists often compared India and Japan. The development thinking of the time assumed that, since both countries were poor, agricultural, and monsoon-dependent in the nineteenth century, the subsequent divergence between these two countries on economic growth was a puzzle to be explained. The unstated assumption was that whatever Japan could do, India could do just as well, but for its state, colonial past, lack of land reform, or caste system. Oshima falls into this trap when speaking about India from the perspective of Japan.[21] Raymond Goldsmith thought that the nineteenth-century Indian economy had more strengths than the Japanese economy. Their subsequent divergence, therefore, was a mystery, implying that India's colonialism should somehow explain the mystery.[22]

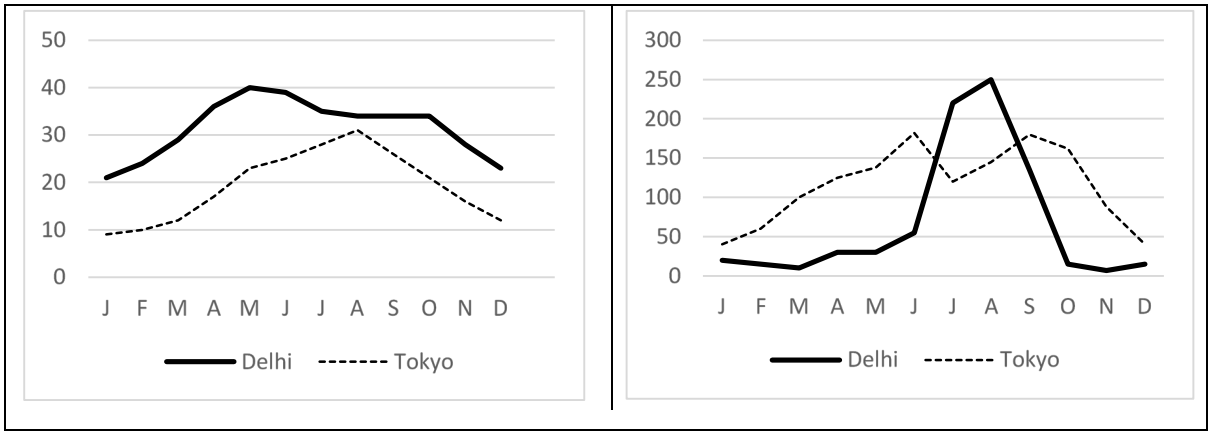
These comparisons and conjectures tell us little. The two countries had radically different geographies. Rainfall, temperature, and evaporation cycle data confirm

[21] According to Oshima, the 'slow growth' of India – another monsoon Asiatic region – had owed to inappropriate policy choices, and its 'socialist/caste institutions,' a concept not defined, 'Transition from an Agricultural to an Industrial Economy,' 809.

[22] Consider this: 'If a percipient and knowledgeable economist, for example, John Stuart Mill or Karl Marx, had been asked in 1870 whether a century later India or Japan would be more advanced economically and financially and thus closer to the levels of Western Europe and North America, it is possible, and indeed likely, that he would have named India. .. Neither Mill nor Marx would ever have envisaged the abysmal difference that marks the observed economic and financial development of the two countries.' Goldsmith, *Financial Development of India, Japan and the United States*, 4-5.

this conjecture by suggesting that whereas much of India (like the Sahel) is an arid region with a short and sharp monsoon added, Northeast Asia is a temperate region with a protracted and flatter monsoon added. On temperature and rainfall, Tokyo resembles London more than it does Delhi (Figure 4). Both water-shortage and seasonality were features of India to a much greater extent than they were of Northeast Asia. To reinforce the point, I add China and Japan as well as some representative north Atlantic countries in the climatic and geological data charts (Figures 2 and 3).

Figure 4. Maximum temperature (Celsius) and average monthly rainfall (mm) in Delhi and Tokyo.



Geography and natural resource endowments in the poorer countries have played a significant role in development economics and policy discourses. From the time these scholarships began, there was a singular fixation with land and little awareness that land counted for little without water. This fixation reached a peak around the 1970s and the 1980s when the belief that the key to solving the problem of rural poverty was a redistribution of land or property rights became an article of faith. '[W]ith great scarcity and an unequal distribution of land,' writes one survey of the policy and the ideology behind it, '[land reform] received top priority on the policy agenda at the time of the Indian Independence in 1947.'[23] Prominent Indian economists and European analysts of India

[23] Ghatak and Roy, 'Land reform and Agricultural Productivity.'

endorsed this preoccupation. 'Ownership of land,' wrote K.N. Raj, 'determines to a considerable degree .. the range of choices effectively open to different members of agrarian societies.'[24] The Swedish economist Gunnar Myrdal said of India that '[t]o own the land is the highest mark of esteem; to perform manual labour, the lowest.'[25] Consistent with these premises, analytical works on agricultural change in the poorer world stayed focused on market-relations and landed property rights, and rarely considered climatic-geographical variables. Explanations of 'backwardness' and synthetic surveys and overviews continued with this formula.[26]

The recipes that followed from the land fetish in development economics were outlandish. The land fixation meant staying focused on the quantity of land distributed from the rich to the poor. The water data shown in the previous section suggest that rural poverty owed more to the quality of the land, a joint outcome of shortness of the season of limited employment because of uneven distribution of water over seasons, and high cost of mobilization of water. It is easy to see that the quality problem could be so serious as to make any reform of property rights to land practically irrelevant, without a water property reform at the same time.

The criticism is so obvious that the land fixation seems like a very odd habit for economists working in or on a tropical monsoon country like India. A possible answer to the puzzle is that early development economics unthinkingly recycled an Anglo-centric disregard for water into their analyses of water-scarce developing countries. A misplaced belief in the universal validity of the laws of economics meant that theorists who wrote for water-rich geography were thought to be just as relevant to the water-poor ones. If David Ricardo did not

[24] Raj, 'Agricultural Development and Distribution of Landholdings.' Cited text in p. 7.
[25] Myrdal, *Asian Drama*, 1057.
[26] For example, Bhaduri, *The Economic Structure of Backward Agriculture*, which offers a general theory of agricultural backwardness using class power. Ha-Joon Chang says why radical property right reforms worked for East Asia, generalizing the insight to the rest of the poorer world. See the two essays in an overview type work, both conspicuously neglectful of geography, Chang, 'Institutions in Economic Development,' and Byers, 'Agriculture and Economic Development.'

mention water in the *Principles of Political Economy* – which he did not, in fact – it could become hard for an Indian economist trained in England in the 1950s to mention water.[27]

In the late-1970s, the focus of development discourses in India shifted from land to labour. In part, this was an effect of the surplus-labour models of development and attempts to measure the social opportunity cost of labour.[28] And in part, it was a response to the occurrence of near-famines in the late-1960s, and the spread of unrest and revolutionary movements in the countryside. In the backdrop of a growing sentiment that both redistributive land reforms and industrialization had failed to generate sufficient employment in India in the previous two decades, a team of researchers began to study ways of increasing employment intensity in the village. The team observed that per hectare labour inputs in agriculture differed significantly among countries, and that lower labour input was associated with higher poverty. The team concluded that there was unutilized scope for creating employment in rural areas. If this utilization were indeed possible by introducing small changes in technology and market access, it would offer a path to tackling rural poverty that was easier institutionally speaking than the land reforms and cheaper financially than industrialization. The study team led on the Indian side by K.N. Raj drew comparisons with Japan, where Shigeru Ishikawa showed, labour absorption in agriculture was especially high.[29]

The initiative died in the next decade, partly because the Green Revolution was beginning to push up rural wages and encouraged interregional migration. In my view, it died for another reason as well. It had underestimated the environmental obstacles to raising employment intensity in the Indian

[27] India's ancient intellectual tradition has not been so blind to the quality of land problem. 2400 years ago, an adviser to a Maruyan king asked the king to avoid land fixation, saying that the quantity of land captured during invasions was no measure of a successful rule, the quality of land was. 'Which is better for colonization: a plain or watery land?' Kautilya asked. The answer to that rhetorical question was obvious. 'A limited tract of land with water is far better than a vast plain.' Arthashastra.
[28] Harberger, 'On Measuring the Social Opportunity Cost of Labour.'
[29] Ishikawa, *Labour Absorption in Asian Agriculture*.

countryside and drew a superficial comparison between Japan and India without regard to their vastly different climatic conditions.[30]

A more recent strand in development policy discourses dealing with sustainability has been mindful of water though not equally mindful of economic history. One of the sources of inspiration for the sustainability literature is the problem known as the tragedy of the commons. The tragedy of the commons as generally understood in ecology and economic theory occurs when many people exploit a common property resource leading to a bad outcome, implying that certain old rules of exploitation that could provide good outcomes – what Garrett Hardin called 'social arrangements that produce responsibility' – were given up in the process.[31] What I describe in this paper is not that. I describe a set of old rules that sanctioned segregation of water rights and provided a bad welfare outcome but a sustainable environmental one. Breaking these rules was a good thing – certainly no tragedy – if risky. Societies faced a trade-off between welfare and environment when it came to water. The tragedy of the commons is a not the right model to reveal that trade-off.

The tragedy of the commons makes the current water discourse in the tropics futuristic. The scholarship is preoccupied with the reverse causality, how economics is expected to impact ecosystems, rather than how ecosystems impacted economic change in the past. One strand in the literature focuses on population growth, which is a historical variable but did not seriously matter to the environment before 1910.[32] The Indianist counterpart of the sustainability literature is mindful of the potential imbalance between supply and demand for water, but again with its main focus on the reverse causality.[33] While limitedly

[30] A cluster of writings on African development stress geographical barriers to agricultural intensification and trade. See Bloom and Sachs, 'Geography, Demography and Economic Growth in Africa.' There is some overlap between these writings and the present paper in the characterization of arid agricultural conditions, but not a lot of overlap. The accent in this paper on seasonality and institutionally conditioned access are not present in the Africa scholarship.
[31] The cited text from Hardin, 'Tragedy of the Commons.'
[32] Gleick, 'Water in Crisis: Paths to Sustainable Water Use.'
[33] Several essays in Shah and Vijayshankar, eds., *Water*; Chopra, 'Sustainable Use of Water.' Vijay Shankar, Kulkarni and Krishnan, 'India's Groundwater Challenge.'

useful as a guide to economic history, the sustainability literature has done a service by making water stress an issue for mainstream policy debates, and also broadening the scope of the phrase. I will draw on some of these works in the next section.

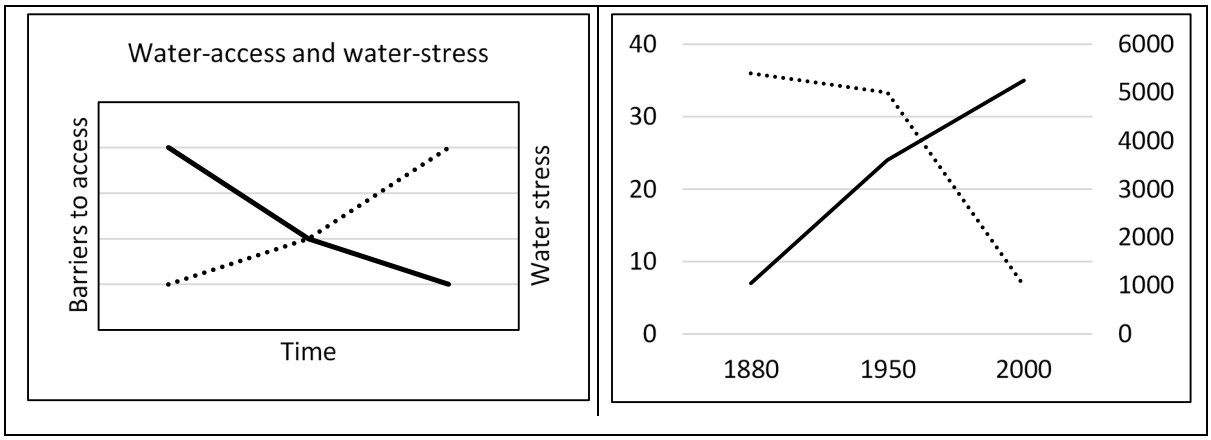
I now show how the modern times created increased water-security, but at a cost.

4 The first climate story: Creating water access at a cost

Before 1850, the access to controllable sources of supply of water was either private or restricted. From that situation, access increased in the long run, in turn, generating water stress. Figure 5 shows this relationship. The graph on the left shows the explanatory model, and the graph on the left uses a proxy each for water-access and water stress, to show with examples how the model might work. The second figure charts the canal-irrigation-percentage as a proxy for increasing access (I later explain why this is a good proxy), and per capita water availability as an index of water stress. The two lines cross as expected from the graph on the left.[34]

[34] This procedure can be questioned, because whereas the graph on the left suggest a causal link between water-access and water stress, the two indices shown on the right chart were technically independent. However, the message stands: water access increased in a vulnerable region, adding to the vulnerability in turn.

Figure 5. The expected relationship between water-access (solid line, left axis) and water stress (dotted line, right axis), and an example.



Notes: The graph to the left shows the stylized relationship. The one to the right shows the percentage of canal-irrigated land as a proxy for the reduced barrier to access, against per capita availability of water in cubic metres, a proxy for water stress, coverage India and Pakistan.
Sources: Tirthankar Roy, *The Economic History of India 1858-1947*, New Delhi: Oxford University Press, 2022 on canal irrigation data; Per capita water availability from R.K. Mali, A. Gupta, R. Singh and R.S. Singh, 'Water Resource and Climate Change: An Indian Perspective,' *Current Science*, 90(12), 2006, 1610-26.

Classical Hindu writings on statecraft and social conduct suggest that the rights to water entailed segregation cemented by ritual status rather than wealth inequality. Summing up almost a millennium of injunctions about caste, P.V. Kane said that '[i]n most of the works on the castes in India a few features are pointed out as the characteristics of the caste system.' One of these is who could (or could not) take water from whom.[35] The underlying idea was that water was not a sharable good, and rights were arranged by caste.[36] The condition that these statements draw our attention to is that private right to water had a religious sanction, especially sanction from the ritual context, which drew an opposition between purity and pollution, and formulated the highly specific notion of differentiation based on the idea that purity was lost by touch or the

[35] Kane, *History of the Dharmashastra*, Volume 2, Part I, p. 23.
[36] 'A reservoir of water belonging to Chándálas is serviceable only to Chándálas, but not to others,' Kautilya said in Arthashastra, 35. See also Joshi and Fawcett, 'Water, Hindu Mythology and an Unequal Social Order in India.'

exchange of bodily substances.[37] This notion of purity made denial of water to a thirsty person a moral act.

We cannot draw a line between classical texts and the historical process. There is, however, enough evidence to show that the coalescence of private rights and purity was present in the countryside in the late nineteenth and early twentieth century.[38] Was this a persistence of past practice? We cannot be sure, for research on the economy of the village has generally overlooked water rights and been preoccupied with land rights. When evidence does begin to come forth, exceptions to this norm were practically unknown.

The first historically significant moment that underlined this connection was the Mahad Satyagraha of 1926, when a spontaneous movement emerged from the people forbidden from using a town's public tank to assert their right to its water. Surely, such protests had happened before in history. But this event stands out for three reasons. First, it highlighted how universal the exclusion had been in western India until then. Second, it helped the emergence of B.R. Ambedkar in politics, who later became the most influential campaigner for caste equality. And third, the movement failed.[39]

After independence from British colonial rule was achieved in 1947, the democratic state made a difference. But it did not eradicate exclusionary rights. A survey done around 1973 found that more than half the population of oppressed castes in the rural areas of Karnataka state was not permitted to use the public well or tank. The proportion was much smaller at 15 percent in urban areas. Similar levels of discrimination were also reported from other states and as late as the 1990s.[40] In the early 2000s, one estimate reported that the women

[37] Guha, *Beyond Caste: Identity and Power in South Asia.*
[38] A turn-of-the-twentieth-century Indian administrator and amateur ethnographer, Herbert Hope Risley, tried to conceptualize caste with reference to ritually sanctioned modes of sharing water.
[39] Omvedt, *Dalit Visions*, 44.
[40] Thorat, 'Oppression and Denial: Dalit Discrimination in the 1990s.' See also on persistence of water-discrimination, Johns, 'Stigmatization of Dalits in Access to Water and Sanitation in India.'

of oppressed caste households spent an average of three hours daily to gather water for the household.[41] A 1990s survey found that whereas caste sentiment had been generally in decline in most areas of life, water shortage aggravated it. 'Untouchability is not experienced in normal times, but when water is scarce, the [oppressed castes] experience difficulty and discrimination in taking water from high caste localities.'[42]

Data like these were collected only after the 1960s. It is possible to make two claims about history based on these contemporary descriptions. First, the levels of discrimination in the past were greater. Almost all of these statistics related to the village, implying that the town experienced weak discrimination. Surely, the exclusion would not easily work with piped water. If this were the case, then urbanization ratios, combined with the urban proportion of the oppressed caste population, should indirectly confirm the level of discrimination. In 1901, this joint proportion was considerably lower in India than in 2001.[43] Second, it is plausible that instead of water-discrimination deriving from cultural sentiment, both discrimination and the cultural sanction that it received, derived from geographical conditions.[44] Projected back to the past, the relationship between geography and water rights would mean that water-insecurity and untouchability were both more intense in the era before public provisioning of water took off, roughly, from the nineteenth century.

From a grim baseline, water became more accessible, and more of a semi-public and eventually a public good during the period of this paper. Recent surveys of standards of living of the oppressed castes find that most families living in the

[41] Phansalkar, 'Water, Equity and Development.'
[42] Thorat, 'Oppression and Denial,' 575.
[43] In 1901, 11 percent of the Indian population was urban. In 2001, 28 percent was urban. In 2001, 20 percent of the 'scheduled caste' population was urban. India, *Handbook of Social Welfare Statistics*. The corresponding percentage for 1901 is unavailable. If we assume that the proportion rose at the same rate as the average urban ratio, then the 1901 percentage for the oppressed castes would be eight. However, it is also well-established that the oppressed castes had historically weaker access to education and capital; such resources should ordinarily raise the urban ratio. Therefore, the percentage in 1901 should have been smaller than eight.
[44] Bharti, 'Wealth Inequality, Class and Caste in India, 1951-2012.'

cities have access to 'some form of communal running water supply.'[45] In the countryside too, piped water extended, though the situation may have turned adverse during colonial times.[46]

Beyond caste-based access data, the evidence is varied and often indirect. Colonial property rights reforms created strong ownership rights over land but left the right to the commons undefined. That oversight may have made the upper castes and elites more eager than ever to take control of the sources of water. But not all members of the political elite in the countryside could do this. Some of the biggest gainers from agricultural growth and commercialization both in the colonial and the postcolonial times were not members of the upper-castes in a ritual sense. The British colonial rule in India introduced several changes that weakened the link between water-control and fiscal intermediation. The village landlord who had a say on the use of the commons and performed a tax collector's role in pre-colonial times turned into a specialist cultivator in the nineteenth century, as the colonial government took over the tax collection function. Some members of the upper caste landowning elite failed to adapt, or sensed other opportunities, and left the village for the city.

Irrigation technology changed in the nineteenth century, with a large investment in canals taken off the rivers of Punjab and constructed in the south Indian deltas. With canal irrigation, individuals could do little to restrict access to other individuals. With globalization and expansion of commodity export trade, the less water-stressed seaboard played a larger role in driving economic change from the mid-nineteenth century, attracting migrants from the agrarian inland to the port cities and their hinterlands. The move entailed increased access to water per capita (and some mitigation of seasonality, as I argue later). It is almost certain that the disappearance of dryland famines in India after 1900 had

[45] Martin, 'Rural Elites and the Limits of Scheduled Caste Assertiveness.'
[46] Economic power stemming from commodity trade concentrated in the hands of landowning castes, who sometimes came from the upper castes. Agricultural expansion encouraged some of these landowners to capture common streams. For examples of capture from the recent times, see Joshi, 'Caste, Gender and the Rhetoric of Reform in India's Drinking Water Sector.'

a causal connection with mass water-security, though hardly any research exists on the connection.

The cities of colonial India had an ambiguous relationship with water. Bombay, Calcutta, and Madras were not short of water sources. However, until the late-nineteenth century, the city administration neglected drainage, sewage, and centralized water supply systems, increasing the risk of malaria and cholera, especially in the densely settled areas where the Indian population and new migrants lived. Water channels inside the cities tended to degenerate under population pressure. In the engineering corps of the army, there were advocates of gravity schemes that had found an application in the enormous canal projects of the same time. But many people doubted how receptive the Indian quarters of the cities would be to the idea of a common tap, and to paying a tax to get it.

These fears were well-founded. In the 1880s, the pioneering industrialist of Ahmedabad, Ranchhodlal Chhotalal, was beaten up by members of his community for his campaign for water supply and drainage system in Ahmedabad.[47] The resistance notwithstanding, the cities did develop gravity systems and piped water, thanks in part to the growing economic and political power of businesspersons like Chhotalal, and partly, a moral concern that originated in Britain and migrated to different parts of the empire. 'At home and abroad,' writes the author of a study of urban water supply in colonial India, 'rulers and reformers identified the same practical problems, the unhygienic habits of the working class or native city dweller, and the same abstract predicament, the moral degeneration of townspeople living among "filth," and applied the same environmental solutions.'[48]

In the late-twentieth century, urbanization speeded up. From 18 percent in 1951, the urban ratio exceeded 30 in the 2000s. The environmental sustainability scholarship acknowledges the positive link between urbanization and water

[47] Roy, *Business History of India*, 113.
[48] Broich, 'Engineering the Empire.'

access.[49] The two waves of the Green Revolution in India, a 1970s one based on wheat and a 1980s one based on rice, increased water access. Subsidization of electricity and subsidized bank credit for pumps made extraction of groundwater much cheaper than it would otherwise be. As agricultural production increased, the scale of subsidization grew too.

As barriers to access fell, water stress rose. On a smaller and local scale, the dual-process had occurred in Indian history many times before 1850. Medieval cities like Fatehpur Sikri near Agra or Goud in Bengal were abandoned because rechargeable sources of water ran out. Urban growth, thanks to the low cost of extraction of water, led to overreliance on a fixed source and crises in the manner seen in other world regions before the modern times.[50] But the process occurred on a larger scale from the late nineteenth century because it was mediated not by isolated urban growth but by agricultural expansion, irrigation development, and population growth. It was regionally variable. Making more water accessible to more people was technologically easier to achieve in the seaboard, the river valleys, the floodplains of the Himalayan snowmelt rivers, and wetland zones. It was a much harder process in the semi-arid Deccan Plateau. Between 1872 and 1902, canals taken from Himalayan rivers in Punjab increased from 2,700 miles to 16,900 miles, enabling a rise in cultivable land from 27,000 to over 40,000 square miles. In the peninsular regions, the growth in both was much smaller.

Concern over rising water stress started in the second decade of the twentieth century when the study of economics and agronomy was institutionalized. There were three types of water stress. First, the irrigation canals that were taken from the Himalayan rivers sometimes degraded or created environmental hazards.[51] Second, in the western part of the Indo-Gangetic Basin, where subsoil water was used for cultivation, groundwater reservoirs were depleting. In some

[49] '[A]s India urbanises, the growing proportions of its population would come into contact with formal water service providers,' which implies reduces barriers to access. Shah and van Koppen, 'Is India Ripe for Integrated Water Resources Management?'
[50] See Tana, 'Towards an Environmental History of the Eastern Red River Delta, Vietnam.'
[51] Whitcombe, *Agrarian Conditions in Northern India*, Agnihotri, 'Ecology, Land Use and Colonisation: The Canal Colonies of Punjab.'

tracts within this area, the uncertainty raised the cost of constructing a new well as well as the cost of extraction of water.[52] And third, in the eastern part of the Basin as well as the Bengal delta, which mainly relied on the deltaic and rainfed rivers for subsistence and winter cultivation, there was beginning to occur a change in the morphology of the river system. Deltaic Bengal became fertile and retained fertility through a natural process, change of course of the rivers. In the monsoons, numerous small channels carried excess river water into depressions, turning them into tanks. As the tanks drained again, the dried-up tank-beds provided fields for rabi (winter-sown) crops. In some tracts, particularly in western Bengal, overexpansion of cultivation since the nineteenth century had started to restrain this twofold process, with the result that the soil surrounding the rivers had begun to deteriorate.[53] An example of the manmade crisis was the Damodar river, which deteriorated into a narrow and fixed channel on reaching lower Bengal. In eastern Bengal, many agricultural tracts were said to be 'dying,' and the reason was that the tanks neither had enough water nor did they dry in time.[54] In turn, this was a result of the silting up of the rivers, and the silting of the channels that carried river water. The tanks became swamps in the dry season and breeding grounds for mosquitoes carrying malaria. 'There is little doubt that deltaic Bengal has become populated a geological age before its time, and the legacies of fever, deterioration of rivers, etc., is [*Sic.*] at least partly due to this.'[55]

For at least forty years after India's independence and the adoption of a statist development strategy, these pieces of evidence of the declining quality of surface water did not trouble the policy-makers too much. Nor was there a radical shift in the paradigm of hydraulic engineering. In the 1990s, however, water returned to the mainstream development policy thinking, and now as a major worry. The worry stemmed from growing evidence of depletion of groundwater thanks to the

[52] India, *Royal Commission on Agriculture*, Vol. VII, Evidence taken in the United Provinces, 377-9.
[53] For a contemporary discussion, see Mukherjee, *The Rural Economy of India.*
[54] Roy, 'Agrarian Crisis in Interwar India.'
[55] India, *Royal Commission on Agriculture*, Vol. IV, Evidence taken in the Bengal Presidency, 7, Director of Agriculture, Bengal.

overuse of the aquifers for agricultural uses. India's rice-based Green Revolution of the 1980s was a success of food production, at an enormous environmental cost. Soil nutrients depleted in many cases, and groundwater was mined recklessly.

Between 1995 and 2004, the proportion of the Indian population living in 'unsafe' districts – unsafe being defined as the declining capacity of the aquifers to recharge and to sustain current levels of water extraction – increased from 7 to 35 percent.[56] In the northern districts that had led the earlier wheat-based Green Revolution, exploitation of groundwater in the 1990s reached levels that far exceeded the capacity of the aquifers to sustain. Pakistan faced the same problem on a much bigger scale. Elsewhere, the hydrogeological conditions influencing supply varied too much to make predictions on future supply a simple matter. The main issue, however, was not the quantum of potential supply, but that groundwater appeared as a private good to the users, whereas it came from a common pool, the classic tragedy-of-the-commons syndrome.

As the sense of an impending ecological crisis grew, water turned political. The generally rapid economic growth in India since the 1990s added the fear that non-agricultural demand for water was growing too fast. Again, the worry was the private exploitation of common resources. In the last 15-20 years, water conflict has grown in India's mega-cities, where 'a combination of institutional path dependence and a neoliberal restructuring' has 'extended the ability of [the cities] to establish new forms of water entitlement in rural and peri-urban areas.'[57]

Hydro-political analysis grew alarmist at the same time. Within South Asia, which contains over a fifth of the world's population and eight percent of global freshwater, and which relies critically on freshwater harvested from sources like

[56] Vijay Shankar, Kulkarni and Krishnan, 'India's Groundwater Challenge and the Way Forward.'
57 Punjabi and Johnson, 'The Politics of Rural–Urban Water Conflict in India.'

Himalayan snowmelt or underground sources, both resources the South Asian countries shared, the prospect of going to war over water is not beyond imagination.[58] As of now, the nations of South Asia cooperate more than dispute their rights to riparian resources. But critics believe that the terms of negotiation reflect the economic weight of the nations more than ecological considerations.[59] And the prospect of climate change shifts the geographical knowledge base on which some of the treaties were drawn.[60]

Similarly, 'the potential for political instability over domestic water distribution and development' becomes increasingly real.[61] A study of the Indus Basin shows that these conflicts do not directly stem from absolute scarcity, rather they are enmeshed in the discourses on entitlement to water, and relate to broader political processes such as 'democratization, .. social justice, [articulation of] ethnic, religious, and linguistic identity,' and perceptions of groups of claimants about justice and economic security.[62] In short, a simple land-population-water accounting cannot explain the emerging conflicts at the local levels. These conflicts embed in beliefs that water is a democratic and human right, which some stakeholders violate at the cost of others. The mega-cities conflict mentioned above is another example of the problem.

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[58] Chellaney, *Water: Asia's New Battleground*.
[59] Hanasz, 'Power Flows: Hydro-hegemony and Water Conflicts in South Asia.'
[60] The most famous international agreement in South Asia is the Indus Waters Treaty between India and Pakistan. Both countries rely heavily on the five major rivers of the Indus Basin for irrigation and power. All of these rivers originate inside India, and four of them flow inside Pakistan. The Indus Waters Treaty in 1960 allowed Pakistan to exploit the Western rivers more intensively while allowing India rights to the Eastern rivers. Although the two countries often fought wars, the Treaty survived. Between 2002 and 2012, threatening words were exchanged over the Treaty. And in the recent months again, tensions rose. On the Treaty, see Ramaswamy R. Iyer,'Indus Waters Treaty 1960: An Indian Perspective,' 16 March 2014, available at https://www.boell.de/en/2014/03/16/ indus-waters-treaty-1960-indian-perspective (accessed 2 August 2016). On the Eastern borders, India's decision to build a barrage on the Ganges on the Bangladesh border (1973-4) caused much uneasiness between the two countries. Comparatively speaking, river-sharing arrangements between India and Nepal, and India and Bhutan, were more peaceful.
[61] Mustafa, 'Social Construction of Hydropolitics.'
[62] Mustafa, 'Social Construction of Hydropolitics.'

5 The second climate story: Overcoming seasonality

That extreme seasonality also means widespread underutilization of labour, and therefore, rural poverty is well-known. But seasonality is much more than poverty. It can shape labour market contracts and investment behaviour. Seasonality can be overcome. Migration and reallocation of labour and capital can mitigate its effects over time.

How did seasonality shape contract? How did contracts change and why? Did mitigation happen in the 150 years of interest? I will focus mainly on the colonial era because that is where my expertise lies, and suggest that they did happen, but within strict limits. The key examples to show that mitigation happened are seasonal migration of peasants and agricultural labourers to non-farm work, which increased in scale, institutional changes that enabled such movements, and some narrowing of seasonal variation in interest rates. There was evidence of a narrowing of the gap between busy and slack season interest rates in India in 1874-1914.[63] During the same period, inter-regional migration and circulation of labour also increased. However, neither did the average real wage rate significantly increase nor the average interest rate decline during the same years. So, what happened, and what were the limits?

Let me first discuss what makes non-farm employment possible at all under conditions of high seasonality. A short productive season suggests that there is surplus labour. Should that be good news for generating non-farm employment? Not necessarily. Most people engaged in highly seasonal agriculture should have a lot of free time off-season or there should be a labour pool available for non-farm employment at a very cheap rate. The prospect is good news for employers in industry and services. On the other hand, there being only one productive season, yields are low, marketable surplus small, and therefore, local demand for

[63] The annual average of the bank rate of the Bank of Bengal fell slightly over 1874-1919, and so did the variation around the monthly rates. See Roy, 'Monsoon and the Market for Money,' Figure 1.

industry and services weak. That is bad news for prospective employers in non-farm activity.

When we observe any non-farm employment at all, we need to ask which one of these two pathways is working for that would tell us what is needed to generate more such employment. If local demand for non-farm goods is not a problem, then arranging for investments in industry should generate more employment utilizing cheap surplus labour. If limited local demand is a problem, then first demand has to rise via commercialization of agriculture and investments in agriculture before industrial employment can rise utilizing surplus labour.

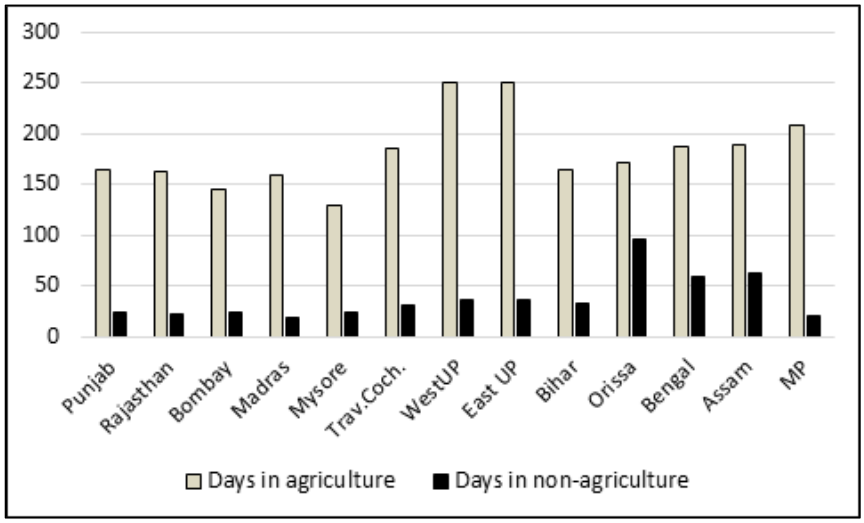
If demand is not a problem, and just the availability of surplus labour can generate non-farm employment, we should see a negative correlation between days of work in agriculture and days of work in non-agriculture among rural households. The shorter the agricultural season, the more do the peasants and labourers take part in nonfarm activity. We should also expect to see a negative correlation between average wage in agriculture and days of work in non-agriculture. If local demand drives such diversification, we should see a positive correlation between days of work in agriculture and days of work in non-agriculture, as well as a positive correlation between average wage in agriculture and days of work in non-agriculture.

There is some data to test which way these relationships go. The 1954 Agricultural Labour Enquiry collected data on days of gainful work in agriculture and non-agriculture across regions. The data related to one year and the wage-dependent people rather than landowners. Subject to these qualifications, they showed that seasonality was acute. The number of days of paid work on average was small (more than 100 days of idleness in all but two regions, see Figure 6 below). The data also show that the days worked in non-agricultural activity was correlated positively with days worked in agricultural activity, though the correlation was not significant. The data finally show that the days worked in non-agricultural activity were again positively (but not

significantly) correlated with the average wage in agriculture. These results provide some support to the second of the two models, suggesting that merely having surplus labour was not a sufficient condition for nonfarm work to develop, the necessary condition was that rural incomes should grow first. The precondition for that would be actions mitigating the effects of seasonality.

Between 1870 and 1920, agricultural production and trade did increase. Rural workers migrated more than before. Rural incomes did grow, not equally in all regions, and the peasants and workers did consume more non-food articles. Estimates of average cloth consumption suggest a significant increase from six square yards in 1840 to 15 in 1940.[64] The extent of the increase in consumption could not just happen by relying on small urban demand for textiles. Peasants too bought more cloth and good-quality cloth. They did because, in some parts of rural India, incomes did grow with irrigation expansion and commercialization of agriculture.

Figure 6. Days labourers worked in agriculture and non-agriculture, 1952.



Source: India, *Agricultural Labour Enquiry: Report on intensive survey of agricultural labour*, vol. I (All India), New Delhi: Ministry of Labour, 1954.

[64] Roy, 'Consumption of Cotton Cloth in India, 1795-1940.'

That process, however, did not make the rural labourers work harder and produce more craft goods. How do we know that the rural population did not supply the new demand for non-farm goods? Since the scale of non-agricultural employment was small in 1952, not much could have happened in the previous century. The big process that the rural workers were subjected to was institutional change, a change in the contractual form of employment. It did enable more reallocation of labour. But it was not a very radical change, driving agricultural labourers usually towards other forms of labour rather than towards industrial production.

An argument that has become known as the land-abundance view of pre-colonial Africa suggests that an abundance of low-quality land and labour scarcity induced the emergence of regimes of labour coercion in precolonial Africa.[65] In India, labour was always potentially scarce during the busy seasons, and land was by definition of low-quality thanks to the seasonal shortage of water. There was little outright slavery in India, but farm servant arrangements were indeed quite extensive in the dryland areas of southern India.

There were four features of these farm servant arrangements. First, they were caste-based and often bordered on serfdom, if not slavery. The workers were attached to plots of land. For some groups, their caste status made for a weak entitlement to land and water; it made sense to enter year-round arrangements like this one. Second, servitudes of these sorts involved a lack of specialization. The workers were attached to the land, but in the slack season, they were available to work in a range of services. Third, these activities were not market-driven or chosen by the servants but dictated by their employers. And fourth, these were manual and unskilled work, rarely involving more than the most basic tools and basic skills. Where artisanal activity was a part of the portfolio, such as weaving or leatherwork, the quality of the work was basic and far simpler than the work produced by specialist artisans.

[65] Austin, 'Cash Crops and Freedom,' Fenske, 'Does Land Abundance Explain African Institutions?'

Farm servants in colonial India were not all alike. In colonial Madras, they belonged in castes that could not effectively own land. In Punjab, on the other hand, farm servants were cultivators on the side and worked under negotiated contracts. In some parts of central India, farm servants were like apprentices and a prospective groom for the daughter of the family.[66] Significantly, Madras was the driest of these three examples around 1900. Despite these differences, there might be a single motivation behind these arrangements. To avoid a shortage of workers in the peak season, the employers offered a contract that carried a small wage but contained an implicit insurance element for those months when there was no work and less food.[67] In areas like dry Madras, water shortage would add to the motivation on the part of the worker to get into long-term contracts. Seasonality did not mean complete idleness in the slack months, it could mean instead performing a different range of tasks, or being available for any odd job. The farm servant worked as a non-specialized or 'general labour.'[68]

The 1881 census defined 'general labour' as persons who 'take to miscellaneous tasks involving as little as possible of anything beyond bodily strength.'[69] In the 1960s, Daniel Thorner, who made the first serious effort to understand the nature of work in rural India, considered that this group consisted of agricultural labourers mainly.[70] This interpretation left unexplained why women crowded general labour more than field labour. This group consisted of persons who did not specialize and moved between agricultural and non-agricultural labour, while always sticking to manual labour. Because women were necessarily non-specialized workers, they were usually counted as general labour in the nineteenth century.

[66] India, *Census of India, Central Provinces and Berar*, vol. XIII (Part I), 213.
[67] For an application to a later time, see Sanghvi, *Surplus Manpower in Agriculture and Economic Development with special reference to India*.
[68] Minding livestock was an important task. See Atchi Reddy, 'Work and Leisure: Daily Working Hours of Agricultural Labourers.'
[69] India, *Census of India, Bombay Presidency*, vol. I, 1881, 196.
[70] Thorner and Thorner, *Land and Labour in India*.

General labour was shrinking in scale in the late-colonial times, so much so that the census gave up this category from 1901.[71] Consequently, the proportion of agricultural labourers in the rural work-force increased in the census period (1881-1931). Early Marxist readings of these data said that debt-ridden peasants were losing control of land. There is little direct evidence that this was the case. More plausibly, attached workers were moving around more, and non-specialized workers were turning into more specialized workers. The percentage of farm servants in 1901 or 1921 and the percentage of attached labour in 1951 moved in the range of 12-15. But the most hierarchical caste-based arrangements were in decline. In Madras, the proportion of farm servants among labourers fell from half in 1881 to about a third in 1931 to just one percent in 1951.[72] After the 1950s, official sources discarded the term 'attached' labourer on the ground that 'attached labour is no longer attached to any particular household in the old sense. Such attachments are now conditioned more by economic considerations and may not extend beyond a season or a year at the most.'[73]

Increased migration possibilities and a fall in the costs of migration thanks to the railways induced contractual change. I believe that there was another factor at work. From the end of the nineteenth century, after famines dispeared from the dry lands, the population irrespective of social status would have experienced reduced barriers to access to water. More people than before would have access to the water-secure environments of the city or the deltaic regions. Therefore, one condition for entering year-round commitments – securing access to food and water if these things ran out in the dry season – did not operate as powerfully as it did before.

Migration drove many men in farm households to go to the port city seeking work. The women who stayed behind joined farming work and sought more causal type of contract. That kind of intra-family reallocation of labour had an

[71] Roy, *Rethinking Economic Change in India: Labour and Livelihood*.
[72] India, *Agricultural Labour Enquiry*, Vol. I (All India).
[73] India, 'National Commission on Agriculture.' Cited text on p. 65.

obvious connection to climate; if successful, it was very effective mitigation of seasonality. Migration opportunities also increased in the newly emerging agricultural regions like the Punjab, which did not have its traditional labour pool. Commercialization made people specialize. As rural consumption increased, the process benefited the specialist artisan more than the peasants and the agricultural workers. The specialist artisan gained from this change because new consumption goods being traded more widely embodied skills, and the general labourers or farm servants faced barriers to acquiring these skills.

In parallel with these changes in the labour market, the capital market changed too. A rich commercial tradition, especially along the coasts, had created in India a large indigenous banking system before the British colonial empire appeared in the region. Colonialism and globalization, however, changed the structure of trading, and in turn, financing of trade. Unlike artisanal and high-valued goods traded in the past, from the mid-nineteenth century, agricultural commodity exports became the main item of trade, sustained by the railways, the telegraphs, the port city infrastructure, and indigenous banking. The entire financial system, including a nascent corporate banking segment, had to reorient to this new and vast field for deployment of money.

Despite the rise of corporate banking, the core of the banking business became ever more tied to commodity trade, thus increasing the seasonal influence on their business rather than reduce it. The biggest of the indigenous banking firms funded export trade, funded other bankers, sometimes did some deposit business, and were somewhat less susceptible to seasonality. These firms were in the port cities. A key feature of their operation was the extensive use of negotiable instruments, especially a group of instruments collectively known as 'hundi.' The common meaning of hundi was a banker's draft or promissory note, though sometimes merchants' bills of exchange were also called hundi. An important piece of British Indian legislation, the Negotiable Instruments Act (1881) partially covered hundi.[74] The reputation of the acceptors as banking

[74] Martin, 'An Economic History of the Hundi 1858-1978.'

houses and the customary law and conventions that they followed ensured that the corporate banks discounted the hundis they issued. The biggest of these banks were partially European owned and again in the port cities. The discounting of hundis, therefore, made for an area of convergence and cooperation between modern and traditional banking firms. In other words, their inherited institutional strengths and colonial legal intervention together helped these bankers expand their business. Some of the port city banks, therefore, managed to develop a sufficiently diversified portfolio to mitigate seasonality.

Local banking was trapped ever deeper in seasonality. Neither hundi nor a diversified portfolio characterized those layers of banking that funded the merchants operating in the countryside, who moved goods by the railways from the source and lent money to landlords and peasants. The business of agricultural lending in the villages and small towns involved a very different institutional setup and different sets of actors from those described above. Even the large banking firms had some exposure to agriculture, but they rarely dealt with the peasants and local grain merchants directly. Those who mainly dealt with the peasants needed to adapt to extreme seasonality.[75]

The monsoon concentrated rainfall into a two-to-three-month span in an otherwise hot and arid region, thus squeezing the sowing season, when peasants needed credit, and the harvest season, when the trade needed credit, into short periods, sometimes as short as two-to-three weeks. In the busy season, bankers needed to expand credit a lot and very quickly. Local banking adapted to the unpredictable fluctuations in demand in a variety of ways. They usually dealt in the most liquid of assets, such as cash and gold, made unsecured loans, relied on their knowledge of the clients, insisted on short-term loans, and avoided deposit banking, which would add a non-seasonal liability. The rest of the year was the slack season when the circulation of money in the countryside greatly reduced in extent.

[75] For more discussion on the financial market, see Roy, *A Business History of India*.

It is not surprising, then, that despite the growth of their business, indigenous bankers rarely invested money in modern industries like cotton textile mills. Except for a few textile firms of Ahmedabad, industry tended to be financed by mercantile profits, public shareholding, and public deposits. And despite the growth of indigenous banking, the rates of aggregate saving and investment remained low in the early twentieth century. Indigenous bankers met the needs of agriculture but diversified little and had little noticeable effect on saving habits. Interest rates stayed high, much higher than in the money markets of Europe, and fell only marginally between 1880 and 1940.

The reason is that, extreme seasonality limited financial intermediation.[76] Attracted by the prospect of making a killing in the busy seasonal market, lenders hoarded money rather than lend long-term outside agriculture. The persistence of huge inter-year fluctuations in interest rates was a sign that the banking business did not increase credit sufficiently in the busy season without running into unsustainable default and did not deploy surplus funds profitably in the depressed months. The money supply into the agricultural interior was not very elastic. Lenders in agricultural credit did not usually transact using negotiable instruments or bills. Their clients did not understand or accept papers, and the courts of law and discounting counters were too distant. The local financial markets dealt with only physical money.

In part, the preference for cash over papers reflected the limited reach of laws. The acceptors of hundi were too remote and unknown to the merchants, moneylenders, and peasants engaged in local trade. Legislation on negotiable instruments was piecemeal in that it did not extend to local moneylending and to the contractual documents that were potentially usable in agricultural transactions (like promissory notes). A string of provincial laws restricting land mortgage obstructed the use of the mortgage document as a negotiable

[76] Goldsmith found that the level of financial intermediation was relatively low in interwar India. *Financial Development*. Across emerging economies of the time, the level was not highly correlated with per capita income, even though all showed a rise in intermediation in the long run.

instrument. There were other hurdles to legislation. The diverse profile of the actors, many of whom were merchants and bankers of small resources, and immense variation in local conventions would have made designing a proper legal framework for bills a frustrating enterprise. Therefore, the financial system was poorly equipped to spread credit between seasons and types of borrowers.

The subject of finance already brings us closer to the port city, where seasonality was a weaker effect.

6 The seaboard where the climatic agency was weaker

The seaboard was not a part of this story – water-access → increased production and wellbeing → water stress. Discussion of the concept of 'monsoon Asia' observed that the concept did not explain the economic history of Singapore and Hong Kong all that well. The reason it did not was that services and not agriculture were the economic foundation of many seaboard cities. So it was in India. Before 1850, trade and finance in the port cities did respond to the seasonality effect, for shipping needed to use the monsoon winds and avoid the monsoon storms. But the port cities were not water-scarce, thanks to higher rainfall in the coasts, and their ability to situate on estuaries and deltas where there was a constant flow of water even in rivers that tended to shrink in summer. They could grow bigger because they could provide food and water to more people.

Outside the port city, towns had limited capacity to provide water. India's urbanization ratio was low and stagnant as far as we can measure, until the mid-nineteenth century. There was nevertheless a reshuffle between the interior and the coasts that probably began in the mid-eighteenth century. For the next 70 or 80 years, the three ports that the British East India Company had owned from the seventeenth century (Bombay, Calcutta, and Madras; Karachi joined them in the 1840s), grew rapidly in population, whereas several cities in the

formerly Mughal-ruled Indo-Gangetic Basin depopulated.[77] The reshuffle was an effect partly of political shifts and partly the growth of Indo-European maritime trade in goods like indigo and opium. After 1850, technological change aided the process. Steamships were less reliant on monsoon winds and more able to withstand violent weather. The volume of rail borne trade increased very rapidly. Being able to carry the produce of many regions meant that the railways were busy throughout the year since local crops did not all follow identical seasonal cycles. Further, irrigation water had enabled the production of year-round water-intensive crops like sugarcane, which again created business for the railways. Thus, if the seaboard had been less susceptible to the water constraint from before, it now had the means to overcome seasonality and do business all year round.

In this way, urban business growth and agricultural growth started to diverge from the end of the nineteenth century.[78] Agricultural growth gained from water access via irrigation projects, but as irrigation investment slowed in the twentieth century, the gains dissipated. After that, national income data show significant growth in real national income in 1900-1946 in non-agricultural activities like finance, industry, and trade, whereas agricultural income changed little. There was a near-doubling of productivity of labour in the former, and little change in productivity in agriculture. The mainstay of business growth was long-distance commodity trade. Cargo carried by the railways and the ports increased from 5 to 140 million tons between 1871 and 1939. Finance and banking expanded to support that growth. Merchants and trading firms invested trading profits in mechanized factories, especially cotton and jute textiles — all of these activities gained from the greater water-security of the cities.

The balance between the seaboard and the interior changed after 1947. Independent India's autarkic and statist development policy meant that some of the earlier businesses – commodity trade, foreign trade, and traditional industry

[77] For the data, see Roy, *Economic History of Early Modern India*.
[78] The rest of this section draws on Roy, *How British Rule Changed India's Economy*.

like the textiles – declined. The seaboard cities retreated in economic importance. The major cities, Bombay and Calcutta, experienced an extended period of urban unrest and de-industrialization in the 1970s and the 1980s. On the other hand, the rates of public saving and public investment increased dramatically and concentrated on heavy industries located in interior cities and on the subsidized provision of agricultural inputs. While Bombay and Calcutta retreated, interior cities like Bangalore and Bhopal forged ahead based on heavy doses of public investment in industry. Private and government efforts to mobilize water also increased as part of these policies. There was, in a general sense, a convergence between the interior and the seaboard as a result. The recent return of 'neo-liberal' economics in India may have caused a further shift. Towns that led business growth, and agriculture, reached crisis points. Bangalore city, for one example, is now severely water-stressed.

7 Lessons

The essay says that climate shaped the long-term pattern of economic change in India and that the climatically conditioned economic change generated environmental consequences in the region. The nineteenth-century forces that transformed the world economy – trade, technology, colonialism – worked through geography. And because geographic mediation varied within India and between livelihoods in India, these forces generated inequality.

The environmental filters of interest are water shortage and seasonality. The water story in this paper is formally similar to how most of us think about the link between natural resources and politics or economics. Over a century or more, widening access to a finite resource – be it land, water, or minerals – causes shortages to build up, attempts to capture the resource, political onflicts, and environmental crises. But water is also unique in some ways. It is not, like cobalt in batteries, an instrument for the consumption of luxuries like phones and cars, but a necessary condition for life to exist. It sustains population growth and food production. Water security makes societies better-off in a more

fundamental way than would a growth in per capita income, whereas water-security acts also as a precondition for per capita income to rise.

This argument brings me to the subject of what economic history and environmental history can learn from a study like this one. On that point, I wish to make three general comments.

The first set of comments concerns what economic historians often consider to be the yardstick of the economic success of societies, growth in average income or productivity. The paper tells us that this is a misleading yardstick. In a dry region, water-security should count as the biggest breakthrough for material life, not a rise in income or productivity. There are additional and more technical problems involved in ignoring water access or seasonality in an account of standard of living. For example, where per capita incomes are unavailable, economic historians use either real wage or consumption data to measure changes in standards of living in the long run. They need to consider that real wages are impossible to read for a tropical region unless accompanied with data on the effect of seasonality, that consumption of food has little meaning where water access is insecure, and that the same level of living measured in wages or consumption-bundles could mean variable risks to life.

Second, the paper has a lesson on how economic historians choose their key questions and the key regions to compare in answering these questions. Many economic historians take for granted that the most important task for the profession is to answer the question, why some countries grew rich, and other countries stayed poor from the beginning of the nineteenth century to the present times.[79] Having decided that this must be the central task, comparative economic history remains wedded to a Europe-Asia comparison that ends up being a celebration of Europe's success in raising average income and goes on to explain the rest of the world's failure to do so. But is the question – why some

[79] 'Why are some countries much poorer than others?' Acemoglu and Robinson, 'The Role of Institutions,' 1, call this 'the most important question' for the social sciences.

countries grew rich, and other countries stayed poor – a good question? Is answering it with statistical data a good use of statistical data? Are Europe and non-Europe the right geographical units for comparison? I believe the answer should be no to all three questions.

Long-run economic performance needs to be understood with other benchmarks than average income. Much of the world is dry. Western Europe, Japan, and North America are a lucky exception to that rule. For the rest of the world, the societies' ability to control water determined their ability to sustain population and economic growth. The paper shows how water control can be a benchmark of economic performance with one example. The proposition that water-control should be a benchmark of performance frees up global economic history from the increasingly sterile and sometimes outlandish Europe-Asia comparison and enables comparisons among the drier regions. For example, the evaporation map of the world tells us that the arid tropics, the so-called monsoon Asia, and the monsoon tropics share some similarities and some differences in their ability to control water. Did their economic pathways differ too? Were these more similar than different? Did the differences stem from geography?

My third and final comment concerns the tropes through which economists make sense of environmental history. Much of the ongoing discourses on environmental stress remains trapped in simplistic tragedy-of-the-commons rhetoric. The maxim that emerged from Hardin's framing of the problem, that 'freedom in the commons brings ruins to all,' does not apply to water stress in the tropical monsoon regions.[80] Increasing water access involved deliberate democratization of rights to access and a change from the old rules that sanctioned segregation, inequity, and inequality. This is 'freedom in the commons' in a substantive sense but not in Hardin's sense. It is freedom as freer access to a basic human entitlement, not the freedom to destroy. The equivalence of water access and human freedom suggests that dealing with this kind of environmental crisis is a more complex affair than environmental activists may

[80] Cited text from Hardin, 'Extensions.'

think. In a dry region, there is a trade-off between welfare and the environment. The right response to that trade-off is not asking individuals to consume less.

This history of India is an unfinished one and should gain from improvements in measurement and a better understanding of causal links. Much relevant climatic-geological data cited above comes from recent surveys because older data do not exist or historians did not look for them. Sometimes, the paper comments on institutional conditions in older times by extrapolating the results of recent studies that explore the link between ecology and economic change. Fortunately, geography does not change quickly. Even so, it would be much better to build data on the older times, on such benchmarks as water access, water stress, seasonal movements in wages and interest rates, and rise or fall in the degree of seasonal variations.

Similarly, some crucial relationships are obscure. How premodern states set entitlements to water in practice; whether or not the entitlements mitigated famines or broke down during famines; how tenacious caste-based rights have been and why they have been tenacious; inequalities within castes; whether a concept of common pool existed in the times past; how the demographic transition from the mid-twentieth century complicated the story, remain some of the unexplored areas.

Another unexplored theme is the nature of the interaction between external economic agents – trade, colonialism, technology, nationhood and citizenship rights – and water access and seasonality. Did these forces increase the dependence of the poor upon unreliable jobs and limited subsistence, or improve their access to better jobs and more reliable subsistence? Given the extreme degrees of water-exclusion that Indian society displayed throughout history, I am inclined to think that external forces like states, markets, and technologies would supply, in the net, more escape routes from social oppression, even if these factors consolidated some traditional forms of power. But this is only an informed guess.

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