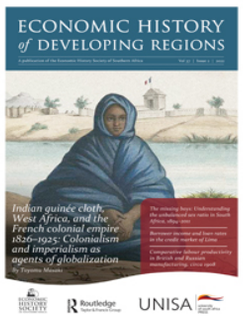


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RESEARCH ARTICLE

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# The development of the arid tropics: Lessons for economic history

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**ABSTRACT**

For centuries, the world's tropical regions have been poorer than the temperate-zone countries. Does tropicality make the struggle for economic development harder? What do people caught up in the struggle do? The paper defines 'tropicality' as the combination of aridity and seasonal rainfall, and in turn, high inter- and intra-year variability in moisture influx. In the past, this condition would generate a variety of adaptive strategies such as migration and transhumance. In the twentieth century, the response pattern changed from adapting to moisture supply towards control of moisture supply. This process unleashed conflict and environmental stress in the vulnerable geography of the semi-arid tropics.

**KEYWORDS**

Tropical; economic growth; inequality; drought; development

**JEL**

Codes: N10; N55; N57

## 1. Introduction

It is well known to development specialists that countries situated on or between the two tropics (23°27′ north and south latitudes) are poorer than the rest of the world. 'In 1992', we read in an NBER blog, 'GNP per capita in the tropical regions was 25 percent of that in the temperate zone' (Sachs 2001). Angus Maddison's data suggest that the inequality was present in the early nineteenth century. In 1820, gross domestic product (GDP) per capita in major intertropical regions (South Asia, the Middle East, Sub-Saharan Africa, and Latin America excluding Argentina and Chile) was 30–32% of that in Europe and European settler regions (Maddison Project Database 2020). Indeed, it was present, less starkly, from much before that. In 1600, the average income in Africa was 47% of that in Western Europe, and in India it was 60%.[1] In other words, the three great nineteenth-century forces economic historians sometimes cite to explain the origin of modern world inequality – industrialization, globalization, and European colonial rule – would not explain this inequality.

These numbers may suggest that the temperate-tropic inequality increased in the long run, and the great nineteenth-century forces may well have worsened it. However, the late twentieth century saw more convergence than divergence in average incomes

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[1] http://www.ggdc.net › horizontal-file_02-2010.

across countries (Bourguignon and Morrisson 2002). Unless shown otherwise, it is reasonable to assume that the more recent decades saw a catching up.

The long-term presence of inequality and the prospect of a catch-up more recently raises three questions. Does tropicality make the struggle to achieve economic growth more arduous than in temperate regions? What did people living in these lands do to change their condition? Why did their efforts succeed relatively more in the recent decades? In economic history and comparative development studies, the first question has received some attention, the second and the third questions much less attention. The paper first develops a geographical characterization of the intertropical zone and then suggests a narrative that answers the three questions.

The rest of the paper has six sections. First, I develop a definition of tropicality by building on the data on and concepts of climatic zones. The types of special interest to the paper are the arid and semi-arid regions with seasonal moisture influx (rain or flood). In the next section, familiar uses of 'tropical' in comparative history are assessed against this definition. The next three sections develop a long-range narrative of response to tropicality, which shows why this definition is useful for the economic historian. The last section restates the contribution and relevance of the project.

## 2. Tropicality

The area situated within and close to the two tropics is diverse. The characterization of tropicality in this paper and the corresponding historical process of interest do not apply equally well to all parts of the region but do apply to a substantial area within this zone. Tropicality in this paper means a combination of two features: high temperature throughout the year and a seasonal moisture influx.

I build this concept using the Köppen climate classification system, which uses the letters B for seasonal concentration of precipitation, W and S for volumes of rainfall subject to seasonal concentration, and h for average temperature. This leads to identifying two bands – extremely arid with low seasonal rains (BWh) and extremely arid with moderate seasonal rain (BSh) – that stretch mainly across the northern and southern tropics. This exact combination does not appear in non-tropical regions, though some experience significant aridity.[2] BWh is the largest area in size but is thinly populated. BSh is usually densely populated and occurs as a band contiguous to the deserts. This is not always the case; the Sertão in Brazil and the Deccan Plateau in India are BSh because of the combined influence of the tropical and regional climates. Some of the largest population concentrations occur in the Sahel; Gujarat, Rajasthan, Punjab, and Deccan Plateau in India; and southern Africa.[3]

The tropical region has a strong association with extreme aridity. Thirty-three countries in the world, all in Asia and Africa, have an average annual rainfall level of less than

[2]In the northern hemisphere, the BWh consists of mainly deserts, but also all of Egypt, Sudan, and Sindh (Pakistan), where agriculture and cities rely on the Nile or the Indus, and central Mali containing the inland Niger delta, besides much of Somalia, the Ethiopian deserts, and South Asian deserts. In the southern hemisphere, BWh contains the Australian desert, the Kalahari and Namib deserts, the Andean desert and the Bolivian salt flats.

[3]Other significant BSh regions are: contiguous areas in Namibia, Botswana, South Africa, Angola, and southwest Mozambique; the southern coast of Madagascar; the Sonora Valley in Mexico; southern California and the area of the Dust Bowl bordering Mexico; and areas to the southeast of the Australian outback. The 'Sahel' is the transition zone between the desert and the humid savanna south of the Sahara.

500 mm or 20 in. The tropics pass through 14 of these, and 12 more contain extremely arid lands within 500 miles of the 23°27′ latitudes. In most countries (18 of 26), the maximum summer temperature exceeds 50 degrees Celsius (122 degrees Fahrenheit). Excessive heat means that the evapotranspiration rate is considerably higher in the tropics, and surface water bodies evaporate much faster than in temperate lands.

A fully arid area cannot sustain life easily, let alone material life. High aridity would turn the tropical land into a desert but for the intertropical convergence zone (ITCZ) or the area where the trade winds of the two hemispheres converge, causing rainfall. The ITCZ is a low-pressure and high rainfall belt that shifts northward or southward with the thermal equator and at variable speed over land and sea. These rainfall episodes are concentrated in a few months, sometimes a few weeks, of the year and are often collectively called monsoons. Monsoons, however, differ significantly in strength and predictability. The combination of aridity and a bell-shaped rainfall pattern (Figure 1) implies a degree of seasonality or intra-year variation in economic activity that the temperate zones do not experience.

The heat-rain balance is enough to create grasslands over a large tract in the intertropical zone. These grasslands sustain pastoralism, typically migratory herds of cattle, for an extended part of the year before high summer sets in. Some of these lands, even in the wettest seasons, cannot sustain agriculture. Others can, in a short season. Farming and herds share these lands in different seasons.

In Sub-Saharan Africa and South Asia, 50% of the land is under savanna. In the remaining half, moisture inflow compensates for heat enough to create conditions for agriculture. The compensatory mechanism operates in broadly two ways. In India, of the total annual moisture inflow of about 4000 cubic kilometres, 100% comes from seasonal rains.[4] In the inland Niger delta, of the total yearly moisture inflow of 40 cubic kilometres, 13% comes from rains, and 87% comes from flooding of the larger rivers that receive rains near their sources (Ibrahim et al. 2017). Much of the Niger river plains is semi-arid. But in the inland delta in Mali, a land of lakes formed from the river's annual flooding, these floods sustained cultivation and fishing over thousands of square miles. In South Asia and the Sahel, evaporation and seepage losses are considerable. They remove 50% of India's inflow (as mentioned) and 43% in the inland Niger delta. The dry season can be relentlessly hot and dry and force herders to move to more moist lands or forest fringes and farmers to migrate in search of jobs.

The strength of the ITCZ varies from year to year, and so does its exact position, causing frequent droughts or inter-year variation in moisture influx. Droughts, of course, can happen in any geography, tropical or temperate. A severe drought is more likely in the tropics for the same percentage shortfall in moisture inflow because of aridity and high surface water loss. On average, two severe droughts occur every year somewhere in the tropics. Droughts seriously affected nearly two billion people in Asia, Africa, and the Middle East in the twentieth century. The corresponding number in Europe, the Americas, and Oceania was 5% of that figure, even though the rainfall shortages were often quite similar between these two regions (Below, Grover-Kopec, and Dilley 2007).

[4]'India's Water', https://economictimes.indiatimes.com/news/politics-and-nation/the-precarious-situation-of-indias-water-problem/articleshow/57965416.cms?from=mdrInland.

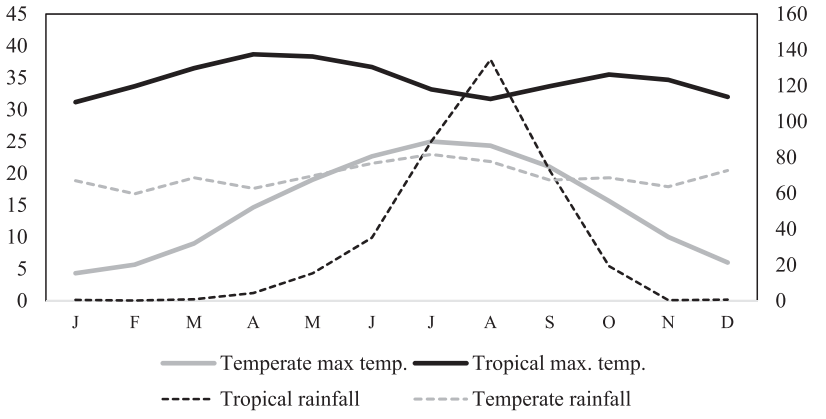


**Figure 1.** Maximum temperature (°C, left axis) and rainfall (mm) by month.

Notes: The samples consist of the capitals of six countries in Sahel-Sudan (tropical), and New York, London, and Berlin (temperate). In each case, the figures are the average maximum monthly temperatures and the average monthly rainfall. Source: https://en.climate-data.org/.

These elements can be combined to answer the first question, why tropical development is a harder struggle. There are four implications. First, seasonality implies underemployment for an extended part of the year. Second, aridity and seasonality jointly mean that the technology to generate economic growth would involve impounding seasonal water inflow on a large enough scale to withstand evaporation, or deep drilling underground where aquifers exist. The engineering responses to the challenge fit to serve large populations – dams and drilling – were not available until the early 1900s. When these systems do not exist or are insufficient, the third effect follows. The reliance on seasonal monsoon can reduce agricultural productivity because rainfed agriculture provides the farmer with fewer options to control the application of water to match it with fertilizer use and soil condition.

Fourth, climate variability can depress economic growth in several ways. It can create a preference for precautionary savings or make people lose hold of their savings too frequently, resulting in underinvestment. A well-known example of precautionary savings is animals rather than land as an asset in the dry savannas. In a discussion on premodern China, Parthasarathi (2011) suggests that the natural priorities of premodern states in arid regions were to avoid famines, not to generate economic growth. A substantial scholarship shows that the premodern and colonial states in Asia and Africa earned too little money per head to sustain a robust public goods drive (Frankema 2010; Karaman and Pamuk 2010). Limited state capacity derived from the poverty of the rural livelihoods that were taxed.

The data to directly test the causal model outlined above do not exist. This is so because the outcome variables (land yield, per capita income) are available by political units and not ecological regions. Its plausibility rests on the concept of tropicality as a combination of aridity and seasonality. If this foundation is sound, a single model can explain both the divergence before 1900 and the convergence after 1900, as I show later.

It is necessary to state certain limits of this project. First, the paper does not claim that tropicality, as defined, was the dominant causal factor behind world inequality. It has a different purpose. Insofar as tropicality influenced long-term economic change, we

need an acceptable definition of the climatic condition that can show *how* this relationship works. The paper addresses that task.

Second, the paper does not apply to all parts of the intertropical zone. It focuses on regions that experience significant aridity; not all tropical regions do, nor do all areas that experience aridity fail to develop. For example, the paper is not about the equatorial regions. The ecology of the equatorial region is different from that of the semi-arid region, with lower moisture variability both inter-year and intra-year and lower risk of droughts.[5]

Most counterexamples do not challenge the rule that tropicality predicts poverty; they only show that local geographies sometimes moderated that effect. There are many tropical deserts and near-deserts that border the sea.[6] But even in the harshest climates, the seaboard had a better chance to overcome the dual condition, sometimes thanks to the more stable flows of a deltaic river, and sometimes by trading with the rest of the world, which reduced its dependence on agriculture and pastoralism. The richer drylands – southern California, south of the Dust Bowl, north-eastern Mexico, and Australia – share one feature with the poorer drylands, an exceptional drought risk, but the former set has a lot more groundwater. Botswana and the oil-producing Middle Eastern countries are well-known users of mineral export income to combat drought and subsidize vulnerable livelihoods.

The monsoon of the Indian Ocean is exceptionally strong, and regions in its pathway – South and Southeast Asia, Taiwan – receive a larger volume of seasonal rainfall than most arid tropics. India receives a great deal more moisture per head than does Sub-Saharan Africa, which is one factor behind their divergent experiences with the green revolution. Microclimates in the highlands can sustain a different economy from the plains. For example, the Ethiopian plateau did not suffer famines and droughts with the same intensity as that observed in the desert fringes. Similarly, in precolonial and colonial Eritrea, Namibia, and Madagascar, the political elite lived in the mountains that moderated aridity, whereas much of the surrounding country experienced aridity. Taiwan has an extensive highland zone. River morphology can alter the impact of the dual condition. The Blue Nile, whose annual floods enabled intensive agriculture in a narrow strip of land that extended for hundreds of miles in a desert, is a well-known example. The Himalayan Mountain range gave rise to a riparian system that carried water throughout the year thanks to snowmelt. The Fertile Crescent rivers, the lower reach of which is arid tropical, are also snow-fed.

Economists and historians have used geography as an argument in models of development, and these concepts sometimes acknowledge aridity. A brief survey is necessary to show how this paper is different.

## 3. Tropicality and comparative history

The most discussed and debated concept is 'hydraulic society' or 'hydraulic state', introduced by the historian of China Karl Wittfogel in the 1950s. Wittfogel made three points.

[5]There is, however, a significant shared feature between the dry areas within a few hundred miles of the 23°27′ north and south latitudes and the wet areas near the equator. This is limited human control over moisture flow, of which floods and droughts were the symptoms. Reclamation of land for productive use was relatively difficult compared with the temperate regions in both.

[6]Western Sahara, north-western Australia, Peruvian and Atacama deserts, Sonora, the Namib, the Middle East, and North Africa.

First, in 'a landscape characterized by full aridity', the possibility of agricultural societies depended on artificial irrigation. Second, the typical form of irrigation was a canal drawn from a river. Third, arid regions saw the emergence of despotic states because canal systems required considerable political, bureaucratic, and military resources. 'The administrative officialdom [in China, Egypt and India formed a] mighty hydraulic bureaucracy' (Wittfogel 1957, 8). At the same time, the power of non-state institutions, like private property or courts of law, were relatively weak in such societies, hence low levels of development.

Wittfogel's claims about politics stand largely discarded. For example, most studies of Asia question whether arid-area or Asiatic water control was either canal-based or large-scale; and whether the large-scale systems had an association with despotic power (for example, Leach 1959). His geographical claim that drylands needed canals is problematic because canals do not solve aridity. They recycle water; they do not trap more of it. Tropicality was the combination of aridity with seasonal rains or floods. Wittfogel, and most of his followers and critics, overlooked seasonality. Wittfogel mentioned 'monsoon' just once in his book; he did not see it necessary to fit seasonal rains into his model. A specific kind of projects, impounding rainwater or digging underground, was needed to meet seasonal shortages, and such projects were scarce in the ancient world.

In 1970, the economist W. Arthur Lewis published an edited collection of essays called *Tropical Development* (Lewis 1970). Contributors to the book explored the idea that the nineteenth-century history of the tropical regions was distinct from that of the temperate zones, in that whereas 'the engine of growth in the temperate world has been industrial production, the engine of growth in the tropical world until quite recently has been exports to the temperate world' (Johnson 1971, 132). The argument begs the question, why were the tropical regions poor? Lewis' answer was inefficient agriculture, an idea that did not see much elaboration beyond a few suggestive remarks. Lewis' characterization of comparative history has been influential with the historians of nineteenth-century globalization. But the definition of tropicality is not rooted in geography.

A third literature to engage with tropicality is famine history. The benchmark contribution here is a 1981 book by Amartya Sen, which suggests that droughts are more frequent in arid geographies, and droughts can cause famines (Sen 1981). The proposition for which the book became famous is that droughts, while a sufficient cause, are not necessary for famines to occur. Legal access to available food can also cause famines. This latter argument shifted the attention of famine historians away from the environmental agency behind these shocks.

Droughts are indeed crucial because these events are intrinsic to the climate and because frequent droughts, by destroying assets or locking up savings in precautionary forms of assets, can depress economic growth. But then, trying to understand droughts through the lens of famines is misleading and distracts from a sound conception of tropicality. Droughts are moisture stress, and famines are shortages of food. The two things are different. Famine deaths represented less than 0.5% of the more than two billion people affected by droughts in the twentieth century.[7]

[7]This historiography of famines generated a discourse on public action to mitigate food crises. My criticism applies to the interpretation of history, and not the public action discourse.

A fourth cluster of works identify geography as an obstacle to 'modernization'. The agronomist René Dumont's writings, mainly on Africa, discussed natural resource conditions and risks in that way (Dumont 1964). He was, however, mainly interested in political conditions rather than climatic conditions that made development a hard task. Statistical studies on comparative development have established that '[l]ocation and climate have large effects on income levels and income growth through their effects on transport costs, disease burdens, and agricultural productivity' (Gallup, Sachs, and Mellinger 1999; see also Sachs 2000). This scholarship confirms the intuition that overcoming tropicality can be a hard struggle. But the scholarship does not do history. Cross-country correlations would not tell us how the peoples subjected to tropicality tried to overcome their condition. This scholarship acknowledges seasonality, but only just (Bloom and Sachs 1998, 235).

This survey tells us that a definition of tropicality that combines aridity and seasonality is not available in economic history yet. It is worthwhile to use such a definition for economic history. The next three sections show this by outlining a narrative of long-term change consisting of three significant movements. I will draw on a range of tropical drylands as examples. The purpose is not a comprehensive regional history but to gather enough examples to construct a credible and connected story.[8]

## 4. Before modern

I use the phrase 'before modern' to suggest that whereas people in the tropics acted to mitigate tropicality throughout recorded history, it is only in the last 150 years that this response took the form of controlling moisture flow on a large scale. History reveals a range of adaptive responses before that, such as chasing moisture via migration or transhumance. Modern (control) and premodern (adapt) did not separate at a precise date. Nor did all tropical regions see the transition in the same way.

Transhumance should come first in this discussion of mobility. Against a century-old Europeanist academic convention to treat pastoralism as an unstable and vulnerable livelihood, prone to overgrazing and decline, newer scholarships saw transhumant pastoralism (in Africa) as an adaptation to the tropical environment, especially where farmlands and grazing lands were not available year-round, savanna abounded, and droughts placed checks on herd size (Warren 1995).

'Mobility and migration', reads a study of the drylands, 'are core adaptive strategies within dryland pastoral systems in response to unpredictable and irregularly distributed resources … ' (Balbo et al. 2016, 2). Unpredictability refers to droughts. And irregularity refers to the seasonality of moisture flow, which makes lands in different places usable at different times of the year. Movement is a constant theme in the economic history of tropical Asia and Africa before colonialism. 'Half of India's population' in the eighteenth century, speculates the historian David Ludden, was mobile, and many were seasonal

[8]Sources on premodern tropical ecology derive from European colonial, merchants', and explorers' accounts, whereas those on present-day ecological responses to tropicality come from policy documents of nation states and academic writings. This difference makes using single regions as case studies of a long transition difficult, perhaps a project for future work on the subject. In this paper, the before-modern discussion uses material from West and southern Africa and South Asia, whereas the discussion in the next two sections draws on a wider set of regions.

migrants (cited by Kerr 2006, 89). Throughout India, two occupations – soldiery and construction work – relied on seasonal migrants from the farming village in winter who returned to their villages in summer. One of these fields, construction, continued to draw seasonal workers after the advent of British rule.

Similarly, in Africa, vast stretches of less stressed and more water-secure lands could be found next to the drought-hit ones. The seaboard, deltas, riparian floodplains, and lacustrine highlands like the Great Rift Valley provided insurance, and sometimes opportunities for resettlement and farmland development. Tree rings, the Nile water level estimates, and oral traditions enable the recreation of a long history of drought-generated migration (Webster 1980).

Large movements occurred not only in response to short-term crises but also in response to climate change – like shifts in the isohyet and along with it the start of disease-prone zones – in turn enabling military conquests that would have been impossible before. Shifts in desert edge and the uprooting of people in the seventeenth-century savanna zone in Sub-Saharan Africa 'had harsh consequences for many [as] ecological change … expanded zones of conflict and the loss of human freedom' (McCann 1999, 269; see also Webb 1995). Transhumance was a moisture-seeking movement. In the savanna lands, pastures appear in contiguous areas at different times of the year, depending on the amount of rainfall, floods, and retained surface water. Stockkeepers, even whole agricultural systems, would display considerable mobility chasing moisture (Iliffe 2007 has examples).

The interdependence between the 'desert-side' and the savanna has long been recognized as an important characteristic of the Sudan, the west-to-east expanse of habitable land to the south of the Sahara. Before European rule emerged in this area, the interdependence was based on the trans-Saharan trade. The economic ties that developed between people of the marginal lands, people of the savanna, urban merchants, and nomadic herders 'provided a safety valve for the desert during droughts', particularly those lasting more than several years (Lovejoy and Baier 1975: 572).

A second theme that often shows up in accounts of movements is unfreedom. In 1796, the traveller Mungo Park observed that the supply of slaves in the part of the Sahel that he toured rose due to war, drought, and debt. The three things sometimes occurred together. Droughts created the condition 'in which … a free man becomes a slave to avoid a greater calamity' (Park 1909, 226). '[F]amine', writes a study of early-nineteenth-century droughts in Mozambique, was '[a] major factor in filling the slave barracoons'. '[T]he Atlantic slave trade', wrote Joseph C. Miller, 'flowed in part from the tides of drought and disease' in that the 'historic peaks in exports' (from Angola) came when the most lasting and severe droughts were running their course. The link suggests that the slave trade was 'in some ways less a cause of depopulation than a consequence of it when viewed in terms of droughts and demographic changes in West-Central Africa' (Miller 1982, 30). However, another study suggests that the relationship between famine and slave trade was mediated by the cost of conducting raids, which was high during droughts (Fenske and Kala 2015). The general point – that people with insufficient means to cope with shortages became dependent upon strangers during crises – may still hold.

There is a long-term dimension to this link between subsistence crises and unfreedom: persistent risk seemingly led to the consolidation of hierarchy. 'Periodic waves of refugees

from the surrounding dry land', wrote Miller on premodern Angolan droughts, 'fled into these areas when the rain failed. There the refugees often accepted subordinate civil status as "guests" or "slaves", a price for asylum on the land of local communities of landowners. Many of these newcomers ended up later at the courts and markets of slave-selling kings and merchants' (Miller 1982, 29). An analytical narrative of Indian economic history in the *longue durée* contends, similarly, that frequent famines in the ancient past drove 'aboriginals [to contract] away their freedom for bare but regular subsistence' (Kosambi 1965, 88). A broad claim like this one is almost impossible to verify with evidence. But in fact, there is an indirect confirmation of the link. With a significant rise in food production and water distribution in the Indian countryside from around 1900, many long-term and caste-based attached labour contracts quickly crumbled (Roy 2022).

Unfreedom had an association with tropical agriculture. An argument known as the land-abundance view of precolonial Africa suggests that an abundance of low-quality land and labour scarcity encouraged labour coercion (Austin 2009; Fenske 2013). Rainfed or recession agriculture imposed prolonged idleness upon the workers and acute labour shortages during the few days or weeks when moisture supply was just right for sowing. Coercive arrangements helped employers solve shortages on those days.

The third form of response was technological. Cultivation practices in the tropical lands used various systems to retain soil moisture: from terraces to slow runoffs along slopes, to water-saving crops and plants (millets, sorghum, citrus trees), planting grass, mulching, and dew harvesting. In a tropical monsoon climate with high evaporation, storage of excess inflow in sufficient quantity to withstand evaporation can significantly enhance the quality of life – none understood that better than the people who lived in these regions. India offers plentiful examples of '[a] rich historical tradition of local water harvesting … from the *ahar-pyne* system in Bihar, the *tankas* of Rajasthan, the Himalayan *dharas*, the *talabs* in Bundelkhand to the *eries* of Tamil Nadu'.[9]

More extensive works did exist but were rare. Archaeologists could study these better. Examples would include the Sadd-el-kafara dam in Egypt, built in the third millennium BCE; the Marib dam in Yemen, built in the first millennium BCE; Mesopotamian canals drawn from the perennial rivers; dams, wells, cisterns, aqueducts, and *qanats* in the Jordan Valley and *foggaras* in Algerian Sahara; brick-lined urban water systems in the Indus Valley sites; tanks of the southern Deccan Plateau; and canals and reservoirs in Sri Lanka built between 300 BCE and 1200 CE. Even the largest of these works served the immediate hinterland of a town, sometimes just one oasis settlement. Storages were not of a scale to withstand exceptional dryness, and it is improbable that any of these systems sustained intensive year-round cultivation. Geodetic satellite data show for recent times that the human-made lakes or 'tanks' in southern India would shrink so much during exceptionally dry times as to be unusable for human or livestock use (Roy 2022).

The documented history of hydraulic intervention by states or societies became more or less continuous from the nineteenth century, thanks in part to colonial bureaucracies. European rule in Asia or Africa (roughly between 1800 and 1960) did not set off a series of top-down interventions and revolutionary changes. Colonial states did not share a single

[9]Shah (2013, 44). *Ahar-pyne*: network of channels and retention ponds; *tanka*: rainwater-harvesting tank; *dhara* : a tank to harvest natural spring water; *talabs*: human-made ponds; *eri*: another name for the tanks.

plan, origin, and ideology, and while militarily a success, they had too little tax revenue to do anything other than defend themselves. There were some common patterns to their legacy, nevertheless.

## 5. The colonial transition

This section discusses four legacies: transborder treaties on river basin sharing, property rights reform, water quality management as a part of epidemic control measures, and engineering projects with a significant effect on the landscape. None of these changes were specifically colonial, but colonialism helped in three ways: easier access to credit, command over river basins straddling country borders, and fiscal reforms that created the prospect of funding projects with future taxes.

All states, colonial or indigenous, understood the economic importance of perennial rivers in the tropical landscape as the only means to reduce intra- and inter-year variation in water supply. The colonial states went much further than the indigenous ones in terms of transboundary fluvial treaties. From the treaty of Vienna in 1815, the principle was established. Following the start of 'formal imperialism' after the 1885 Berlin conference, there was a systematic effort to develop such principles in tropical Africa. To begin with, this was a commercially motivated action. The treaties allowed for a navigational rather than productive use of rivers. Still, the treaties and limited usage of laws like an easement, public trust, and eminent domain established some rules to share common property resources. A field of public action was defined (Lautze and Giordano 2005). Most of these laws were responses to specific situations. The absence of any radical shift in perspective was evident in the almost total neglect of a vital commons, groundwater. 'No substantive colonial water treaty mentions ground water' (Lautze and Giordano 2005, 1061).

Three prominent examples were West African rivers, the Nile Basin, and agreements between British India and Mysore state on Kaveri River water sharing. Historians have studied only one of these in-depth. Egypt and Ethiopia fought a war in 1875–6 over control of the source of the Nile, which Egypt lost. A few years later, the British colonized Egypt. At the end of the nineteenth century, Britain and Italy had a great deal of influence among the main riparian countries that relied crucially on the Nile. In a series of moves, Britain and Italy, and Britain and Ethiopia, agreed to share some rules about the Nile. The main point of these early treaties was that upstream countries would not build dams. Later, influential among the semi-equatorial riparian regions, France joined these treaties. In the 1929 Nile Waters Agreement between Egypt and Sudan, negotiations went much further than before and fixed the volumes of water that the two countries could have claims over (Swain 1997). These treaties did not serve their aim all that well. The exclusion of Ethiopia illustrates the limits of colonialism in creating transborder arrangements. Still, these treaties created a discourse of cooperation to protect an entire basin and gave rise to a sensibility that river basins were an integrated ecological space – a form of environmental awareness that would last beyond colonial rule.

Where they could, these states consolidated private property in farming or plantations and encouraged trade, hoping to collect more money either from assets or from the businesses sustained by using these assets. Although land tenure was neither uniform nor legally perfect, the peasant-planter property was legally more robust than the right

to the commons. The two drives converged in those areas where forests could be cleared or pastures resettled to create commodity-exporting farms. These farming clusters exported rubber, wheat, rice, tea, cocoa, coffee, palm oil, groundnut, and sisal. Cotton was a semi-arid crop with small success as an African export (though irrigation helped), and gum arabic came from the arid commons. Otherwise, the twin bias favoured the water-rich deltas, basins, river valleys, and newly cleared forests.

Corresponding to the colonial obsession with land rights, oversight of the rights over water and pasture was profound. 'The notion of pastoral land rights was considered an oxymoron' in the early stages of colonialism in Africa (Galaty 2012, 144). Herders understood property and practiced inclusive management of property. But they did not identify one bounded and defined land and water body as their property. Doing so would go against the logic of herding, which involved moving from dry-season pasture to wet-season pasture. Under-legislation of pastoralist rights and consolidation of farmer rights led to a retreat of herding on a broad front. There is considerable evidence that a retreat did take place through the twentieth century and beyond. Still, how far the retreat can be attributed to colonial attitudes and biases, and whether it meant an enforced marginalization or the pastoralists' response to new alternatives, are debatable issues.

Davis (2016) has shown that the colonial bias for farming stood on a misreading of aridity. European colonists, few of whom had direct experience of aridity, read it as the result of human action and thought it could be reversed or mitigated by scientific practices. With that mindset, they often saw herds as a barrier to development and a relic of the past that needed to change. Whereas the states tried to collect taxes from them, it was not a large source of income nor a secure one against the risk of cattle disease and droughts. Sedentarization and farmland development, therefore, remained the overriding aim.

Besides fluvial treaties and property rights, a third field of intervention was technology, but the effect remained localized. The large volumes of water that passed through the South Indian deltas and Himalayan rivers enabled the building of canals in the Punjab plains and the deltas. These gravity projects recycled water from a secure source to water-scarce areas using the slope of the land. New ideas, including silt control and basin management, allowed projects to be built on a much larger scale than the past Indian regimes did in hydraulics (Gilmartin 1994).

Egypt was a downstream country. The fluvial treaties did not stop Egypt from building two dams in Aswan in the south of the country to create reservoirs. The first of these came up in 1889, and the second in 1928. The British were interested in expanding cotton cultivation in the area served by the dams, and Egypt was also crucial to Britain for strategic reasons. Colonial administrators saw that Egypt's existence and political independence from Ottoman influence would depend on economic freedom, which meant an expansion of intensive agriculture using the river's waters. Egypt's indigenous rulers, technically Ottoman viceroys, had reached the same conclusion in the mid-nineteenth century. In the interwar years, the notion that river water was an input for economic development spread in Africa, as abortive Nile project plans and treaties would suggest.[10]

[10]For example, the Nile Waters Agreement 1929, and the Century Storage Scheme, after 1952, suggesting an 'unmistakable shift' in the assessment of rivers (Maluwa 1988: 692).

Late in the interwar period, again, a new model of river project began to be popular, involving the control of water flow by damming rivers as they descended from the mountains to the plains. Such projects would generate water for the dry months and electric power. A dam, in this way, would serve the wet and the dry areas, the countryside and the cities, agricultural intensification, and industrialization. The enthusiasm for the multipurpose river valley projects thus signified the arrival of a new model of world development, one that civil engineers would script to a large extent.

The Mettur dam on the Kaveri was possibly the largest in the world when it was finished around 1935. The dam involved 'mobilization of engineering expertise from across the world … the changing political scenario in British India and … local water politics' (Ramesh 2019: 2). The dam sustained intensive cultivation in one of the drier regions of south India. The electrical power generated in the dam and the thermal plant near it supplied energy to a cluster of engineering and textile towns in northern Tamil Nadu. The almost contemporaneous Markala dam in Mali, meant to encourage cotton cultivation in the north-eastern part of the inland Niger delta, did end up helping rice cultivation. With such impressive beginnings as these, after colonial rule ended, politicians, engineers, and aid agencies zeroed in on this model of river use as the answer to underdevelopment.

With more dramatic results, a fourth field of colonial-era intervention was what Abdel Omran had called the 'receding pandemics' phase of an epidemiologic transition (Omran 1971). Diseases like cholera and schistosomiasis had a direct association with the quality of water, which was ordinarily poor in the arid lands, and became worse during droughts. Public health and medicine to tackle just a few waterborne diseases could substantially reduce deaths from droughts. It appears that in both South Asia and Africa, the initial effect of colonialism – focused on market integration and commercialization – was a rise in epidemic incidence, especially cholera, malaria, trypanosomiasis, and rinderpest. Around 1900, cholera, smallpox, plague, and malaria accounted for 24 of 40 deaths per 1000 people in South Asia. By 1940, however, deaths from these four diseases fell below 14 per 1000.

The turning point came in 1920. 'Populations [in Africa]', writes Manning (2014, 132), 'rose at a very modest rate from 1890, then accelerated from 1920 to 1950'. Manning's figures have been revised, but the revision does not change the inflection point (Frankema and Jerven 2014). In both regions, a part of the actions that led to the epidemiologic transition involved water purification and a centralized supply of filtered water, which significantly reduced cholera deaths and deaths during droughts. Where did these actions come from? The recent history of water quality in India suggests that it owed rather little to a top-down statist desire to improve colonial welfare. Instead, it built bottom-up from many local and initially disjointed efforts: the municipal water supply schemes funded by merchants, easements law, movements for equality, press campaigns, and legislative autonomy (Roy 2022). African demographic history conforms to this pattern to some extent. Life expectancy increased significantly (with inequalities persisting) in 1900–1950 in Cape Colony, partly owing to smallpox control and water control (Simkins and van Heyningen 1989).

General interpretations of the impact of colonial rule on economic development remain sharply divided. The Marxists – Immanuel Wallerstein, Eric Wolf, Walter Rodney, Samir Amin, and A.K. Bagchi – stand on one side. They believe that colonies lost from colonialism because of surplus extraction and transfer. Market-optimists like W. Arthur Lewis,

Hla Myint, Celso Furtado, and D.K. Fieldhouse stand on the other side. They believe that the colonies made significant gains from colonial trade, and do not emphasize surplus transfers.

The account presented in this paper suggests that colonial interventions created new forms of inequality rather than generating either development or underdevelopment. Regional inequality was the most obvious example. The agricultural intensification and commercialization pathway was strong where water was secure, accompanied by business growth in port cities. There was more disruption in seasonal livelihoods in the savanna and drier lands, and sometimes de-urbanization where railways and ports took away trade and people. At best, nothing much changed except population growth rates.

Another form of inequality was intersectoral, on which Indian national income data are helpful. India's port cities were a part of the Indian Ocean trade for a long time before British colonization. The emergence of an empire consolidated their position as business cities, founded on different trades and supported by an extensive railway network. There were areas of dynamism in the countryside, where irrigation water became available, but by and large, the rural economy was dominated by stagnant arid lands. Between 1900 and 1945, real income in industry and services increased by 133%, and real income in agriculture by 26%. In the same period, income per worker in manufacturing and services increased by 180%, and income per worker in agriculture increased by 6% (Roy 2020). The mainstay of business growth was long-distance commodity trade. Cargo carried by the railways and to the ports increased from 5 million to 140 million tons between 1871 and 1939. Finance and banking expanded to support the growth. Merchants and trading firms invested trading profits in cotton and jute textile factories. There was economic growth, but a regionally unequal one.

## 6. Hydraulic developmentalism

Water strategy in the world's arid areas, tropical or not, underwent a profound change in the second half of the twentieth century. Geoengineering was one part of it. Deep drilling, dams, reservoirs, inter-basin transfers, basin management, and hydroelectric power generation for cities and industries – all had a twentieth-century origin. A second part of the change was institutional and political. In the 1980s, the sociologist Peter Evans coined the phrase 'developmental state' to define a type of state that saw itself as an agent in development and stood apart from lobbies and interest groups, even holding dictatorial power (Evans 1989). Such a state also built a partnership with engineers, a politically neutral sort of lobby that would perform a critical role in economic modernization. The extensive scholarship that debated this concept understood by 'development' mainly one thing – industrialization. That focus on industrialization limited the cases where the developmental state could be seen in full flourish to just a handful.

In fact, developmentalism was an old idea, if we consider that the desire to catch up with the West had a distinctly hydraulic dimension. In water, the developmental state started in the tropical world in the interwar period or in India in the 1880s, when colonialism was still active. Its fiscal and technical capacity changed radically after 1950. Geoengineering supplied the hardware and foreign aid the finances to meet states' ambition to develop waterworks on a grand scale. Waterworks also tells us that too much attention to the developmental state is misleading. In arid Australia and the Americas, private

enterprises took care of groundwater exploitation. Whether state or private, the agents making a change listened to engineers and included them in policymaking more than before.

In the world's arid areas, this was a revolution. José Luis Moreno says that a burst of private investment in deep wells in north-western Mexico ushered in 'the golden age of agriculture' (the 1940s; Moreno 2012, 546). Large-scale groundwater exploitation in and near Mexico City from the late nineteenth century, bringing about the 'beginning of an age of hydraulic opulence', would serve as an example for the drier areas (Walsh 2018, 73). Josephson (2017, 170, 175) calls the enormous water-diversion projects of mid-twentieth-century Soviet Central Asia, to help cities and cotton farming, attempts to 'industrialize nature' and 'rebuild nature'. These were not all tropical lands. But the tropical lands shared the same ambition when they became free from colonial rule between 1947 and 1965.

The scale of dam building around the tropical world between 1965 and 1990 was staggering. The golden age of dam building began when Western European governments and the World Bank offered cheap loans to finance the projects. The governments wanted to create work for large engineering and consultancy firms looking to go global after the postwar reconstruction boom began to flag. Gigantic projects were designed on the Nile, Niger, Volta, Senegal, Zambezi, Jordan, Euphrates, and Indus Basins. By 1990, there were over 2000 dams across Indian rivers. Most of these had appeared in the Deccan region, where there was less water overall, yet the topography permitted storage more easily than in the flat Indo-Gangetic Basin.

That the expectations were partly fulfilled, no one can doubt. The data are patchy but tell a story. Figure 2 shows that worldwide there was an acceleration in the scale of water harvest from the 1950s, though the rising trend began in all regions of the world from the early twentieth century. This may seem like an attempt to catch up with population growth, and it was to some extent. But there are two differences between regions.

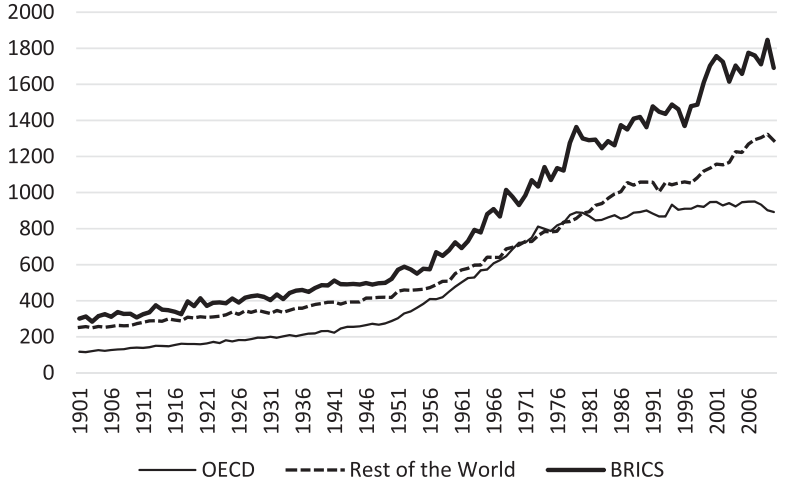


**Figure 2.** Annual freshwater withdrawal, 1901–2000 (billion cubic metres).

BRICS stands for Brazil, Russia, India, China, and South Africa. All five countries contain extensive arid lands. In Brazil, India, and South Africa, these are tropical drylands. Source: Hannah Ritchie and Max Roser, 'Water Use and Stress', Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/water-use-stress.

First, domestic and industrial use of fresh water dominated the total in the richer countries, whereas in the poorer countries, agriculture did. World Bank data show that more than 90% of freshwater withdrawal in South Asia (2017) is used in agriculture. In Sub-Saharan Africa, nearly 80% is used in agriculture. In other words, relatively more water in these regions is allocated to the production of food. This is so because of the much higher risk of drought and famine in some of these areas, and because intensive agriculture is naturally more water-intensive in many. The second difference is that vast inequality in water access persisted. OECD members have 28% of the world's renewable fresh water, South Asia 4%, and Sub-Saharan Africa 10%. The combined population of South Asia and Sub-Saharan Africa is well over double that of the OECD members. This imbalance is due to geography, attributable to water availability and the cost of extracting water, the former being lower and the latter higher in the tropics.

The vast river valley projects killed three birds with one stone: cheap electricity, irrigation, and flood control. Further, dams displaced people settled in the areas where a reservoir hundreds of square miles in extent would appear. Many displaced people were resettled as peasants in the savanna lands, for example near the Niger River basin dams in Nigeria, Ghana, and Senegal. That move helped diffuse political tension while contributing to agricultural improvement. Directly or indirectly, development, dam-building, and a pro-peasant bias in policy reinforced each other. The impressive record of agriculture in the developing world proves that geoengineering delivered. Between 1970 and 2020, cereal output in South Asia and Sub-Saharan Africa increased by 300%. The urbanization ratio about doubled in both regions. People's access to basic drinking water service was much higher in the urban areas and rising fast in both regions from the end of the twentieth century. All that effort aided the late-twentieth-century catch-up with the West that the paper began with.

If the solution to tropicality was so obvious and pursued with so much energy, why isn't the whole world developed? Why do the tropics remain relatively poor? A partial answer is that controlling moisture generated costs. Dams and drilling are capital-intensive technologies. Besides economic costs, there were two other types of cost: conflict and environmental stress.

'The utilization of water, more than any other resource[,] has experienced tremendous conflicts', writes the geographer Josephine Msangi (1987, 63). Controlled water harvesting on a large scale unleashed three types of conflict. First, there is a potential conflict between two principles in transboundary river-sharing. One of these asserts sovereign territorial rights over resources (known as the Harmon doctrine of 1896, after an opinion expressed by a US Attorney General), and the other seeks to maintain the unity of the source. Countries situated in different places in a river basin can choose the principle that best suits their interest. The choice depends on whether a country can access the source or the river's basin. The clash of interest is like that between a farmer operating upstream and one downstream, except countries can try to address the clash by legislation, negotiation, or arm-twisting. Even with an agreement, the problem does not disappear. As the water reaches more distant fields, seepage and evaporation losses ensure that the quantity and the quality deteriorate. These losses are never easy to price.

Second, the accent on intensive agriculture worsened farmer–herder conflicts in countries where pastoralism was a significant livelihood. Despite resilience and adaptability, transhumant pastoralism has declined all over the world, and conflicts between

herders and farmers have grown more intense. Transhumant pastoralists and sedentary cereal farmers are not and never were completely distinct sets. Each depended on the other for dry-season pasture or manure. Nevertheless, conversion of grazing lands into lands suitable for year-round farming, as well as changes in feeds and fertilizers, reduced this interdependence and created a competition. In many places, the response has been a peaceful one: conversion of farmers and herders into agropastoralists (see below). The same tendency also pushed specialist nomadic herders into dependence on more limited resources, hence conflict. The conflict came under the spotlight when mentions were made of it in the wake of the 2007 Nobel Peace Prize for awareness about climate change (Benjaminsen and Ba 2009). Climate change, however, did not create the conflict. Colonial property right reforms, growing livestock trade, and the accent on intensive agriculture did.

Third, water inequality is not mainly an interpersonal inequality; it is an interregional and inter-ethnic inequality. Where regions have different cultures, water access or deprivation feeds inter-ethnic wars. 'Coping with drought, [and] shift[ing] between agriculture and pastoralism', writes an analyst of the Darfur conflict, 'have been not only adaptive processes, but have also been characterised by shifts in identities' (Manger n.d., 1). Examples of contests over resources spilling over into ethnic bloodshed abound in the Sahel–Sudan. If one of these regions acts as a centre of political power, the inequality is a recipe for civil war.

One of the most violent countries of the late twentieth century, Sudan, is a telling example of how politics joined with vulnerable geography to fuel such conflicts. The concentration of business and intensive agriculture in the riverine areas and the main urban-industrial centre Khartoum was aided, if not created, by the British colonial accent on commercialization. The 'alliance of riverine, northern Arab elites' sustained an ethnic-religious nationalism formed in reaction to British rule (Straus 2015, 244). Colonialism, however, ruled with a light touch here, which left a legacy in weak land titles. Successive failure in land titling initiatives left landed property vulnerable to capture.

The paradox of Sudan was that it was too weak and impoverished a state to impose a strong form of federalism. In Darfur, the elites could provide only logistical and moral support in a battle fundamentally about land and water. That battle turned fierce in the wake of the devastating droughts as pastures decreased and herders threatened to encroach on farmers' lands. Ethnicity was one dimension of the battle that made the conflict brutal for the non-combatants, but competition for natural resources rather than ethnic sentiments was the driver. '[E]nvironmental stress on a vulnerable landscape … forced some to defend their land and others to migrate or find new land' (Straus 2015: 250).

A second adverse side-effect of hydraulic developmentalism was environmental stress. Traditional livelihoods depended on seasonal rains and floods. Land productivity was low, and most farmers were poor. Still, agriculture was environmentally sustainable because it adapted to moisture flow rather than controlling it. From the 1920s, it was not economically unsustainable anymore because of population growth and the drive to catch up with the western world, leading to systematic attempts to control moisture flow. These projects were more intrusive on the environment than before, raising water stress.

Water stress measures the withdrawal of fresh water as a percentage of renewable sources. The dataset is noisy because it does not factor in the costs of accessing

different sources, thus delivering low stress for some of the driest countries. For what it is worth, in 2016, stress levels ranged from 42% in India to 105% in Pakistan and parts of Sub-Saharan Africa. The levels were considerably lower in the UK (10), USA (22), Japan (28), and China (30) (World Resources Institute 2021). A close cross-country correlation between average temperature and stress suggests a geographically located stress pattern.

With few exceptions, big dams built on rain-fed rivers were a high-maintenance, inequality-creating, and environmentally damaging pathway. In a water-scarce economy, cheap or free water leads to wasteful use of the resource. The shift to paddy in the arid areas is a good example of the syndrome. Arid-land crops like sorghum and millet require moist soil when the plants are young but can then withstand dryness. Therefore, they are better suited to arid monsoon conditions than rice varieties that require moisture throughout their life cycle. But rice is traded over wider areas and promises more profits. Since the 1990s, the dam drive started to recede. Dams are built on a much smaller scale than before, and multilateral funding for such projects has dramatically decreased.

A further area of concern is desertification. The human agency behind desertification supposedly owes to overgrazing. The control of disease contributed to a sharp rise in livestock (in East Africa) and, in turn, to overgrazing and declining quality of pastures (Heady 1965). Overgrazing can impact the climate.[11] Over almost a century, in the inland Niger delta, there was a gradual shift away from pastoralism towards agropastoralism, a regime where farmers kept herds and herders farmed. The 1970s drought hit the region hard and left a variety of legacies. The droughts and the Niger dam projects permanently shrunk the active delta in some accounts. At the same time, the droughts encouraged agropastoralism as a strategy to diversify risk. The reliance upon artificial irrigation systems increased. The pressure on year-round fields still available for grazing increased.

The late-twentieth-century green revolution raised land yield significantly. However, the rate of growth in average grain yield has been declining since the 1980s (on the India data, see Mathur, Das, and Sarkar 2006–7). Among other factors, the diminishing returns syndrome owes to land degradation and over-extraction of groundwater. In India again, estimates suggest that of the 329 million ha of land area, anywhere between 121 million ha to 190 million ha is subject to soil and wind erosion levels that can impair the productive power of the land. The precise reasons for land degradation remain open to question. Increasing land use for agriculture and settlement has led to a decline in forest cover, but sometimes, increased density of settlement can lead to better vegetation conservation. One thing is certain: the problem is more severe in arid environments. About 80% of the degraded land occurs in rain-fed or dry zones, where a fall in soil quality has led to productivity loss and loss of nitrogen, phosphorus, and a host of minerals in the soil (see discussion in Roy 2017).

These examples of the degradation of resources do not cause as much alarm as they might because the technology to mine water from deep aquifers has been used far more extensively in the last 30 years in both Asia and Africa. It is a costly enterprise with big payoff. Indeed, groundwater extraction is now the mainstay for India's irrigation and

[11] In the Otterman cycle, overgrazing leads to a rise in surface albedo (a measure of diffuse reflection in total solar radiation) and reduced convection.

urban water supply. Since India's economic miracle began about 30 years ago, borewells and urbanization became interdependent. Eighty percent of urban and industrial water now comes from wells.

Groundwater resources are technically plentiful, but groundwater mining is expensive and triggers a legal problem the colonial regimes avoided dealing with. The tap or well above ground is legally protected private property, but the water below is a common property of too unknown features for regulation to work efficiently. The resolution of this problem requires laws to incorporate the public trust principle, and countries have moved at different speeds in doing that. Besides, entire nations and large regions have little underground water in the first place. Many aquifers in the desperately water-scarce Pakistan are saline (Sindh) or overused (Baluchistan). Outside the Nile Corridor, which has most towns and industries in Sudan, geological conditions (the hard rock formations of the basement complex where little underground water can be found) make sinking wells an unprofitable enterprise.

Economists, activists, and scientists offer other solutions to scarcity. Water markets are one potential solution, but pricing water from the commons is complicated and does not necessarily help conservation. Conservation technologies like drips and sprinklers, *diguettes* (mounds built to reduce runoff), and watershed management do work. Some work only on a small scale, and others – like overground drips – work better for a few commercial plants and rarely for the main food grains. Many non-governmental organizations inspired by the tragedy of the commons discourse advocate cooperation, which again works on a small scale and breaks down in a large region with a diverse population. Perhaps large-scale regulated water trade, which has had a tentative beginning, artificial aquifers recharge, and the discovery of drought-proof seeds, hold some promise, but a fuller discussion of these new frontiers will distract the paper from its main aim, which is to place patterns of response in a historical perspective.

## 7. Conclusion

The paper began with three questions. Does tropicality (the focus here is on the arid tropics) make the struggle to achieve economic growth more arduous than in the temperate regions? What did people living in these lands do to change their condition? Why did their efforts succeed relatively more in the recent decades? I suggest that a persuasive answer to the three questions requires a geographically sound definition of tropicality. The definition has two dimensions – aridity and seasonality – jointly causing sharper intra- and inter-year variation in the supply of moisture than the temperate zones experience.

Tropicality makes the struggle to develop harder because there is no cheap, reliable, and peaceful response to moisture stress and because economically successful responses have adverse environmental effects. What do people caught in the struggle do? In an earlier era, moisture stress episodes induced migration and the prevalence of livelihoods that chased moisture. Since the late nineteenth century, responses took new forms, including medical intervention, gravity projects, impounding projects, river-sharing, and legislating property rights. These interventions delivered positive results (mortality decline, green revolution) and some adverse ones (regional inequality, ethnic conflict, environmental stress).

Roughly between the 1920s and the 1960s, the tropical societies did much better at reducing mortality than raising productivity. The outcome was a sharp rise in population

growth and a relatively low rate of income growth. We see these societies as failures if we assess performance by observing per capita income trends. Rather, they successfully solved one immediate problem stemming from tropicality: shorter lives. After the 1960s, hydraulic developmentalism took over, and income growth picked up, hence catch-up.

The paper has two lessons for economic history and development. First, per capita income is an unreliable index to measure long-term changes in living standards in the tropics. Whereas geography limited population and income growth, the interventions to ease the obstacles were different and took shape at different times. Second, while the lessons from comparative history on accelerating economic growth via institutional changes or sound public policies are still useful, they are useful to a limited degree. Tropical development is a package of measures that includes geoengineering, conflict management, and environmental management. Economic historians wishing to study the pathway of economic change in the poorer countries need to build dialogues with political scientists and environmental scientists and bring the trade-off between geoengineering and stress into the mainstream. This trade-off marks the arid tropics as distinct from the temperate zones. An example of a relevant research question is why the trade-off leads to negotiated outcomes in one case and civil war in another.

Finally, the paper has lessons for environmental activism. Movements to save the Earth tend to be preoccupied with emissions and climate change. The unhappy history of multilateral negotiations on this issue shows that the poorer countries (most are tropical) do not share the same passion for climate change as politicians and activists in the western world do. The explanation is an obvious one. While there is credible evidence that climate change could intensify droughts and water shortages, droughts and water shortages have happened in the tropics without climate change. Even if human interventions mitigate the effects of climate change, droughts and water shortages will continue to occur in the tropics. A historical piece like this paper reminds us that tropicality is a condition independent of climate change. Indeed, some of the current critical environmental crises the tropics face have proceeded from a successful response to tropicality. The response to tropicality and its damaging side effects need to be recognized as a field independent from climate change, even though that factor may complicate the response.

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